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# Análise antracológica nos concheiros da Idade do Ferro Antigo na Praia do Tofo e Praia da Rocha, Inhambane, Mozambique

UNIVERSIDADE DO ALGARVE
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Master in Archaeology

Work carried out under the guidance of:
Doctor Sandra Lennox
Doctor Nuno Ferreira Bicho

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Declaration of authorship of work

I declare to be the author of this work, which is original and unpublished. Consulted authors and works are duly cited in the text and are included in the list of references included.

*“(...) by 50 000 to 60 000 years ago, African man was also using fire, a tool with which he could cook and make tender the tougher parts of his prey, and so make more efficient use of his food supply and allow a further enlargement of the size of his communities".*

Fage & Tordoff, 2002: 14

# ACKNOWLEDGMENTS

The completion of this dissertation was the result of the support, availability and trust of a group of people deposited in me and that helped me to evolve personally, as well as, a researcher in Archaeology.

First, to Nuno Bicho and Jonathan Haws for the proposal to study the anthracological material of a set of shell-middens located in Mozambique, through the VIP 2016 project (PTDC / EPH-ARQ / 4168/2014). Then, for the persistence of Nuno Bicho to find an advisor specialized in African anthracology and whose dedication let me to know Sandra Lennox. Thank you very much!

This way, I would like to thank Sandra Lennox for the availability she soon showed to be my advisor. So, I thank Sandra Lennox for all the help she provided during my stay in Johannesburg. I am also grateful for the opportunity, patience, guidance, friendship, sympathy and willingness to teach, as well as for the criticisms, corrections and relevant suggestions made during the orientation. I also thank the Evolutionary Studies Institute (ESI), University of Witwatersrand, Johannesburg, South Africa, for the friendly way they received me. All the members of the Institute made me feel safe, gave me a great working environment and I also really enjoyed the company of all of them, who insisted that I participate in some formal activities but also that I socialize and enjoy the country. Thank you very much, everyone will always be remembered!

I could not fail to mention the “Association of Archaeologists of the Algarve” (AAA) and the ICArEHB Center for the financial assistance required to make my trip and stay in Johannesburg possible to study the anthracological material presented in this dissertation. A fundamental help, no doubt. Thank you!

I also owe a huge thank you to the InMoz project (PTDC / HAR-ARQ / 28148/2017) led by Ana Gomes, who proposed my participation in the project and, with that, allowed me to know the landscape of the archaeological sites under study, fundamental aspect for the dissertation. Thank you very much to Ana Gomes and to the rest of the InMoz team for the memories.

I would also thank all my teachers from the University of Algarve, for the wise and valuable teachings provided during my Master in Archaeology. To date, several teachers have believed and placed their trust in me, teaching me with sapience, making me grow as an archaeologist, feeling more secure about my work and my abilities and I really thank you for that. It should be added that the work environment is also essential for a good team spirit and for the productivity of those who work and, certainly, that the entire Faculty transmits this environment. Thank you!

To Célia Gonçalves for having been my “third advisor” during the last stages of the Thesis. Always with good advices and motivating words to continue with the work.

To Pedro Francisco, for the teachings on image treatment, which were certainly a great help. I also thank all the companionship you have shown. You were the one who “took the boat” beside me, with sympathy, patience, motivation, perseverance and love. Thank you!

To Patricia Monteiro for introducing me to the world of “charcoals” and for being a faithful friend during these years. Thanks for everything!

To the rest of my colleagues, who are also important to “keep the boat”, I thank you for the comforting, confident and motivating words that you were able to give at the right times.

To my friends, who always believed in me and gave me the strength and courage to continue with my goals, that is, to all those that came across me in this stage that were undoubtedly a great support during this period. Thank you for your unconditional support, for your love, for your wise words, for your friendly smile, for your comforting hugs, for your madness and laughter.

Finally, I want to thank my parents as lovingly as possible for the opportunity, support and trust they have always placed in me. They are the ones who never really doubted me and were always in my good and bad times, always giving me strength and courage to continue with my dream. In addition, a big thank you for giving me what is really essential in life, allowing me to become the person I am today.

To Altura, for the memories that remain ...

# RESUMO

Na África Austral, para o período do Holoceno, já são numerosos os sítios arqueológicos que aplicam análises antracológicas (Cartwright *et al.*, 2016; Chikumbirike, 2014; Cowling *et al.,* 1999; Deacon, 1979). Compreender a presença do carvão vegetal nos sítios arqueológicos ao nível paleoetnobotânico permite entender a relação entre as sociedades humanas e a paisagem circundante e, por sua vez, ao nível paleoecológico pode aferir as possíveis alterações na formação da vegetação lenhosa. Assim, estudos antracológicos em sítios arqueológicos são de grande importância e constituem uma fonte de informação com muitas possibilidades interpretativas.

Esta dissertação apresenta o estudo dos carvões arqueológicos recolhidos em sete concheiros situados na costa do município de Inhambane, Moçambique. Dois concheiros foram identificadas no topo das dunas na Praia do Tofo, os outros cinco concheiros foram identificados na Praia da Rocha, datados de aproximadamente 400 anos BP.

O principal objetivo deste estudo é compreender a relação entre as comunidades humanas do passado e o paleoambiente, sob a perspectiva da aquisição de lenha, ainda pouco conhecida em Moçambique. Assim, os padrões espaciais resultantes da distribuição dos táxons lenhosos foram analisados para obter informações paleoetnobotânicas sobre a seleção e uso de madeira durante a Idade do Ferro Antigo, na costa do município de Inhambane. Nesse sentido, o objetivo do estudo será avaliar as estratégias de exploração e uso de espécies lenhosas do ponto de vista sociocultural e econômico. Por outro lado, outro objetivo será determinar possíveis mudanças na vegetação, tanto por ação antrópica como climática.

A maioria dos carvões analisados provém de recolhas superficiais, onde os materiais se encontravam confinados a uma pequena área. A maioria do carvão arqueológico recolhido corresponde a depósitos de carvão dispersos (Setor Shell, Tofo 2, PR1, PR14, PR15, PR4 e PR7), que são o resultado de atividades e diferentes tempos de combustão durante um período e transportados após uso para depósitos de lixeira (Bentsen, 2013, 2014). Outros contextos estudados (Hearth1 e Hearth2) podem ter tido uma função específica como estrutura de combustão. O carvão concentrado presente pode refletir atividades específicas ou de curto prazo. Finalmente, além de carvões domésticos, um dos concheiros na Praia da Rocha (PR1)

corresponde a um enterramento humano. Aí, os carvões recolhidos provêm de material disperso (depósitos de lixeira) e de um contexto específico (natureza funerária), podendo apresentar dois momentos de depósitos, com parte do carvão arqueológico possivelmente associada ao enterramento.

529 fragmentos de carvão vegetal foram analisados nos três planos diagnósticos (transversal, longitudinal tangencial e longitudinal radial) com o apoio de microscópios de luz refletiva (Olympus BX51TRF e Leica DP2500) ampliado até 500 vezes. Como nenhum atlas anatômico de madeira específico para esta região está disponível, foi criado uma base de dados para conhecer a vegetação moderna da província de Inhambane (Digital supplementary materials 2 - Taxonomic and taphonomic Database study. xlsx). Consiste essencialmente em três tipos de informações: a flora moderna (Burrows *et al*., 2018), referências on-line que possuem imagens com a descrição da estrutura celular (Allott, 2005; Chikumbirike, 2014; Lennox, 2016) e os códigos anatômicos da lista da "International Association of Wood Anatomists" (IAWA) para a identificação da madeira (InsideWood, 2004-onward; Wheeler, 2011).

A análise antracológica revelou o uso de onze taxa, são eles: cff. *Avicennia marina*, cff. *Harpephyllum*, *Combretum* sp, *Burkea* cf. *africana*, *Diospyros* cf. *natalensis*, *Ekebergia* cf. *Capensis*, *Mystroxylon aethiopicum*, *Brachylaena* cf. *discolor*, *Catunaregam* cf. *spinosa* e *Euclea* cf. *natalensis*. Dos 529 fragmentos de carvão analisados nos concheiros da Praia do Tofo e da Praia da Rocha, 314 foram identificados como *Euclea* cf. *natalensis*, seguido por 77 fragmentos de *Diospyros* cf. *natalensis*. Estes dois taxa em termos quantitativos surgem em todos os concheiros estudados e são os mais representativos.

Assim, por meio da análise taxonómica, conclui-se que 1) a combinação destes dois táxons (*Diospyros* cf. *natalensis* e *Euclea* cf. *natalensis*) parece representar um padrão de utilização da madeira principalmente escolhido como combustível, 2) algumas espécies terão tido fins domésticos, como os identificados em Hearth1 e Hearth2, 3) maioria dos carvões analisados, provém de depósitos secundários (transportados para um depósito de lixeira após uso como combustível) e 4) a provável associação de *Combretum* sp. e *Ekebergia* cf. *capensis* com o enterramento. Estas duas últimas espécies podem estar relacionadas a crenças culturais ou a certos tipos de cerimônias fúnebres. *Combretum apiculatum, C. zehyeri* e *Ekebergia capensis* são usados pelas comunidades *Incwala* e *Zulu* como encantos ou em cerimónias, incluindo funerais (Hardwick, 2013).

Quanto à análise tafonômica dos carvões em estudo, uma vez que a porcentagem de madeira afetada por microorganismos no complexo antracológico estudado é pequena, é pertinente supor que a madeira utilizada como combustível pelas comunidades de Inhambane estaria principalmente em boas condições (Théry-Parisot *et al*., 2010). Por sua vez, as mudanças morfológicas, nomeadamente os nódulos (Martín Seijo, 2013), podem sugerir a recolha de madeira pequena, sustentada pelo fato de *Euclea* cf. *natalensis* ser o táxon onde mais nódulos foram identificados, táxon mais representativo e quantitativo dos concheiros analisados.

Mesmo sem ter concluído a análise antracológica total dos carvões recolhidos (Hearth1, Hearth2, PR1 e, PR14), os resultados obtidos através da análise de carvão apontam para uma relação semelhante com as espécies de savana da floresta de Miombo no diagrama de pólen de Vilanculos, particularmente com a presença de Combretaceae e *Euclea* na paisagem há cerca de 400 anos BP, o que é corroborado pelos dados antracológicos apresentados nesta tese. Isso leva a considerar que a paisagem circundante da Praia do Tofo e da Praia da Rocha não terá sofrido grandes mudanças em termos de composição vegetativa, pois os táxons identificados permanecem presentes ao longo do tempo.

Assim, o conjunto antracológico permitiu compreender a relação entre as comunidades humanas do passado e o paleoambiente, sob a perspectiva da aquisição de lenha. O tipo de paisagem que floresceu durante as comunidades agrícolas tardias, reflete a distribuição das árvores e arbustos ao redor dos concheiros estudados na costa de Inhambane e são, igualmente, o testemunho de um sistema de assentamentos na costa de Moçambique (Senna-Martinez, 1969).

# ABSTRACT

Archaeological charcoal specimens from seven shell-middens were identified and the spatial patterns resulting from the distributions of the woody taxa were analyzed for paleoethnobotanical information about wood selection and use during the Late Iron Age in coastal Inhambane.

Most of the charcoal samples come from surface collections. Some samples were collected from two hearths identified in one of the shell-middens. Other samples came from trach areas from five shell-midden. The last sample is associated to a human burial and may have resulted from two different deposition moments.

Of the eleven taxa identified the species *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis* are present in all shell-middens and represent probably a preferential woody resource. *Combretum* sp. and *Ekebergia* cf. *capensis* are probably associated with the burial. Lastly, the surrounding landscape of the shell-middens will not have major changes in terms of vegetative composition, as the taxa identified remain present over time.

**Key words:** Late Iron Age; Anthracology; Shell-middens; Taxonomy; Taphonomy; Landscape; Inhambane Coast; Mozambique.

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# 1. Introduction

In southern Africa, for the Holocene period, there are already numerous archaeological sites applying anthracological analyzes. The results have been complemented with other archaeobotanical data, demonstrating climatic variations and a selection of wood by human societies. (Cartwright *et al*., 2016; Chikumbirike, 2014; Cowling *et al.,* 1999; Deacon, 1979). However, some countries lack such analyzes, including Mozambique.

Understanding the presence of charcoals in archaeological sites at the paleoethnobotanical level allows us to gauge the relationship between human societies and their surrounding landscape and, in turn, at the paleoecological level to verify possible changes in the formation of woody vegetation. Thus, anthracological studies at archaeological sites are of great importance and constitute a source of information with many interpretative possibilities. Thus, if there is a human selection of woods, according to their intended purpose, it assumes a thorough knowledge of the raw materials and it becomes crucial to try to access the process inherent to this choice (Piqué & Huerta, 1999).

Embedded in the project "*Stone Age Vilankulos*" (VIP 2016 - PTDC/EPH-ARQ/4168/2014), this dissertation aims to study the archaeological charcoals collected in seven shell-middens located on the coast of Inhambane municipality, Mozambique. Two shell-middens have been identified at the top of beachrock dunes on Praia do Tofo, dating back approximately 300 years ago. The remaining five shell-middens, maybe a bit older (400 years BP), were identified due to the exposed surface materials and scattered in the dunes of Praia da Rocha, located a few kilometers south of Praia do Tofo.

Although the total analysis of the collected charcoals was not carried out, it was possible to make cultural interpretations of possible uses and acquisition of wood. Data from the taxonomic and taphonomic analysis of the shell-middens presented suggest a pattern of wood management and selection by communities based on Praia do Tofo and Praia da Rocha. Anthracological analysis also contributed to the landscape reconstruction around the archaeological site and to further testify to the occupation of communities on the southern coast of Mozambique, corroborating with other authors on the presence of these kind of structures, named shell-middens, which record the presence of the economy, community activities and utilization of wood for a long time, including those presented in this study, the late farming communities off the coast of Inhambane municipality.

## 1.1 - Aims

As mentioned, the main objective of this study was to understand the relationship between the human communities of the past and the paleoenvironment, through the perspective of the acquisition of fuel wood, still scarcely known in Mozambique. In this sense, the aim of the study of the charcoals will be to assess the strategies of exploration and management of woody species from a sociocultural and economic point of view. In turn, another objective will be to determine possible changes in vegetation, both due to anthropic and climatic action. To achieve these objectives an anthracological analysis will be carried out and samples were collected from two shell-middens at Praia do Tofo (~300 BP) and five shell-middens at Praia da Rocha (~400 BP) off the coast of Inhambane municipality. This way, this dissertation is based on unique anthracological materials to answer these questions:

1) What were the woody species collected?

2) Why are they present in archaeological sites?

3) What was the use and management of wood by these communities?

4) What is the quality of firewood in terms of combustion?

5) What are the climatic requirements for the presence of the identified species?

6) Were there any changes in vegetation over the last 400 BP?

7) What is the association with the other artifacts?

This research, based on taxonomic and taphonomic identification of woody species, will provide a broader sociocultural, economic and paleoenvironmental knowledge. It is noteworthy that to better consolidate the obtained data, these was compared with other archaeobotanical studies dating from the same chronology. This makes it possible to ascertain, at both paleoenvironmental and paleoethnobotanical levels, parallels or alterations with other archaeological contexts.

## 1.2 - Structure

This dissertation is organized in eight chapters, they are:

- **State of Art: The development of the Anthracology:** the theoretical framework of the subject of anthracology, its theoretical perspectives (paleoecological and paleoethnobotany) and the background of research in Europe and Southern Africa are presented here. Later the development of anthracology for the study of late farming communities in coastal Mozambique and the climate change occurred in Southern Africa during the Late Holocene is pursued.
- **The environmental background:** the geographic location and the geomorphological description of Mozambique will be presented, followed by a more detailed description of the Inhambane Province. The paleoclimatic framework and environmental changes related to the Holocene chronological period will also be presented.
- **Historical context of Iron Age in Mozambique and Shell-Middens under study:** presented here is the history of the settlement of the first Iron Age communities in Southern Africa, tapering to the Mozambican coast and introducing the shell-middens under study.
- **Methodology:** in this topic, I will present the methodology applied in both the collection of anthracological materials in the field and laboratory analysis through the incident light microscope.
- **Results:** the results of the taxonomic and taphonomic analyzes of the archaeological charcoals from the shell-middens under study are presented here.
- **Discussion:** from the perspective of archaeological charcoals, it intends to return to the initial questions posed here and to characterize the economy of the collection based on the criteria of wood acquisition by the communities of Praia do Tofo and Praia da Rocha.
- **Conclusion:** here are the main suggestions and conclusions drawn from this study.

# 2. State of Art: The development of Anthracology

### 2.1 - Europe

The history of the development of anthracology was largely due to the evolution of various recovery and analysis methods and techniques, but also due to the opening of new theoretical perspectives for the full study of an archaeological site, giving rise to new strands of research, including archaeobotany. Many works in archaeology have been using charcoal to reconstruct the past climate and environment, as well as to know the interaction of humans with the environment.

In the second half of the nineteenth century, however, the interest in contextualizing the micro- and macro plants remains associated with archaeological contexts had mainly a paleoethnobotanical character and lacked deep methodological knowledge. The working method used at the time, based on thin slides, observed in transmission microscopy (light passes through the object observed from the bottom up), was slow and difficult, and research had not yet a paleoenvironmental character (Fliche, 1907; Heer, 1866).

One of the first explicitly paleoecological interpretations based on evidence of charcoal appeared in Britain with the publication in 1940 by E.J. Salisbury and F.W. Jane of charcoals from the Maiden Castle archaeological site in Dorset (Salisbury & Jane, 1940). In this paper, Salisbury and Jane suggested that the observed rate frequencies could correspond to their actual proportions in prehistoric forest vegetation. They also looked at tree rings to reconstruct past weather patterns. However, their interpretations were questioned by H. Godwin and A.G. Tansley, who drew attention to the role of ecological variables (plant community structure and species physiology) and cultural parameters (wood selection) to determine availability of species (Godwin & Tansley, 1941).

From the 1970s onwards, a great impetus has emerged in microscopic analysis and systematic collections of plants, using reflected light microscopy (light is projected from top to bottom without passing through the object) and diffused primarily by Fietz and Jean-Louis Vernet in Montpellier, France. They developed anthracological analysis allowing the observation of the three anatomical planes of wood charcoals (transverse, radial longitudinal and longitudinal tangential) which provided the multiplication of anthracological analyses and the most frequent emergence of paleoecological approaches (Vernet, 1976, 1973). Studies began to focus on the systematic collection and analysis of anthracological remains associated with archaeological contexts, giving rise to numerous anthracological works throughout Europe (Badal, 1992; Chabal, 1992, 1997; Fietz, 1933; Figueiral, 1995; Pearsall, 1998; Prejawa, 1896;

Stieber, 1967, 1969; Théry-Parisot, 1998; Thiébault, 1988, 1980; Thinon, 1992; Vernet, 1976, 1973).

Throughout this new millennium, anthracology has continued to be increasingly used in archaeological contexts. Archaeological sediments, often very rich in charcoal fragments, allow the taxonomic identification interpretation of the landscape, the relationships between humans and the environment and the uses that past populations have made of plant products (Aura *et al*., 2005; Badal *et al*., 2012; Caruso Fermé, 2012; Espino, 2004; Figueiral & Terral, 2002; Figueiral & Carcaillet, 2005; Lee, 2012; Monteiro, 2012, 2013, 2017; Monteiro & Bicho, 2016; Monteiro *et al.,* 2014; Queiroz & Van Leeuwaarden, 2003; Schriek *et al.,* 2007; Tereso & Queiroz, 2006; Théry-Parisot *et al*., 2009).

Thus, the emphasis of these studies is a detailed analysis of environmental change through the identification of wood from the anatomical structure (paleoecological) but can also provide information for paleoethnobotanical interpretations. These perspectives are independent and complement each other with data from analysis of microfauna and microflora, for example pollen.

### 2.2 - Southern Africa

In southern Africa, in the 1970s, the potential of charcoal analysis was first recognized by the Stellenbosh University Archeology Department (Deacon, 1979). Anthracological analysis of the Boomplaas Cave (Deacon, 1979) at the foot of Swartberg Mountain, near the Western Cape (South Africa), provided a more complete understanding of its ecological and climatic past.

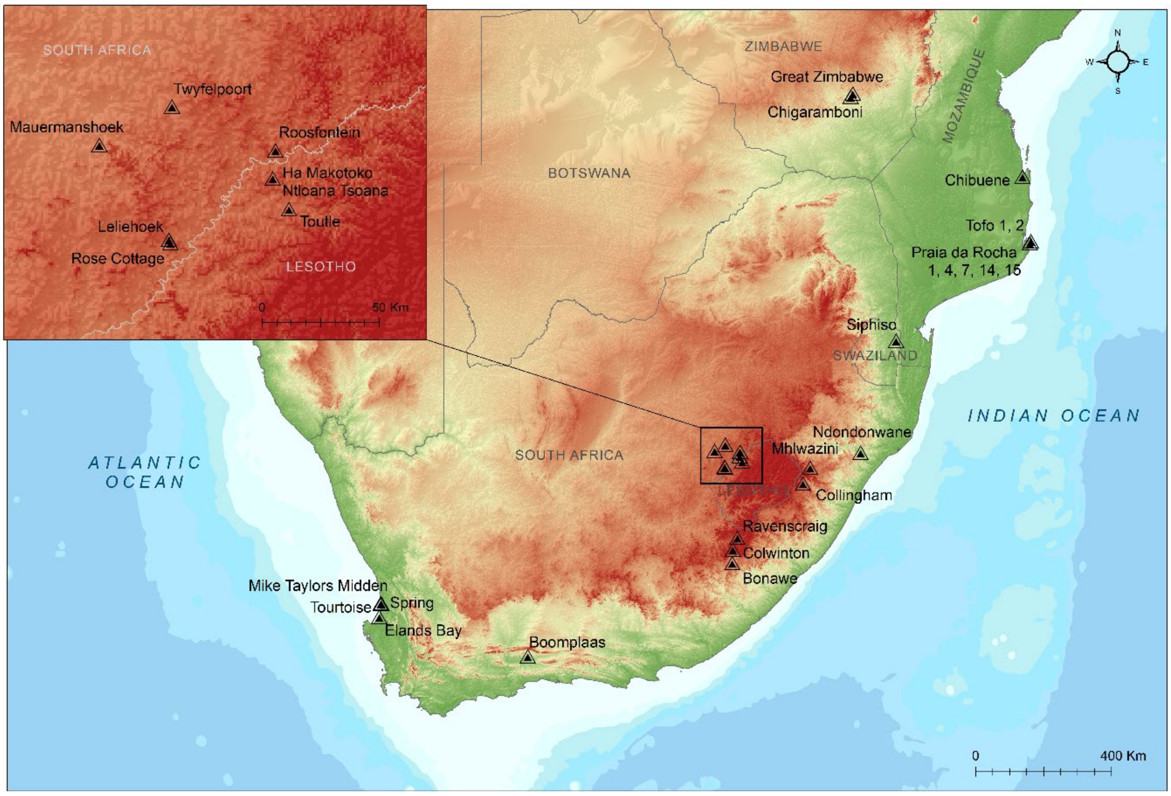
Thus, the anthracological analyses performed complement the paleoenvironmental reconstructions already done, namely through the analysis of micro and macro fauna, pollens and stalagmites present in the cave (Deacon, 1979). This analysis, and later that of Scholtz (1986), provided a continuous and well-dated sequence of vegetation change in the periods preceding and following the late Pleistocene colder period. This pioneering work in southern Africa has given a great impetus to the interpretation of landscape, paleovegetation and, above all, to understand the relationship between humans and the environment and the uses that past populations have made of plant products, still vast in this part of the African continent (Stevens *et al*., 2014).

From this date, the observation of charcoal in archaeological contexts increased frequently. These studies focused mainly on the climate and environmental changes that occurred in southern Africa during the Pleistocene to Holocene transition period (Cartwright, 2013; Cartwright & Parkington, 1997; Cartwright *et al.,* 2016; Cowling *et al.,* 1999; Deacon, 1979; Esterhuysen, 1996; Esterhuysen, 1999; February, 1990, 1992; Scholtz, 1986; Wadley, 2004).

In 1931 it is founded the International Association of Wood Anatomists (IAWA), *"(...) the Association has promoted contacts between scientific such diverse disciplines as botany, forestry, wood technology, archaeology, and forensic science.*" (InsideWood, 2004-onwards). Later, in 1994, IAWA created an international congress that takes place every three years and aimed to define some problems in relation to African anthracological research, namely due to the taxonomic variety present in the African continent. Regarding the amount of archaeobotanical studies carried out on the African continent, Stevens *et al.* (2014) shows how the focus of these studies is on North Africa, mostly Egypt which reflects the uneven advance of archaeobotanical research in Africa.

As regards southern Africa, according to the available literature for the Holocene, 26 archaeological sites, including the two sites presenting here, were identified with charcoal analysis (FIGURE 2.1). Anthracological studies come especially from archaeological sites in South Africa (Bonawe Rock Shelter, Boomplaas Cave, Collingham Shelter, Colwinton Rock Shelter, Elands Bay Cave, Jubilee Shelter,Leliehoek Shelter, Mhlwazini Cave, Mike Taylors Midden, Mauermanshoek, Ndondondwane, Ravenscraig Rock Shelter, Rose Cottage Cave, Roosfontein, Spring Cave, Tortoise Cave and Twyfelpoort). Lesser studies have also been done in Lesotho (Ha Makotoko, Ntloana Tsoana and Thoutle Shelter), Zimbabwe (Chigaramboni and Great Zimbabwe), Swaziland (Siphiso Rock Shelter) and Mozambique (Chibuene, Praia do Tofo and Praia da Rocha) (TABLE 2.1).

These studies have focused mainly on the attempt to identify through charcoal evidence the paleotemperatures, precipitation, and the presence or absence of species caused by climatic fluctuations. Thus, archaeological charcoal remains are often used to 1) reconstruct the composition of the savanna and forests of the past, when possible, and 2) how and why people have selected specific wood species for specific purposes.




Map 2.1 - Distribution of the Iron Age Archaeological sites with Anthracological analysis in Southern Africa. Credits: Célia Gonçalves, ICArEHB.

However, it is important to mention that charcoal from archaeological sites cannot be used to exactly reproduce the environment but rather the surroundings of the archaeological site. It may also suggest the type of tree or shrub species collected, which may be local or regional, already outside of the immediate area. Therefore, it is logical to think that the archaeologist is biased towards favorable fuel wood, that is, wood that was collected by people who made specific choices about the types of wood they wanted to use (Paleoethnobotany), although environmental conditions influence the wood species available for collection. Thus, within these parameters, archaeological charcoal samples can provide a means of determining which trees or shrubs were present before people influenced natural vegetation (Paleoecology).

**Table 2.1**

**List of Archaeological Sites with anthracological analysis in Southern Africa (Holocene Period)**

| COUNTRY | ARCHAEOLOGICAL SITE | NUMBER OF CHARCOAL | DATATION IN cal BP. | | CHRONOLOGY | BIBLIOGRAPHY |
|---|---|---|---|---|---|---|
| South Africa | Bonawe Rock Shelter | 213 | 2 250 ± 80 BP | 8 040 ± 100 BP | Holocene | Tusenius, 1989 |
| | Boomplaas Cave | 1039 | 16/17th centuries | 80 000 BP | Holocene/Pleistoceno | Deacon, 1979/ Sholtz, 1986 |
| | Collingham Shelter | 180 | 1 260 ± 50 BP | 1 880 ± 45 BP | Holocene | Mazel, 1990,1992/February, 1994 |
| | Colwinton Rock Shelter | 195 | 70 ± 40 BP | 6 270 ± 40 BP | Holocene | Tusenius, 1989 |
| | Elands Bay Cave | 6700 | 320 ± 1400 BP | 40 000 BP | Holocene/Pleistoceno | February, 1990, 1992; Cartwright, 1997, 2016; Cowling, 1999 |
| | Jubilee Shelter | - | - | - | - | Dowson, 1988 |
| | Leliehoek Shelter | 585 | 4 860±100 BP | 5 210 ± 100 BP | Holocene | Esterhuysen, 1996 |
| | Mhlwazini Cave | 300 | 1 260 ± 50 BP | 1 880 ± 45 BP | Holocene | Mazel, 1990,1992; February, 1994 |
| | Mike Taylors Midden | 328 | ± 2 000 BP | 2 460 ± 50 BP | Holocene | February, 1990 |
| | Mauermanshoek | 202 | 200 ± 50 BP | 3540 ± 60 BP | Holocene | Esterhuysen, 1996 |
| | Ndondonwane | - | ± 1 000 BP | ± 1 200 BP | Holocene | House & Banford, 2019 |
| | Ravenscraig Rock Shelter | 287 | 460± 45 BP | 10 200 ± 100 BP | Holocene | Tusenius, 1989 |
| | Rose Cotage Cave | 1491 | 680 ± 50 BP | 31 300±90 BP | Holocene/Pleistoceno | Wadley *et al.*, 1992; Esterhuysen *et al.* , 1999 |
| | Roosfontein | 983 | 1290 ± 50 BP | 1920 ± 60 BP | Holocene | Esterhuysen et al., 1996 |
| | Spring Cave | 420 | 460 ± 40 BP | 2 970 ± 60 BP | Holocene | February, 1990 |
| | Tourtoise Cave | 310 | 1 620 ± 50 BP | 4 190 ± 60 BP | Holocene | February, 1990 |
| | Twyfelpoort | 410 | Recent | 1880 ± 50 BP | Holocene | Esterhuysen, 1996 |
| Lesotho | Ha Makotoko | 8798 | 8 370 ± 80 BP | 9 290 ± 90 BP | Holocene | Esterhuysen, 1996 |
| | Ntloana Tsoana | 218 | 8 780 ± 30 BP | 12 110 ± 120 BP | Holocene/Pleistoceno | Esterhuysen, 1996 |
| | Thoutle Shelter | 2271 | 375 ± 65 BP | 8 680 ± 70 BP | Holocene | Esterhuysen, 1996; Esterhuysen *et al.* , 1999; |
| Mozambique | Chibuene | 832 | Recent | 1 050 BP | Holocene | Ekblom *et al.*, 2014 |
| | Praia da Rocha | | ± 1 250 BP | | | Matias, 2020 |
| | Praia do Tofo | | ± 1 450 BP | | | Matias, 2020 |
| Zimbabwe | Chigaramboni | 1653 | - | - | Holocene | Chikumbirike, 2014 |
| | Great Zimbabwe | 364 | 1 190 ± 50 BP | 1 580 ± 50 BP | Holocene | Hufman & Vogel, 1991; Chikumbirike, 2014 |
| Swaziland | Siphiso Rock Shelter | 497 | Recent | 8 700 + 120 BP | Holocene | Prior, & Williams, 1985 |

## 2.3 - Paleoecological and Paleoethnobotanical Perspectives (Southern Africa)

Although anthracology is nowadays increasingly applied to archaeology, its role in the reconstruction of ancient vegetation and climate, as well as what and how humans made use of available wood, has long been underestimated. The general framework for the history of late Quaternary vegetation has always been provided by pollen data. However, as many researchers in anthracology have shown (Badal, 1992; Chabal *et al.,* 1992; Deacon, 1979; Esterhuysen, 1996; Vernet, 1976), it has become evident over the past two decades that anthracology and pollen diagrams are complementary methods that when combined can provide reliable and detailed information for past reconstruction of vegetation and for the knowledge about the impact people have had on their surroundings. Since anthracology is the study of charred woods, when found in archaeological sites, the charcoals are susceptible to cultural interpretations, particularly regarding the strategies for obtaining and using fuel (Badal, 1992; Vernet, 1976). In turn, when collected in sedimentary series they are subject to ecological interpretations regarding the local flora (Deacon, 1979; Esterhuysen, 1996). Thus, anthracological studies in archaeological sites are of great importance and constitute a source of information with many interpretative possibilities.

Methodological differences for anthracological analysis and the controversy between quantitative variables and qualitative interpretation make comparing the results of several decades of anthracological work a difficult task. One of the most debated questions in this new millennium is how far past environmental changes were due to climate or prehistoric humans (Chikumbirike, 2014; Esterhuysen, 1996; February, 1990; Scholtz, 1986).

Researchers whose primary focus is on climate change will try to convey past climatic conditions based on current flora and quantitative analyzes (Paleoecological). Those who focus especially on human interaction with the environment will always consider that the presence of some plant community is often the result of natural and anthropogenic factors (Paleoethnobotanical). Depending on the theorical question that the investigator wants to answer, different interpretation models are possible, even with similar data.

An example for the first perspective, is the interpretations made by the researcher Tusenius for South Africa. Tusenius's research focused on the analysis of three anthracological sets from archaeological sites at different altitudes covering the last 10 000 years in the Drakensberg range (see Tusenius, 1989). For early and middle Holocene, the results showed a dry climate while in the late Holocene, starting around 3000 BP, it seems to have been relatively wetter. The results revealed special emphasis on species with different ecological preferences, such as *Euryops* growing in more arid formations and *Leucosidea, Cliffortia* and *Passerina* growing in wetter habitats. They also recorded a high percentage of *Leucosidea* in the period before 10 000 BP, as well as, for the late Holocene, with the strong presence of *Cliffortia* and *Passerina*, suggesting a wetter climate. In turn, the middle Holocene was drier, verified by the high frequencies of Xerophilic *Euryops*.

A similar climate interpretation in South Africa is given by Prior and Price (1985) for an anthracological Holocene sequence in Swaziland, north of KwaZulu-Natal, KZN. The results suggested drought conditions for the middle Holocene, between 6000 and 4000 BP, while the early and late Holocene would probably have a wetter climate.

In turn, Scholtz (1986) pioneered methods for climate reconstruction based on the relationship between plant anatomy, physiology and ecology, that is, it went beyond paleoecological perspectives. Scholtz analyzed an anthracological set of Boomplaas cave, where he sought to develop a methodology for measuring a wide range of significant ecoclimatic wood characteristics, observable in cross-section, in addition to the conventional taxonomic analysis. This hypothesis has shown that xylem vessel diameters decrease in wet periods while vessel frequencies increase with increasing drought. Thus, Scholtz argued that it is possible to recognize past climate change by measuring the charcoal wood anatomy from archaeological sites. This requires modern samples from the same species in the area, with known temperature and precipitation. The results indicate that, contrary to the post 14 000 BP time period when trees are recorded, during the 30 000 years prior to 14 000 BP only smallish shrubs and bushes grew in the valley. In terms of paleoethnobotany it seems to have some indication of a predicted pattern when wood is systematically transported from some distance to a site, this preference being based on the relative abundance and regularity in size and shape of branches of this diameter, as well as the quality of the wood.

From another perspective, researchers like February consider charcoal from archaeological sites as a conservation tool, meaning it can be useful as a direct way of determining which trees or shrubs were present before people had an appreciable effect on natural vegetation and how they managed it (February, 1990). In his MA thesis, February (1990) analyzed several anthracological sets from four archaeological sites dating from the Holocene (Elands Bay Cave, Spring Cave, Tortoise Cave and Mike Taylors Midden) one of them, Elands Bay Cave, dating to the Pleistocene. In order to better understand how people managed wood and how shaped the landscape, February compared the layer with the most recent dating at Elands Bay Cave (320 ± 1400 BP) with three other archaeological sites as well from Elands Bay. Dating back to the last 4000 years, the anthracological results of these three archaeological sites revealed that in certain layers the use of wood for fire was different (February, 1990). He also included a chapter about taphonomy and the Minimum Piece Diameter Analysis. It is a method that attempts to calculate the diameter of the wood through the growth rings collected for combustion (Scholtz, 1986). Building on the advances of anthracology in understanding archaeological contexts, February (1990) also applied Scholz's (1986) methodology. The results showed that, regarding precipitation, the vessel diameter of a carbonized sample of *Protea caffra* and *Protea robelline* correlated positively while the vessel frequency correlated negatively. The analysis showed various patterns of dry and wetter periods, proving the effectiveness of this method.

In the continuing development of this strand in southern Africa, this perspective has also been applied in two archaeological sites of South Africa's Drakensberg mountain (Mhlwazini Cave and Collingham Shelter) in order to understand the anthropogenic effect on the environment (February, 1994; Mazel, 1990, 1992). Changes in the relative abundance of taxa identified in Mhlwazini Cave and Collingham Shelter suggest a higher proportion of *Protea* savannas in the Drakensberg foothills in the past than is evident in today's area. This decline has been steeper over the past 300 years as the intensity of agriculture has increased with the movement of farmers into the area. Instead of climate change, the reason for this decline of *Protea* species in the savanna is possibly due to an increase in the number of fires in the area surrounding archaeological sites.

In paleoethnobotanical terms, Chikumbirike's PhD dissertation (2014) on the archaeological sites of Great Zimbabwe and Chigaramboni should also be highlighted. The author focuses on the social and wood management aspects of these archaeological site collections (Great Zimbabwe: Hill Complex, Terrace Ruin, Nemamwa Ruin, Great Enclosure, Ridge Ruin, Barrier Hut and 2030BD 57; Chigaramboni: Bondolfi Site, Road Site, Trench 1, Trench 2, Trench 3, Trench 4, Trench 5, Test Pit 5, Test Pit 7 and Chigaramboni site). Chikumbirike proposes that wood fuel for the domestic cooking and warming was different from wood used for industrial and construction purposes. Through taxonomic identification he demonstrated that Chigaramboni species would have been used as fuel wood and flux in metallurgical process. Great Zimbabwe due to this taxonomic variety (30 different species) that would have had multipurpose nature of the settlement, resulted in different types of tree species being utilized. About mobility, Chikumbirike proposes long distance movement of wood particularly *Spirostachys africana* and *Colophospermum mopane* because there are not present on the landscape today and they have excellent construction qualities. Other analysis of charcoal from the sites has revealed that were used for fuel wood or timber. Anthracological identification has also enabled Chikumbirike to embark on what the landscape will look like at that time. The species composition in the archaeological records indicates a miombo kind of vegetation which is the present type of vegetation at Great Zimbabwe and Chigaramboni.

House & Bamford (2019) contributed to understanding how people used the wood. They studied the charcoal from Ndondondwane in KwaZulu-Natal, South Africa. This is an Early Iron Age site of a single, short-term occupation within the time period 750 AD to 950 AD. Most of the charcoal from this site was identified to six distinguishable species, representing especially *Acacia.* This indicates some preferences for this kind of wood. *Combretum apiculatum, Searsia pyroides, Sclerocarya birrea, Senegalia caffra, Vachellia karroo* and, *Vachellia tortilis* are dense, hard wood that is termite resistant, and mostly use for construction (post, enclosures), firewood and diet. On the other hand, the wood of *Acacia robusta, Vachellia nilotica* and *Vachellia sieberiana* are reportedly of poor quality and mainly used for firewood and not construction and, its bark may be used for stringing beads. Some of that species, using their bark, roots, and leaves have a variety of medicinal applications, there are: *Acacia robusta, Sclerocarya birrea, Vachellia karroo, Vachellia nilotica* and, *Vachellia sieberiana.* Some could have been source of forage such as *Vachellia sieberiana* and *Vachellia tortilis*. In paleoecological terms, House & Bamford (2019) only mention that certain species identified in the anthracological set are still present in the landscape today and, especially in the surroundings of the archaeological site as, *Sclerocarya birrea* (Marula tree), evidence that the landscape in this area since 750 AD until the present remained similar. The results show that the presence of these species could support the theory that this community were specifically selecting species for a particular purpose.

For Mozambique, archaeological charcoal data are recent (Ekbloom *et al.*, 2014) and scarce when compared to other countries. However, the anthracological studies made by Anneli Ekbloom stand out. With the help of macro and micro plants remains present in the Chibuene shell-middens, located on the coast of Vilankulos, Inhambane province, the researcher aimed to observe possible changes in vegetation and land occupation. First, she performed pollen analyzes (Ekbloom, 2004) and later anthracological analyzes (Ekbloom *et al.*, 2014). They are three Iron Age shell-middens (400–1900 AD) whose Chibuene landscape passed by four phases of land and resource use that have interacted with changes in the environment. The Early phase,

Phase 1 (400–900 AD), is described with forest savanna mosaic, low intensity cattle herding, cultivation and trade of resources for domestic use. In this phase, the anthracological taxonomic list show the presence of *Sideroxylon/Chrysophyllum*-type, *Mimusops*-type, *Androstachys jonhsonii*-type, *Dialium englerianum*-type, *Ochna*-type, *Phyllanthus*-type, *Tamarindus indica/Cassia*-type, *Cordia*-type and *Fabaceae* unidentified. The most representative taxon in this charcoal set is *Sideroxylon/Chrysophyllum*-type, followed by *Phyllanthus*-type and *Dialium englerianum*-type. Phase 2 (900–1400 AD) is a forest savanna mosaic and high intensity or extensive cultivation and cattle herding. The arboreal and shrubs species exploiting in this phase are, *Sideroxylon/Chrysophyllum*-type, *Mimusops*-type, *Androstachys jonhsonii*-type, *Dialium englerianum*-type, *Phyllanthus*-type, *Bruguiera gymnorhiza*-type, *Tamarindus indica/Cassia*type, *Brachystegia/Julbernardia*-type, *Vitex/Bridelia*-type, *Alchornea laxiflora*-type, cf. *Rutaceae*, cf. *Sapindaceae* and *Fabaceae* undifferentied. The three most representative taxa are *Sideroxylon/Chrysophyllum*-type, closely followed by *Androstachys jonhsonii*-type and *Vitex/Bridelia*-type. In the late phase, Phase 3 (1400–1800 AD), savanna woodland and progressive decrease in forests due to droughts, decline of agricultural activities, higher reliance on marine resources and possible with the trade in resources with the interior. Only four taxa were identified in this phase, they are mainly *Tamarindus indica/Cassia*-type, followed by *Androstachys jonhsonii*-type, cf. Sapindaceae and *Sideroxylon/Chrysophyllum*-type. The last phase, Phase 4 (1800–1900 AD) is described with open savanna, few woodland patches, warfare and social unrest. No anthracological data is presented for this phase.

This anthracological study, pioneer in Mozambican archaeological contexts (Ekbloom *et al.*, 2014), has contributed to providing paleoethnobotanical information on land use and woody resources, as well as the composition of the woody vegetation in the shell-middens surroundings (paleoecological).

Concluding, archaeological charcoal is important for paleoenvironmental interpretations, as well as, for developing understanding of the use of wood by past populations. Although there is much more work in North Africa (Stevens *et al.,* 2014), those two aspects are not yet equally explored in southern Africa, particularly in terms of the paleoethnobotany and vegetation types prior to human interference. In short, much of the work on charcoal identification has served to answer paleoecological and archaeological questions. Thus, the new methods and perspectives require studies on the interaction of the human communities and landscape in Mozambique. It is significant for future research to take advantage of charcoal remains excavated from archaeological contexts and provide more paleoethnobotanical information and about the composition of woody species before any significant anthropogenic impact.

# 3. The Environmental Background

This chapter will focus on the geographic location, geomorphological and on a general landscape description of Mozambique, followed by a more detailed report of the Inhambane province, where the fieldwork was carried out.

## 3.1 - Geographic location

Mozambique is located in southeastern Africa, bordered to the east by the Indian Ocean, to the north by Tanzania and to the northwest by Malawi and Zambia. The west and southern borders are, respectively, with Zimbabwe, South Africa and Swaziland (FIGURE 3.1). The geographical limits of Mozambique are between latitudes -25.96553 to -11.31667 and longitude from 31.99528 to 40.73583 (Google Earth). The country has a total area of 799,380 $km^2$ of which 13,000 $km^2$ are occupied by inland waters, including lakes, reservoirs, and rivers (Cumbe, 2007) and its coastline runs for 2 795 km from the mouth of the Rovuma river to the southernmost point at Ponta do Ouro (Morais, 1989).

The Inhambane province is located in southern coastal Mozambique and comprises an area of 68,615 $km^2$ (Muchangos, 1999). The province is divided into 14 districts and has five municipalities: Inhambane, Massinga, Maxixe, Quissico, and Vilankulos.

## 3.2 - Geomorphology

The topographical relief of Mozambique is composed by plains, plateaus, mountains, and depressions. Almost half (44%) of the Mozambican territory are plains with altitudes up to 200 meters above sea level (a.s.l.) (Cumbe, 2007).

The Mozambican coastline is formed by narrow beaches attached to cliffs or dune systems, lagoons, barrier islands and barrier platforms (beachrock). The beachrock that outcrops in several points of the coast, in the intertidal zone, reduces the wave energy and works as a trap for the sediment transported predominantly northwards by longshore currents, also exerting morphological control on the coast.

In what concerns the Mozambican fluvial system, most rivers run from west to east, due to the morphology of the relief, and successively cross mountains, plateaus and plains, flowing into the Indian Ocean (Muchangos, 1999). In the south, the main water courses are: Save, Govuro, Inhanombe, Limpopo, Incomati, Umbeluzi, Tembe and Maputo. Due to these major rivers, mainly the Limpopo river, and the vast quantities of unconsolidated aeolian sands in the coastal areas, the sediment supply to the coast is high in this region. The coastal zone comprises is composed by sands transported by longshore currents, predominantly northwards due to the preponderance of SE trade winds and swell regimes (Armitage *et al*., 2006).

It should be noted that there is a high number of lakes and lagoons originated by tectonic or exogenous factors in Mozambique. Of tectonic origin, the Niassa Lake is the largest natural lake of Mozambique. The lakes originated from exogenous factors, related to erosion and sediment accumulation, occur all along the coast and riverbanks, mainly to the south of the Save river (Cumbe, 2007).

According to Cumbe (2007), the geographical area of the Inhambane province is characterized by plains. On the north and some areas of the center of the province, the altitude ranges from 100 to 200 m a.s.l. and, when reaching the coast, the plains do not exceed 100 m in altitude (FIGURE 3.1). The geomorphology of Inhambane province can be described by several morphostructures. In the north of the province, on the coastal areas of the Vilankulos and Inhassoro municipalities, the morphostructure presently corresponding to peneplains of extrusive-stripped origin (pediments on the basaltic substrate) (Cumbe, 2007 and Moreira, 2005). These morphostructures are also found in the Govuro river Valley in Vilankulos and at the elevation of Pemba, in Homoine (Cumbe, 2007).

The accumulation plains of sedimentary origin predominate along the entire coast and is mainly composed by white sands of fine grain and remnants of ancient dunes, partially swampy. The accumulation of these sediments started in the Lower Pleistocene and expanded during the Holocene when the rise and subsequent stabilization of the mean sea level occurred (Holmgren *et al*., 2012; Moreira, 2005). Some areas accumulate marine-fluvial sediments, leads to the appearance of mangroves (as it is the case in the Inhambane bay) and, in other areas, coral reefs and islands of biogenic accumulation are formed.

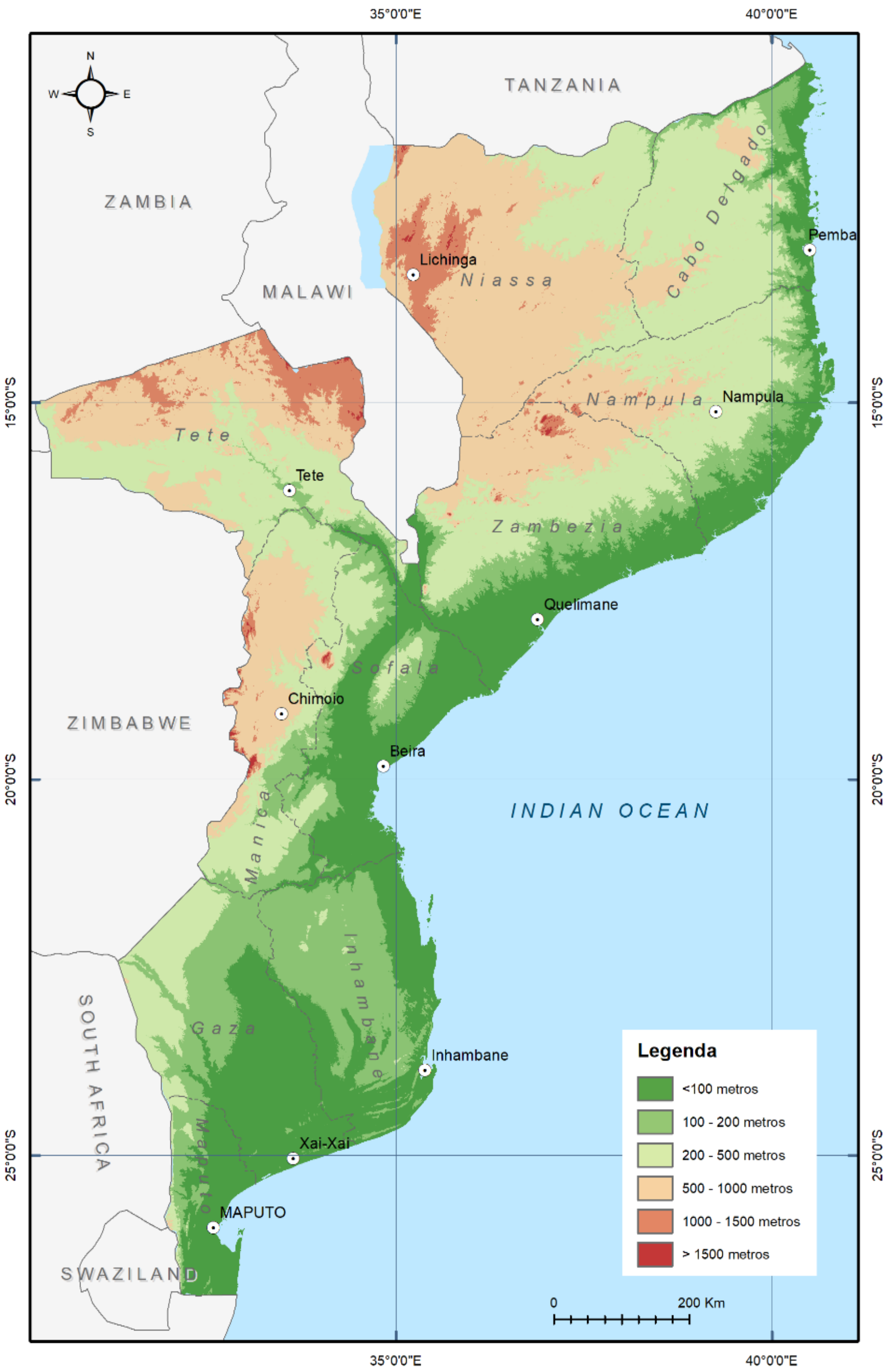


Figure 3.1 - Altitudes in Mozambique. Credits: Célia Gonçalves, ICArEHB.

The coastal plain, composed by Neogene to Quaternary formations dunes, can be separated into two main areas: 1) internal dune system (Pleistocene – Topuito Formation), and 2) coastal dune barrier system (Pleistocene to Holocene) (Moreira, 2005). The intertidal dune system was formed over the Holocene, along the southeastern coast of Africa, during this period of lower sea and migrated inland through wind action (with SSE-NNW direction) (Armitage *et al*., 2006), large dunes with a wave length of *c.* 4 km were formed. After the formation of the internal dune system, the sea level rose to a level similar to that of the present (Moreira, 2005).

The coastal dune barrier system is a succession of paleodunes and active dunes facing the sea. It can be up to 2 km in width and over 100 m a.s.l. (Momade & Achimo, 2004). The dunes of this coastal barrier grew vertically due to a great sediment availability and to the stacking of the dunes (younger above older dunes) (Moreira, 2005).

All this landscape evolution depends, mostly, on coastal processes, mainly due to sea level changes associated with sediment availability and intense wind transport (Armitage *et al*., 2006). The erosion is the phenomenon that dominates the current dynamics of the coastal systems of Mozambique, which, along more than 90% of the coast, occurs due to natural processes (passage of depressions, tropical cyclones and recent elevation of mean ocean level). According to Armitage *et al*., (2006) the high-energy wind and wave-dominated shores are influenced by a SW-NE orientation of the coastline in southern Mozambique. This, in turn, is a result of paleogeographic heritages related to coastline changes, due to sea-level changes that occurred after the Pliocene.

In the Inhambane province two main river systems are present: the Save and the Changane. The first has its source in Zimbabwe, flows south and then crosses Mozambique from west to east, flowing into the Indian Ocean. The river has a total length of 735 km, of which 330 km are in Mozambique. The Changane river runs in the same direction of the Limpopo (OE) (Muchangos, 1999).

### 3.3 – Climate and Landscape

In general, Mozambique has a tropical to sub-tropical climate (FIGURE 3.2). The main climatic variations (temperature and humidity) are primarily related to continentality, altitude, exposure and geographic position. The Mozambican coast is influenced by the Mozambique-Agulhas hot current and by the dominant sea winds in the eastern quadrant (Cumbe, 2007).

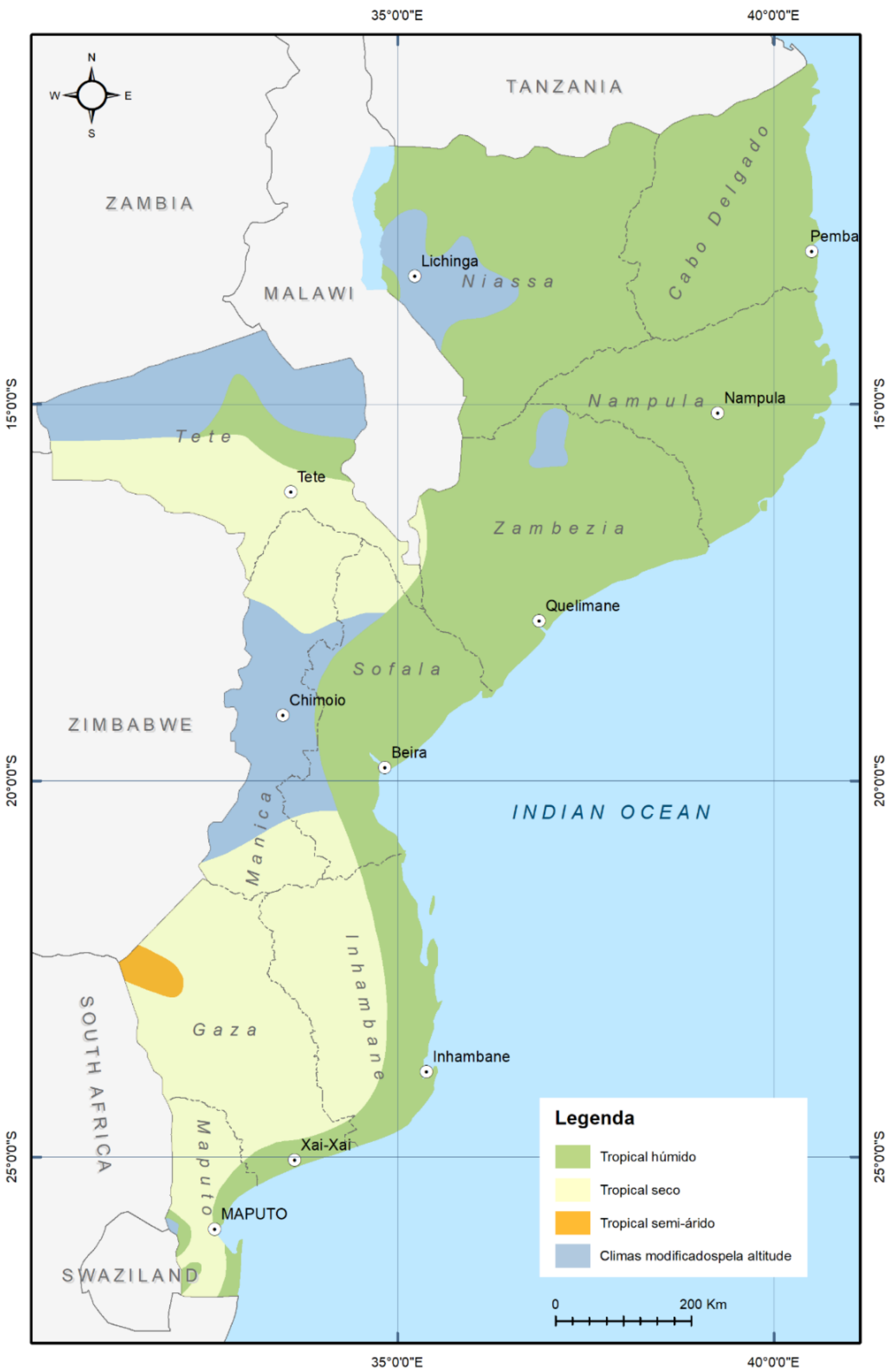



Figure 3.2 – Distribution of climate types in Mozambique. Source: MINED, 1986. Credits: Célia Gonçalves, ICArEHB.

The seasons throughout the territory range from warm and rainy to dry and cool. The warm and rainy season starts in October and ends in March. The dry and cool season runs from April to September. The highest temperatures are recorded between December and February, with the maximum temperatures reaching 38º and, occasionally, 49º C. The coldest months are June and July. The rainy season, which starts in October, is shorter than the dry season, except in some coastal regions where rainfall lasts approximately six months (Cumbe, 2007, Moreira, 2005; Muchangos, 1999).

The composition and distribution of the terrestrial flora in Mozambique is influenced by the regional and local conditions of climate, relief, hydrography, substrate, distance from the Indian Ocean and the degree of human intervention. Thus, the location of Mozambique influences the development of several hydrophilic, mesophilic and xerophilic plant associations of forest and tree and bush savanna (FIGURE 3.3)

In coastal areas, the average temperatures are 27º C in summer and 19º C in winter (Holmgren *et al*., 2012; Noström *et al.,* 2017) and the area falls within the austral summer rainfall zone and receives much of its rain from November to March. The mean annual precipitation is about 832 mm and, the yearly average evapotranspiration is about 1440 mm. The interior regions present dry and semi-arid climates. Wild and Fernandes (1968) describe the characteristics of the Mozambican flora and its regional distribution, placing the region under study on the Zanzibar-Inhambane regional mosaic, characterized by a wide biodiversity seen in one major phytogeographical region with miombo, mopane, and undifferentiated woodlands (FIGURE 3.3). In the NW, at the border with the Gaza province and in the NE, from the coast until the district of Vilankulos, deciduous open forests predominate. In the center of the province, there are dense deciduous forests with some dense evergreen forests.

Also located to the north, bushland occupies a great patch in the landscape, located in the center of the districts of Mabate, Govuro, and Inhassoro. On the coast, there is also bushland but with smaller extensions and only to the north of the Inhambane bay (Cumbe, 2007).

The southern regions of the province are composed by savannah woodland or miombo forest biome. In landscape terms, the human influence is remarkable. As FIGURE 3.3 shows, all along the littoral the savannah woodland expands where the agriculture with forests predominate and, in some areas, just have cultivated fields. It occurs from Vilankulos to the Zavala district, bordered by the Gaza Province and the beginning of a new thicket.

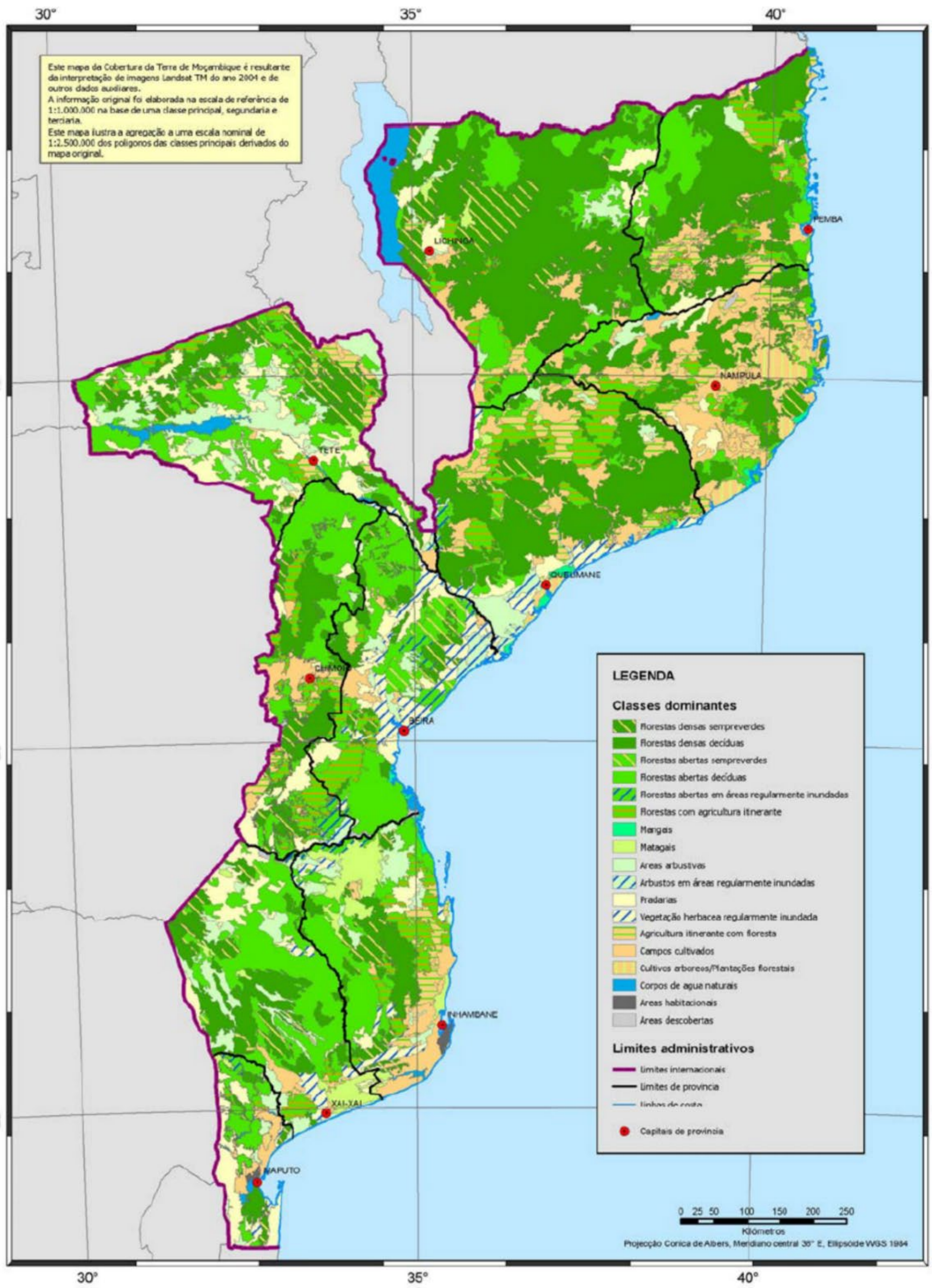



Figure 3.3 – Map of land use and land cover in Mozambique. Source: Retrieved from Cumbe, 2007 (Data provided by the Forest Inventory Unit – Ministry of Agriculture, January 2008).

Based on field observation during the 2018 campaign (InMoz project - PTDC/HAR-ARQ/28148/2017), the vegetation in the littoral is mostly composed of coconut trees (*Cocos nucifera*), mixed with several varieties of fruit trees (*Anacardium occidentalis* (cajus), *Psidium guajava* (goaib), *Mangifera indica* (mango), *Sclerocarya birrea* (canhu), *Syzygium cumini* (jambo), *Trichilia emetica* subps. *emetica* (mafura nuts), *Garcinia linvingstonei*, *Citrus* *reticulate* (mandarine), *Musa paradisiaca* (banana) and *Strychos spinosa* (massala). In vegetable gardens it is possible to find species such as *Manihot esculenta* (manioc), *Lactuca sativa* (lettuce), *Brassica oleracea* (cabbage), *Saccharum officinarum* (sugar cane), *Allium cepa* (onion), *Lycopersicon esculetum* (tomato), *Vigna unguiculata* (cacana), *Phaseolus vulgaris* (bean), *Cucurbita* sp. (pumpkin), *Zea mays* (corn) and *Euphorbia tirucalli*, mixed with other types of arboreal vegetation, endemic to the region as *Brachystegia spiciformis* and *Julbernardia globiflora*. It should be noted that Casuarina (*Casuarina equisetifolia*) and eucalyptus (*Eucalyptus citriodora*) are also present. They are found in lesser amounts, scattered throughout the vegetation, existing sometimes in patches on the landscape.

The mangrove is distributed around 48% of the Mozambican coastline (Cumbe, 2007) and develops on the sea front and at the mouths of rivers, usually in wetlands and subject to the influence of the waters of the sea. In this type of forest *Avicennia marina* and *Sonneratia alba* extend through large patches.

The dune forest, which exists almost all along the coast, is characterized by a mixed arboreal-shrub vegetation with an abundant herbaceous stratum and where the rainfall is greater than 900 mm, the dune forest is more abundant (Cumbe, 2007). However, it is in the south of the Save river that the dune forest has its higher expression.

As for the gallery forest that grows in the alluvial banks of the rivers and the slopes of the lakes, the vegetation becomes less dense and riparian species predominate, such as: 1) shrubs (*Dodonae viscosa, Ceratiola ericoides, Senna petersiana* and unidentified species of the Ericaceae and Phylanthaceae family), 2) herbaceous (*Cynodon dactylon, Waltheria indica, Erigeron bonaciensis, Tridax procumbens, Polypogon monspeliensis*, *Sinecia* sp., *Cyperus* sp., *Gloriosa superba, Melinis repens* and *Solanum* sp.), and 3) aquatic flora (*Hydrocotyle* sp., *Ceratiola ericoides*, *Phragmites mauritianus*, *Dropsteris* sp. *Nymphaea capensis*).

In the study areas the landscape of the dune forest in that area is defined with low arboreal diversity as *Flacourtia indica, Sesuvium portulacastrum, Hyphaene coriacea, Heliotropium fortherianum, Suariana maritima* and some *Casuarina* sp., introduced by people. Mixed with this arboreal vegetation are ground plants or shrubs such as *Canavalia rosea* and *Heliotropium curassavicum* and herbaceous plants such as *Eragrostis* sp., *Panicum maximum, Cenchrus incertus, Cyperus papyrus* and *Digitaria* sp. When leaving the coast, the landscape is mostly covered by coconut trees, fruit trees, agricultural land, mixed with other types of vegetation and on the sandy planes several lakes are formed.

# 4. Historical context of Iron Age in Mozambique and Shell-Middens under study

## 4.1 – Brief Historical Context – Late Iron Age

In Southern Africa, the Iron Age period refers to the first appearance of agro-pastoral communities being divided into Early (0–900 AD) and Late (1000–1900 AD) (Jeiamba, 2017), respectively, 2000–1100 cal BP, and 1000–100 cal BP.

The transition from hunter-gatherers to farmer communities in Mozambique, with an emphasis in the south, was mainly due to the arrival of new communities with innovative production processes, known as the "Bantu expansion". For Cruz and Silva (1976) Bantu-speaking peoples emigrated from a common center whose location is nowadays the subject of great controversy, but which seems to correspond to the Proto-Bantu nucleus in Nigeria/Cameroon.

Based on data provided by archaeological and anthropological research, there is unanimity in considering that: 1) in southern Africa there is no background of pottery production until the Early Iron Age, and 2) the populations came from the northern Zambezi through migratory waves. However, there are divergences in tracing these waves of migration among archaeologists, a fact that gives rise to different theories on Bantu migration. Jeiamba (2017) in his Ph.D. dissertation titled "Contribuição de Senna-Martinez para o estudo da olaria associada aos concheiros de Moçambique. Tentativa de interpretação do contexto Arqueológio" provides a thorough description of the migratory currents according to several researchers (Marjaana, 2014; Senna-Martinez, 1968, 1969, 1975, 1976; Martinez *et al.,* 1969; Phillipson, 2010). Senna- Martinez's studies of shell-middens in Mozambique, allowed the author to identify a settlement pattern on the coast and typical structures (shell-middens), calling it the "Southern Mozambique Coastal Kitchen Midden Tradition". The author has classified this Tradition into two phases. Phase 1 represents the Pre-Bantu hunter-gatherer population and phase 2 which is Bantu, is related to the First Farmer and Shepherd Communities. This way, the idea of a "Bantu migration" has long been argued and accepted in archeology and associated sciences.

However, that idea has divided the archeological community. As Phillipson (2010) shows, during the Bantu settlement in southern Africa there were numerous regional subdivisions that can be recognized mainly on the basis of the stylistic variation of pottery. It is in this context that the ceramic tradition arises. According to several researchers, the term "tradition" refers to "a group of industries whose similarities in the artifacts produced are sufficient to suggest that they belonged to a wider historical-cultural unity, with practices and technological ideas" (Meneses, 2002). Many of these traditions are identified by the shape and decoration of the pottery found in various archaeological sites in southern Africa. In this context, in Mozambique, the pottery found in the Matola archaeological site (I to III AD), was given the name of Matola Tradition by Tim Maggs in 1984, who considers that ceramics have stylistic types common to both ceramic Tradition in Ex-Transval and Natal Regions (Maggs, 1984; Morais 1988). The dates obtained from this archaeological site suggest that it marks the initial presence of farmers and shepherds' communities in southern Mozambique. The archaeological sites with Matola Tradition were mainly found along the southern coast, in the Maputo province and at the mouth of the Limpopo River, in the Gaza province. They also occur in the Zambezia and Nampula provinces. Recently, this Tradition was identified at the archaeological site of Chibuene (Ekblom, 2004), as well as in Marromeu (Macamo & Madiquida, 2004), in the Inhambane and Sofala provinces.

According to Morais (1989), the "Bantu expansion" arrived in Mozambique between the I and the III century, approximately 1800 years ago. Quickly they settled in coastal and estuarine zones (Xai-Xai, Bilene, Chongoene, Campus Universitario, Matola and Zitundo), as well as penetrated the fluvial basins (Hola-Rola, Massingir, Caimane) towards the hillsides and plateaus of the interior. This process of expansion and settlement of the Bantu in Southern Africa meant that they sometimes had to occupy land already occupied or traveled by groups of hunter-gatherers and shepherds, the Khoi-Khoi and the San. These ancient people, also called Koisan, lived in a phase of social organization and development that the Bantu had already passed many centuries ago. Many of these groups were expelled by the Bantu communities but, in other cases, they were absorbed and completely integrated into the Bantu culture and society.

The first evidence of Iron Age human occupation in Mozambique was identified, in the first instance, by the Mozambican Anthropological Mission, beginning in the late 1930s. The testimonies of these communities were found during excavations carried out almost throughout the country, namely in Massingir and other sites south of the Save River. The archaeological sites are well preserved, and the artifacts so far collected in excavations have been important to rebuild fundamental aspects of the past, such as the economy, social organization and regional trade of the first farmers. Anthracological materials were registered in almost every site. Charcoal remains varied from site to site. At the coastal shell-middens, charcoal is mostly associated with the cooking of shellfish, whereas in the living sites with slag, it is conspicuously related to metallurgical practices. However, this might prove to be more complicated, as fireplaces and pottery production also require considerable quantities of fuel. As mentioned before, the majority of the radiocarbon data obtained derived from charcoal but the anthracological analysis is still very scarce. The first anthracological analysis done in Mozambique comes from the Chibuene shell-midden (Ekblom *et al.,* 2014).

Regarding the iron technology used by these communities, they were mostly rudimentary metallurgists, some of which eventually adopted techniques of casting copper to produce ornaments, namely wires for personal use (Morais, 1989). Nevertheless, starting at the 5th century, the settlements appear to achieve relative stability raised by the exploitation of territories with higher agricultural productivity, grazing and reaching a good metallurgical production. The exchange of imported objects from the coast to the interior (seashells), or from the inland to the coast (copper beads and ivory defenses) is also increasingly recurrent from this period (Morais, 1989). These trades manifest themselves through archaeological sites in the interior fluvial basins north of the mouth of the Limpopo River (Massingir, Hola-Hola), and above all the coastal areas with favorable geographical location (Chibuene and Bazaruto Island) (Morais, 1989).

From the third quarter of the 1st millennium, regional exchange patterns were gradually changed by international markets of the Levant and the coasts of the Arabian Sea. This led to considerable changes in the primitive farming communities' self-subsistence (Ekblom *et al.,* 2014). This change is confirmed by the existence of glazed ceramic tiles exported from Siraf (Shiraz port, Ancient Persia) and present among the artifacts excavated in Chibuene, in the bay of Vilankulos, dating from that same period, revealing that this activity had begun probably around 700 AD (Ekblom *et al*., 2014; Morais, 1989).

From the XIII century, new migratory flows of populations originating from the Arabian Peninsula settled in Zanzibar and in Pemba Island. With the increase of migratory and economic flows comes the emergence of the first states and a centralized urban economy. Great Zimbabwe (*c.* 1250-1450) is considered to be the first city in southern Africa to reach a population of around 10 000. Other centers of less marked architectural expansion are related to it, also with remarkable historical expression, namely in the coastal zone, as for example the State of Manyikeni (1200-1650), a Zimbabwe wall located 50 km to the interior of the Bay of Vilankulos and Chibuene. In the western interior was located in the Torwa State and in the territories north of the Zambezi plateau and mid-course, extending to the coastal zone of central Mozambique, where the state of Monomotapa was located in the X century AD. All these states were characterized by the traditional "Zimbabwe" stone walls (Morais, 1989).

From the end of the 14th century, in the southern part of Mozambique, many regions belonging to the former state of Monomatapa ended, being separated due to the weakening of the central power, becoming independent states. Some of these states were the first to have contact with the Portuguese who, since 1505, had established themselves in Sofala.

Inhambane coast was founded by Swahili merchants and was visited by Portuguese for the first time in 1498, who built a fortification factory in 1546, but was only definitively occupied by Portugal in 1763 and received the status of village and seat of country. Later, it was declared a city on August 12, 1956 and, today, with the same name, is one of the provinces of Mozambique.

**4.2 – The study area**

Inhambane is the capital city of the Mozambique province with the same name and has about 77 thousand habitants. The city of Inhambane is located about 460 km north of Maputo, on the west bank of the peninsula that borders Inhambane Bay to west. The eastern shore of the peninsula is an extensive coastline of beaches in the Indian Ocean (Muchangos, 1999). The study area is located on the coast of the municipality of Inhambane.

The shell-middens under study are located about 20 km from the City of Inhambane, on Tofo and Rocha beach. Tofo is a small coastal village composed by extensive beaches and in the same coast, a few kilometers to the south, in a private beach called Praia da Rocha, also several Shell-middens were identified (FIGURE 4.1).

The coastal zone of the municipality comprises sandy soils. Dunes occur all along the coastal zone and they are of primary (recent) and secondary (old, further onshore) types. The vegetation is described with littoral thicket and forest of recent dunes. The climate is tropical humid, characterized by cold and very rainy seasons, which makes the local meteorological conditions unpredictable (Holmgren *et al.,* 2012; Noström *et al.,* 2017).


Figure 4.1 – Location of the shell-middens under study. A) Praia do Tofo and B) Praia da Rocha. Credits: Célia Gonçalves, ICArEHB.

## 4.3 – The Shell-middens of Praia do Tofo and Praia da Rocha

### Praia do Tofo

Next to the Tofo Beach, more precisely, located in Tofinho, there were two shell-middens with approximately *c.* 300 BP (Table 4.1), identified during the survey and excavation campaign of the project VIP in 2016 (PTDC/EPH-ARQ/4168/2014). The anthracological material under study comes from these two shell-middens. These Late Iron Age shell-middens have been designated as Tofo 1 and Tofo 2 and are located at about 500 meters from one another.

**Table 4.1**

**Table with the AMS $^{14}C$ dating from Praia do Tofo and Praia da Rocha**

| Site | Site areas | Material | Lab code | Age BP | C | δ13C | C:N ratio | δ15N | Calibrated Age (cal BP) 2σ |
|---|---|---|---|---|---|---|---|---|---|
| Praia da Rocha 1 | - | Human Phalanx | WK-45800 | 267±15 | 43,31 | -10,89 | 3,19 | 8,58 | 423-286 |
| Praia da Rocha 15 | - | Perna Perna | WK-45799 | 612±15 | - | 0.4±0.3 | - | - | 304-149 |
| Tofo 2 | 2 Lower | Mussel | WK-44422 | 595±21 | - | 2.1±0.4 | - | - | 289-144 |
| Tofo 2 | 2 Upper | Gastropod | WK-44423 | 566±20 | - | - | - | - | 271-131 |
| Tofo 1 | 1 | Mussel | WK-44424 | 610±20 | - | - | - | - | 304-146 |

Legend: C = Carbon; δ13C = Isotopic signature; C:N ratio = Carbon to Nitrogen ration; δ15N = ratio of the two stable isotopes of nitrogen.

**Tofo 1 -** The site is located on top of a dune (FIGURE 4.2A) and the anthracological material was collected in the vicinity of the shell-midden, on geological profiles exposed because they are in an area of water drainage. The great concentration of charcoal present in the two geological profiles caught the attention of the researchers who identified the presence of hearths (FIGURE 4.2B and 4.2C). In another area of the same shell-midden some anthracological samples were also collected (FIGURE 4.2D).

**Tofo 2 –** This shell-midden was identified a few hundred meters south, after the beachrock formation. The team collected about 20 cm of the sediment, distinguishing two archaeological levels and collected a small sample of charcoal (FIGURE 4.3).

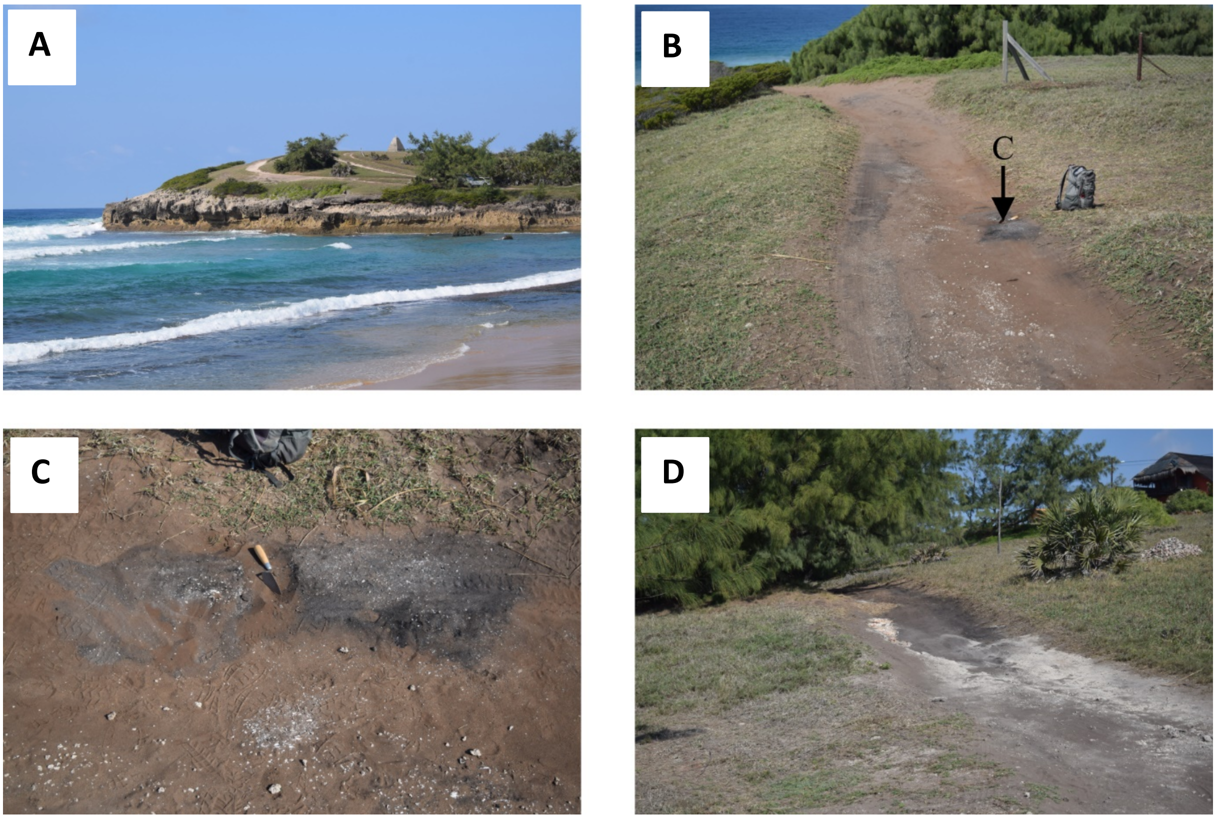


Figure 4.2 – A) Tofo beach with the shell-midden in the top of the dune, B) location of the Hearths on Tofo 1 shell-midden; C) detail of the concentration of shells with charcoals and D) another area of the shell-midden (Tofo 1) with some anthracological samples. Credits: Jonathan Haws, ICArEHB.

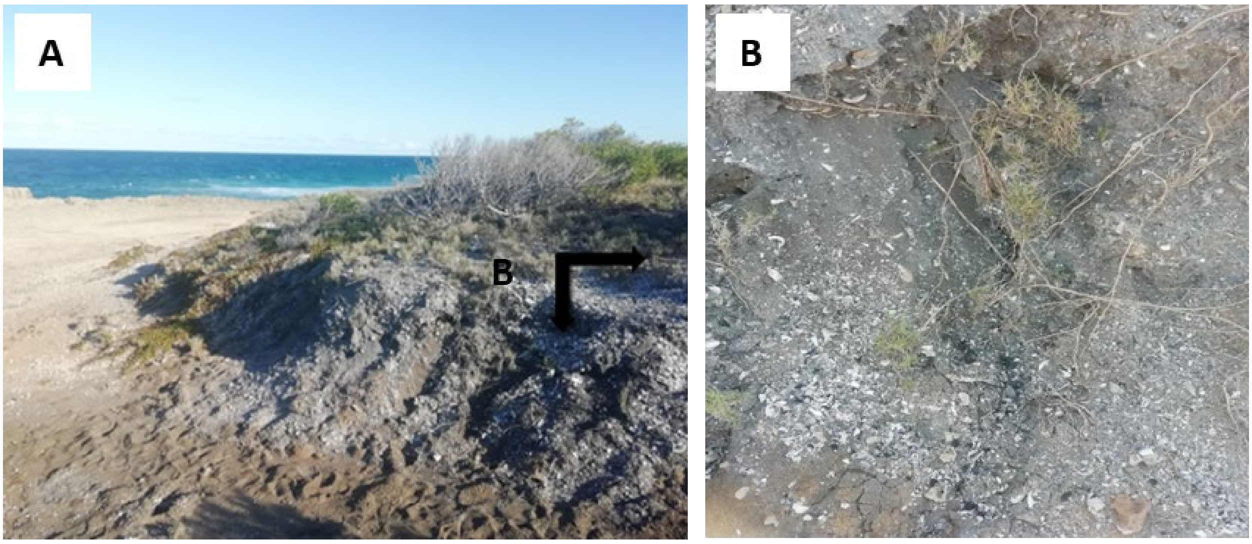


Figure 4.3 – A) Another shell-midden Tofo 2, with some antraclogical samples. B) detail of the charcoals. Credits: Roxane Matias, ICArEHB.

**Praia da Rocha**

Also dated to the Late Iron Age, in Praia da Rocha, the team identified several open-air shell-middens, located within a hundred meters of each other, along the coast, in the sand dunes (FIGURE 4.4). The shell-middens were easily identified because they were partially exposed due to wind erosion. Among the identified shell-middens, the material under study comes from five of them, namely: Praia da Rocha 1, Praia da Rocha 4, Praia da Rocha 7, Praia da Rocha 14 and Praia da Rocha 15.

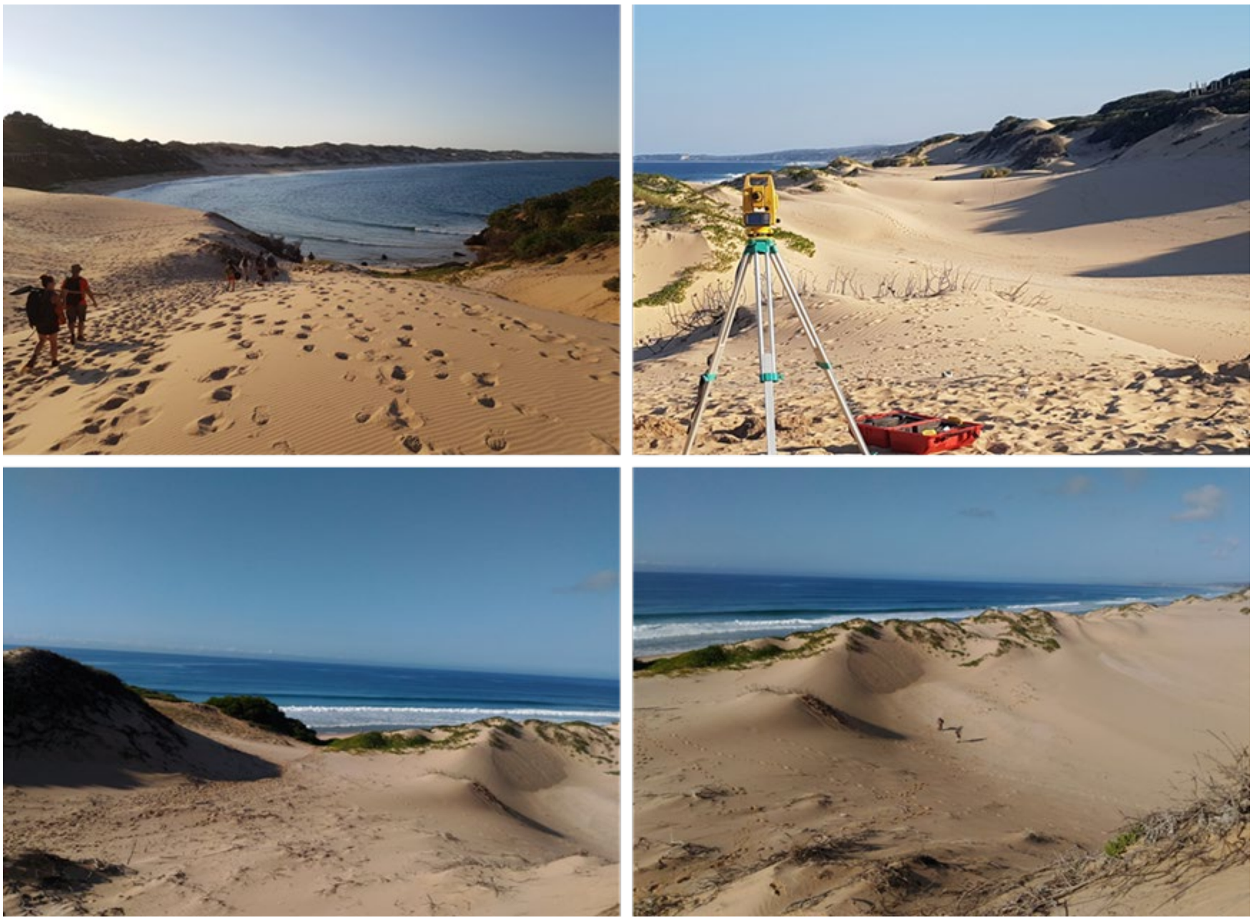


Figure 4.4 – Praia da Rocha Overview. Credits: Ana Gomes and João Cascalheira, ICArEHB.

**Praia da Rocha 1** – The shell-midden was identified as having some material on the surface, namely, human bones (FIGURE 4.5A). An area of 6m × 4m was excavated, screened and all the artefacts were inventoried by total station survey ID numbers. There, an almost complete human skeleton was recovered, mixed with a large concentration of ceramics, charcoals and other materials. Ilona Benedetti's osteological analysis (2018) revealed the burial of a woman over 50 years old at time (FIGURE 4.5C). The estimated stature is between 165-179 cm, some health problems related to disk degeneration and osteoarthritis and the stable isotope analysis ($^{13}C$) made to a mussel shell (*Perna perna*) in another near shell-midden (Praia da Rocha 15) suggests dominantly terrestrial sources (TABLE 4.1). As for the age of this context, AMS $^{14}C$ dating on a phalanx revealed the age of *c.* 423 – 286 BP (TABLE 4.1). The fact that some bones are missing, the discovery is considered to be a re-burial by local residents or environmental factors (Ilona *et al.*, 2018).

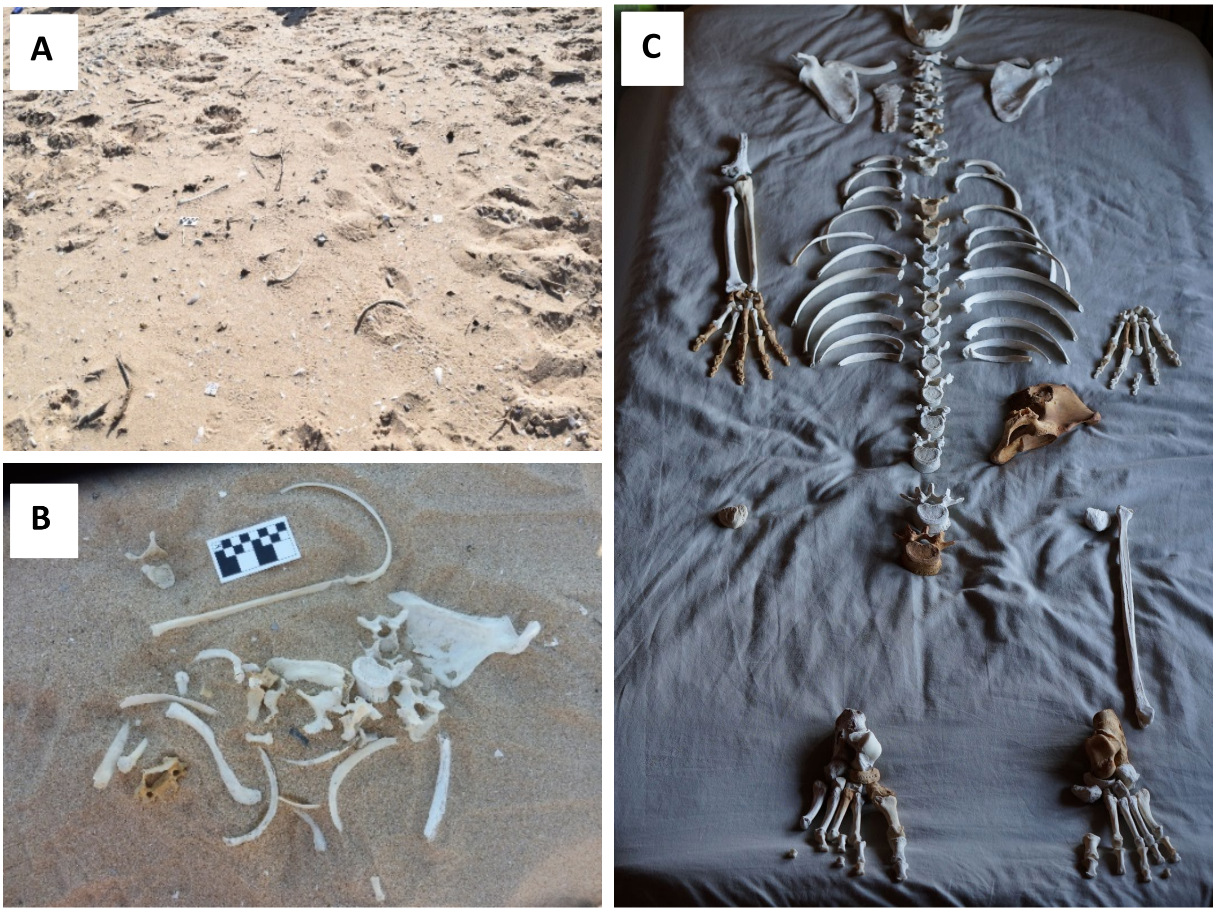



Figure 4.5 – A) Praia da Rocha 1, Shell-midden. B) detail of human bones remains mixed with fragments of ceramic, lithics, shells, charcoal and other materials. C) Almost all the osteological remains. Credits: Ana Gomes, Célia Gonçalves and Jonathan Haws, ICArEHB.

**Praia da Rocha 14** - In addition to shells and charcoals fragments, they also identified some ceramic.

**Praia da Rocha 15 -** In the shell-midden, several dark spots were identified. The excavators delimited an area of 1m by 3m in the center of the shell-midden and excavated to about 80cm of depth. They identified two archaeological levels with two horizons full of charcoals (FIGURE 4.6). There, the AMS $^{14}C$ dating on a mussel shell (*Perna perna*) revealed an age similar to the shell-middens at Praia do Tofo (TABLE 4.1).

Figure 4.6 – Praia da Rocha 15, identification in the Shell-midden of a cut with two horizons full of charcoal. Credits: Jonathan Haws, ICArEHB.

**Praia da Rocha 4 -** This is site is composed of two dark spots dispersed in the shell-midden area. One of them presented a great presence of charcoals. About 5 cm were excavated and most of the charcoals were recovered (FIGURE 4.7).

**Praia da Rocha 7 -** Another shell-midden identified on the slope of a dune with some associated anthracological material (FIGURE 4.8).

Figure 4.7 – A) Praia da Rocha 4, Identification of two scattered black spots in the Shell-midden, and B) detail of one of the spots. Credits: Nuno Bicho, ICArEHB.

Figure 4.8 – Praia da Rocha 7, another Shell-midden identified on the slope of the dune with some anthracological material associated, Credits: Nuno Bicho, ICAr

# 5. Methodology

Anthracology embraces field recovery and laboratory methodology. In this chapter the methodology of collection to the study of wood charcoals will be presented, from two shell-middens in Praia do Tofo and five shell-middens in Praia da Rocha.

## 5.1 - Techniques of sample recovery and laboratory preparation

The distinction between charcoal fragments dispersed in the archaeological contexts and those concentrated in combustion structures or burials is fundamental, since these two types of deposits provide different interpretations (Scheel-Ybert *et al.*, 1998). In the shell-middens under study, two sampling methods were used to collect wood charcoals during the prospection and excavation campaigns in 2016/2017:

1. Manual collection in the burial and in partly exposed shell-middens - dispersed (from the dispersion of charcoals from fires) and concentrated (from hearths and burial structures) anthracological material;
2. Dry screening of the sediments from the burial: anthracological material concentrated.

The sampling of some of the shell-middens presented here refers only to the collection of the anthracological materials that were exposed, representing a reduced number. In turn, sampling from combustion and burial structures represents a larger number but not the total. All the fragments in the samples with highest density of wood charcoal could not be analyzed due to time constraints, thus 100 fragments of each set were sampled for taxonomic and taphonomic analysis. The sampling was made using random number tables (Drennan, 2009). Basically, this is a list with random numeric sequences that define which fragments are selected for analysis.

For the microscopic analysis, fragments equal or greater than 2 $mm^2$ were used, a minimum measure considered necessary for a rigorous identification, whereas charcoal with smaller dimensions have more probabilities that will not allow the necessary observation of the anatomical sections of the wood (Chabal, 1992, 1997; Vernet, 1973). Thus, the taxonomic identification is made of each individualized fragment and assigned a new identification (ID), that will always be related to the original excavation ID. This way, the sampling applied for the laboratory analysis was as follows:

**At Praia do Tofo:**

1. Tofo 1 – in Hearth 1, 170 fragments were collected and 100 were selected for the taxonomic analysis. In Hearth 2, 318 fragments were collected and 100 were selected for taxonomic analysis. In the same shell-midden, an area with a high concentration of exposed shells was identified where three charcoals were associated, which were analyzed;

2. Tofo 2 – all the charcoal fragments collected (11 fragments) were analyzed.

**At Praia da Rocha:**

1. Praia da Rocha 1 – 1405 fragments were collected at the burial, individualized and selected 100 for analysis.

2. Praia da Rocha 14 – of the charcoal collected at the shell-midden, 121 fragments were individualized and selected 100 for analysis.

3. Praia da Rocha 4, Praia da Rocha 7 and Praia da Rocha 15 – all the collected charcoal (PR4 40 fragments, PR7 40 fragments and PR15 35 fragments) were analyzed.

### 5.2 - Analytical procedures

The cellular structure and morphology of the macro-plant species, such as the charcoals, are conserved by carbonization (Caruso Fermé, 2012; Chabal, 1997; Piqué & Huerta, 1999). Consequently, the preservation of the cellular structure allows its taxonomic identification through microscopic observation.

Thus, 529 charcoal fragments were observed in the three diagnostic planes (transverse, tangential longitudinal and radial longitudinal) (Digital supplementary materials 1 are available in the following link: http://www.doi.org/10.17605/OSF.IO/HBQSC - Taxonomic and taphonomic Database study. xlsx). The reflective light microscopes, (Olympus BX51TRF and Leica DP2500) were used, magnified up to 500 times and either bright-field (the background is light, the beam is weakened and the object seems transparent) or dark-field magnification (the background is dark and the light is scattered/reflected by the sample (Gage, 1920). The three sections of each fragment analyzed with the Olympus microscope were also photographed. The anatomical photographs of the fragments being studied were taken by means of Olympus Stream Essentials image analysis software with Extended Focal Image (EFI) capability and through the *Helicon* program on Leica DP2500. In addition, measurements and statistics were generated for all fragments. The measurements concerned were the width (µm) and density ($mm^2$) of the vessels (FIGURE 5.1), the width (µm) of the intervessel pits ($mm^2$) (FIGURE 5.1), the ray length (µm) (FIGURE 5.2) and the frequency ($mm^2$) of the rays on transverse section of all the analyzed charcoals. To classify the vessels density the following terms were used: very low (< five vessels/$mm^2$); low (5-20 vessels/$mm^2$); medium (20-40 vessels/$mm^2$) and numerous (40-100 vessels/$mm^2$). To measure the approximate average of the measurements made, it was decided to make ten measurements for each analyzed feature.

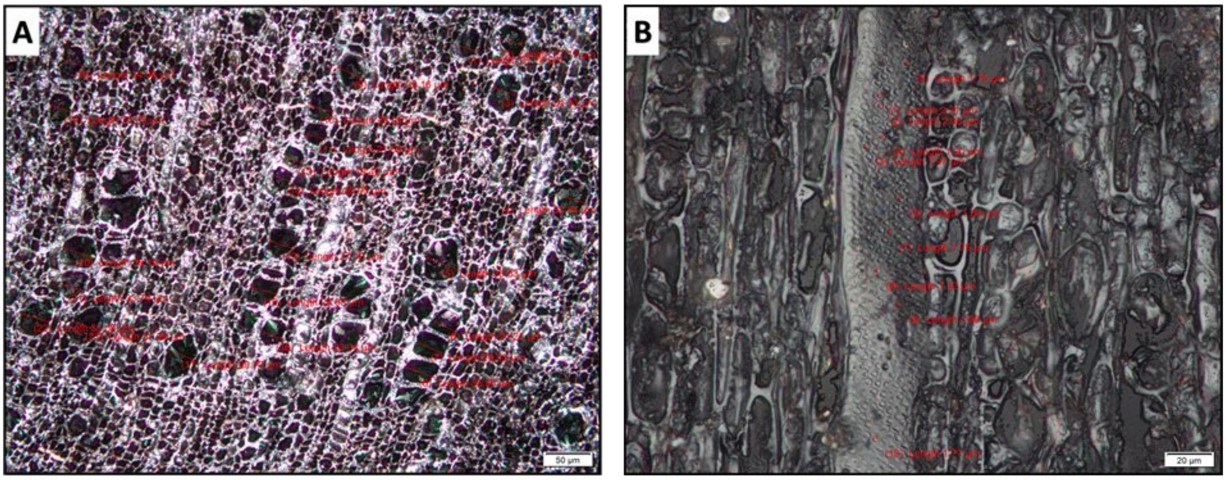



Figure 5.1 – A) *Diospyros* cf. *natalensis* PR15 8, Ts x200, showing measured vessel diameter (µm) and density (per/$mm^2$), B) *Euclea* cf. *natalensis* PR4 7, RLS x500, showing intervessel pits ($mm^2$). Credits: Roxane Matias, ICArEHB.

The charcoal specimens were slit along three planes, placed on microscope slides and orientated to view transverse section (TS), tangential longitudinal section (TLS) and radial longitudinal section (RLS). The three anatomical sections analyzed in each fragment are required for the analysis (Chabal *et al.,* 1992; Vernet, 1973, 1976) and each plane represents a specific cellular structure that enables identification of the species (Figure 5.3).

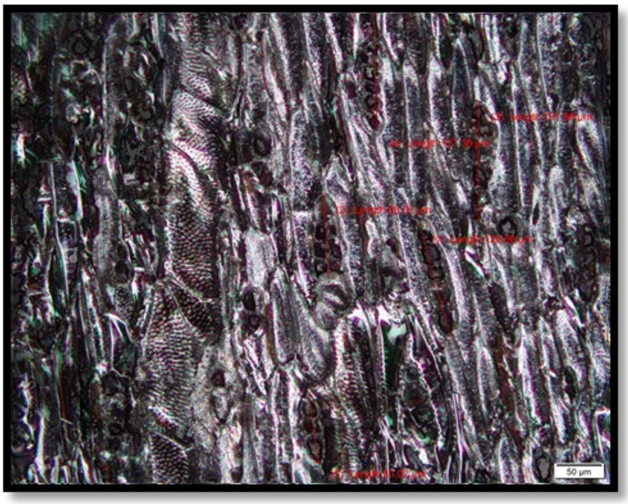


Figure 5.2 – *Diospyros* cf. *natalensis* PR15 34, TLS x200, showing ray width (cell number) and ray length (µm). Credits: Roxane Matias, ICArEHB.

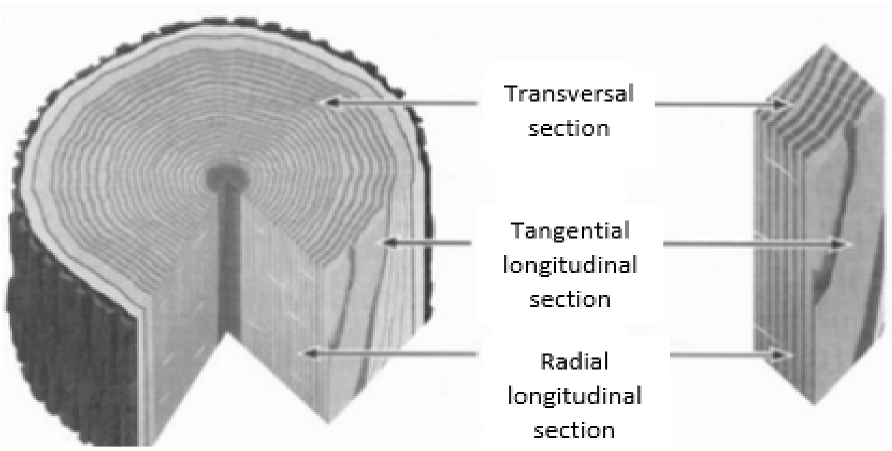



Figure 5.3 – The three anatomical sections. Credits: retired from Carruso, 2009 and adaptated by Roxane Matias.

The study of the archaeological charcoal is carried out by performing clean cuts on the fragment, with the objective to obtain the three anatomical plains of the wood. It is a non-destructive method, which allows better preservation of the cellular structure and the subsequent use of the sample to perform radiocarbon dating. Thus, the microscope observation can identify the species and know which species would have been collected for fuel.

As no comparative wood anatomical atlas is available for the research to that region, a database was created to know the modern vegetation of the province under study (Digital supplementary materials 2 are available in the following link: http://www.doi.org/10.17605/OSF.IO/HBQSC – modern_vegetation.xlsx). It consists essentially of three types of information: the modern flora (Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013), online references that have images with a description of the cellular structure (Allott, 2005; Chikumbirike, 2014; Lennox, 2016), and the anatomical codes according the International Association of Wood Anatomists (IAWA) list of features for hardwood identification (InsideWood, 2004-onwards; Wheeler, 2011). It was also used the modern charcoal reference collection of the Evolutionary Studies institute (ESI), University of the Witwatersrand, Johannesburg, South Africa.

The online database Inside Wood is a project that integrates wood anatomical information from the literature and original observations into an internet-accessible database useful for research and teaching. In addition, the International Association of Wood Anatomists (IAWA) created a List of Features for hardwood identification (Wheeler, 1989). For this study, most of the anatomical criteria defined by IAWA (Wheeler, 1989) were used. In Appendix 1, is a list with most of the anatomical features observed in the identification of the wood charcoals under study, with the numerical codes defined by IAWA (Wheeler, 1989).

Most fragments can be related to modern genera but the species designation has proven to be more difficult as the distinguishing features have not been preserved or they overlap with more than one species. For this, the analyzed fragments were firstly classified into types. The term "type" was used to designate an anatomical category, distinguished either by one distinct feature or a unique combination of features (Appendix 2). Next, taxonomic identification was carried out (Appendix 3). The fragments identified with the scientific name of the species are those that allowed the observation of anatomical characteristics of the species in the three sections, (for example, *Brachylaena discolor)*. The code "cf" means a probable identification while those with "cff.", represent a possible identification (for example, cff. *Avicennia marina).* That term presents a lower degree of certainty in the identification, meaning that some characteristics of this species were observed but the impossibility of observing all the features that distinguish this taxon, led to consider it as cff. *Avicennia marina*. The fragments designated as Indeterminate were those whose anatomical identification was not possible due to the impossibility of observing a great part of the anatomical features that allow any type of identification, mainly due to the fragment dimensions. The fragments designated as

Indeterminable are those that, like the indeterminate ones, were not possible to identify, however, this impossibility of identification was due to taphonomic alterations, mainly to vitrification and mineral incrustation, that deeply altered the original anatomy. The question marks “?” present in the taxonomic description refers to a doubt on observations, frequently due to diagenesis damage, which reduced the quality of the specimen. The "v" abbreviation means variation, the feature observed is not constant in the charcoal anatomy.

### 5.3 - Taphonomic analyzes

Charcoal taphonomy is focused on the study of cell deformation during combustion and post-depositional processes. Taphonomic alterations impact the preservation of wood charcoal remains, in fuel waste debris. This relates to practices of primary deposition (for example, hearth type), redeposition (discard), post-depositional weathering (for example, soil moisture, surface exposure and freeze-thaw cycles) and trampling by people and animals (Théry-Parisot *et al*., 2010). Thus, taphonomy is associated with wood characteristics or exposure to combustion conditions. Analyses relate to a natural formation process or to resource exploitation by human communities.

In this study, in addition to the taxonomic analysis, taphonomic alterations were observed in the charcoals, to obtain more information about the use of wood as fuel. As show below, a set of taphonomic alterations was recovered and organized according to the criteria defined by Euba (2009), they are:

**Morphological characteristics:** The appearance of a knot is one of the most common natural changes during the growth of woody species (Martín Seijo, 2013). This is a distortion of sections where more than one section is observed in the same plane (FIGURE 5.4).

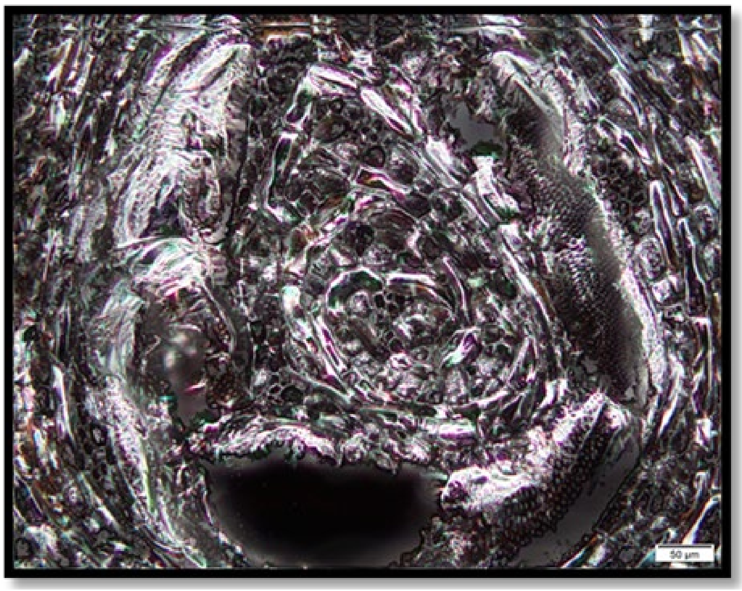


Figure 5.4 – Tofo 2 20. Showing a knot. Credits: Roxane Matias, ICArEHB.

**Alteration by microorganisms:** The wood decay (FIGURE 5.5A) is caused during the growth of the plant related to damages caused by meteorological agents or microorganisms attacks producing the death of the tree or the branches (Théry-Parisot *et al*., 2010). The identification of wood decay within anthracological assemblages permits characterization of wood exploitation by providing information on wood quality (Allué *et al*., 2008). Holes are caused mostly by microorganisms attacks (FIGURE 5.5B).

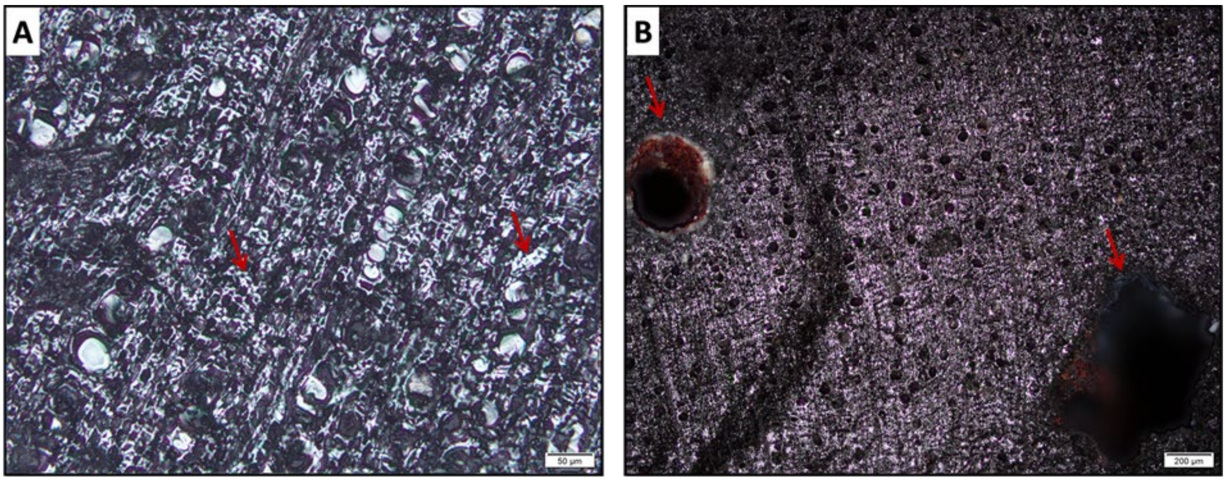



Figure 5.5 – A) Herath1 16 (*Diospyros* cf. *nata*lensis), showing wood decay. B) PR7 20 (*Euclea* cf. *natalensis*), showing a hole. Credits: Roxane Matias, ICArEHB.

**Combustion alteration**: in this case alteration takes place as vitrification and cracks (Théry-Parisot *et al*., 2010). Vitrification is a term used in anthracology to describe the vitreous aspect that sometimes the charcoals have (FIGURE 5.6A). Vitrification is related to the combustion process. It is the homogenization and fusion of several anatomical elements of the cellular structure that lead to the disappearance of some identification criteria, giving rise to various debates about its presence. There are several authors (Braadbaart & Poole, 2008; Braadbaart *et al*., 2009; Carrión, 2002; Fabre, 1996; Py & Ancel, 2006; Thinon, 1992; Talon, 1997; Scheel-Ybert, 1998). They refer to different variables directly linked to vitrification, namely, the state of the wood used as fuel (green, dry, wet, resinous, degraded) and the combustion process (high temperatures, recharge). Thus, at present there is yet no specific cause or factor for this type of change, but most studies point to high levels of combustion and some specific properties of wood. The cracks are also associated with the state of wood used as fuel (green, dry, wet, resinous, degraded) and with the combustion process (high temperatures, recharge) (Théry-Parisot, 1998, 2001; Théry-Parisot & Henry, 2012), The cracks seem to be associated with the first stage of combustion, when the gases and the water steam volatilize suddenly. Then, when increasing the temperature, the wood contracts in different ways and forms cracks (Kim & Hanna, 2006). This alteration is more easily identifiable in transverse section (FIGURE 5.6B).

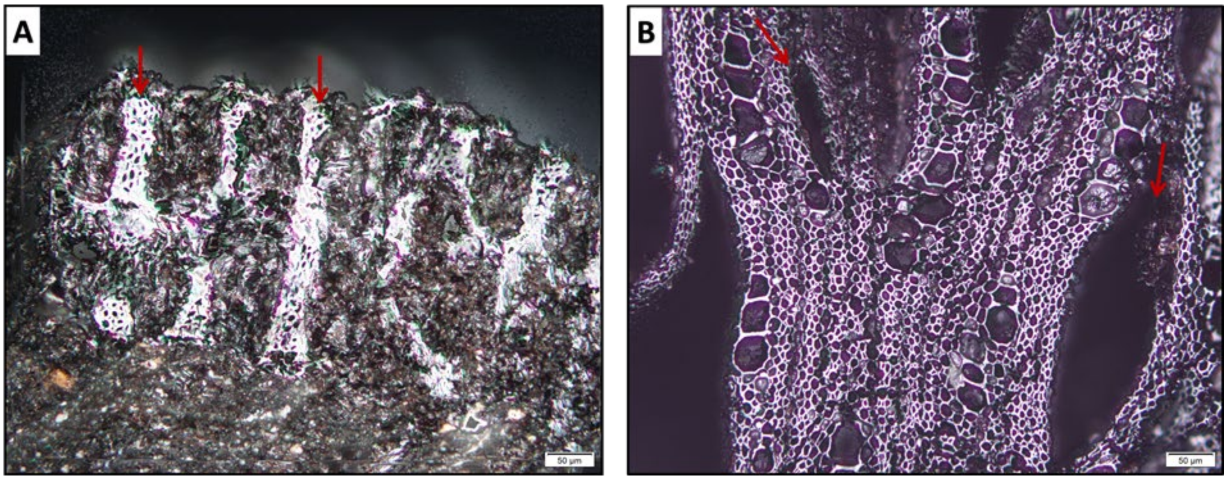



Figure 5.6 – A) PR4 Indeterminable, showing vitreous aspect on diagenesis. B) PR1 52 (*Diospyros* cf. *natalensis)*, showing cracks. Credits: Roxane Matias, ICArEHB.

**Post-depositional alterations:** affect charcoal cell structure, mainly related to natural agents, although anthropic agents are also to be considered. The mechanism producing damages in charcoal cell structure are trampling, water, frost-thaw, sediment pressure (FIGURE 5.7), roots and microorganisms (Allué *et al.* 2008). These affect charcoals by producing fissures, fragmentation and hyper-fragmentation and general distortion of the cell structures, which are determined by the combustion and wood (Théry-Parisot *et al.*, 2009).

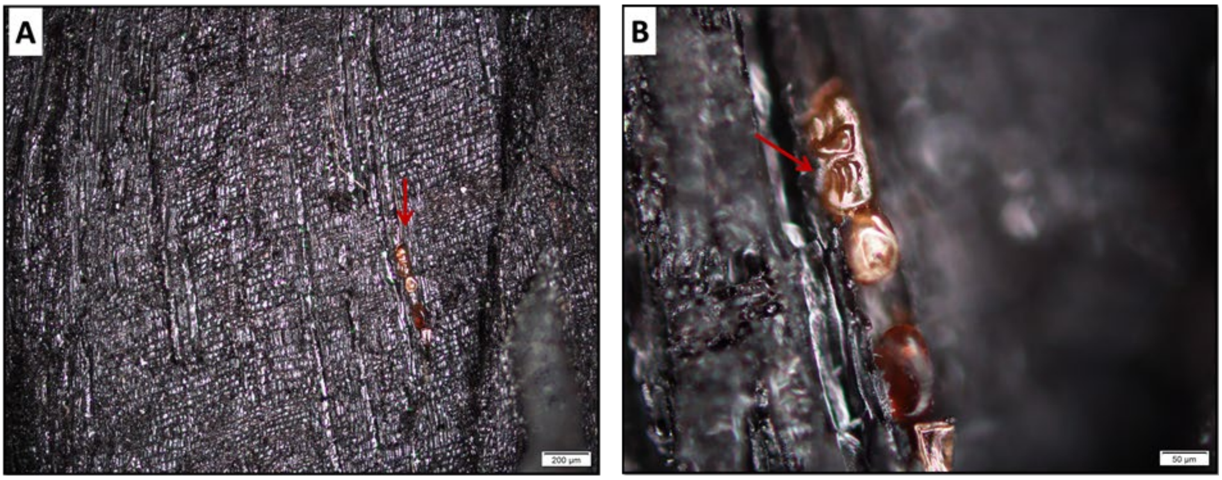



Figure 5.7 – A) PR15 29 RLS x50 (*Euclea* cf. *natalensis*), showing mineral inclusions. B) PR15 29 RLS x500 (*Euclea* cf. *natalen*sis), showing mineral inclusion. Credits: Roxane Matias, ICArEHB.

# 6. Results: Taxonomic and Taphonomic analysis

The anthracological study consisted of the analysis of a total of 529 charcoal fragments, of which 315 come from 5 shell-middens of Praia da Rocha and 214 fragments correspond to 2 shell-middens of Praia do Tofo. TABLE 6.1 presents the results of all the analyzed charcoals for the shell-middens of Praia da Rocha and Praia do Tofo. The results obtained for each shell-midden will be presented separately, as well as their context.

**Table 6.1**

**Charcoal analysis from shell-middens of Praia do Tofo and Praia da Rocha**

| Taxon | Praia do Tofo | | | Praia da Rocha | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | TOFO 1 | TOFO 2 | Total | PR1 | PR14 | PR15 | PR4 | PR7 | Total | |
| *Bauhinia* sp. | - | - | - | - | - | - | 4 | - | - | **4** |
| *Combretum* sp. | - | - | - | 1 | - | - | - | - | - | **1** |
| *Brachylaena* cf. *discolor* | - | - | - | - | - | 7 | - | - | - | **7** |
| *Burkea* cf. *africana* | - | - | - | 5 | - | - | - | - | - | **5** |
| *Catunaregam* cf. *obovata* | - | - | - | - | 3 | - | - | 19 | - | **22** |
| *Diospyros* cf. *natalensis* | 46 | 6 | 52 | 21 | - | 4 | - | - | 52 | **77** |
| *Ekebergia* cf. *capensis* | - | - | - | 1 | - | - | - | - | - | **1** |
| *Euclea* cf. *natalensis* | 121 | 2 | 123 | 57 | 75 | 13 | 26 | 20 | 123 | **314** |
| *Mystroxylon aethiopicum* | - | - | - | - | - | 1 | - | - | - | **1** |
| cff. *Avicennia marina* | - | - | - | - | - | 8 | - | - | - | **8** |
| cff . *Harpephyllum* | - | - | - | 2 | - | - | - | - | - | **2** |
| **Indeterminable** | 9 | 1 | 10 | 2 | 5 | 1 | 6 | - | 10 | **24** |
| **Indeterminate** | 27 | 2 | 29 | 11 | 17 | 1 | 4 | 1 | 29 | **63** |
| **Number of identified charcoal** | **167** | **8** | **175** | **87** | **78** | **33** | **30** | **39** | **175** | **442** |
| **Number of taxa** | **2** | **2** | **2** | **6** | **2** | **5** | **2** | **2** | **2** | |
| **Total** | **203** | **11** | **214** | **100** | **100** | **35** | **40** | **40** | **214** | **529** |

## 6.1 - Praia do Tofo

Of the 214 charcoal fragments analyzed, 175 were identified to species and two woody taxa and one family were distinguished (TABLE 6.1). The following taxa have been identified: Ebenaceae *Euclea* cf. *natalensis* and *Diospyros* cf. *natalensis*.

In a general context, regarding their spatial distribution, as TABLE 6.1 shows, in 203 charcoal fragments analyzed in Tofo 1, 121 were identified as *Euclea* cf. *natalensis*, followed by 46 fragments identified as *Diospyros* cf. *natalensis*. In Tofo 2 the collection comprises only

11 charcoal fragments which were identified as *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis*.

### Tofo 1 - Hearth 1, Hearth 2, Shell sector

In Hearth 1, only one taxon, *Euclea* cf. *natalensis*, was identified (TABLE 6.2). Of the 100 fragments in the sample 91 were analyzed. Two fragments were identified as Indeterminable and seven as Indeterminate.

In Hearth 2, two taxa, *Euclea* cf. *natalensis* and *Diospyros* cf. *natalensis,* were identified. Of the 100 fragments analyzed it was possible to identify 76. The taxon *Diospyros* cf. *natalensis* is the most frequent (46 fragments) followed by *Euclea* cf. *natalensis* (30 fragments). In Hearth 2, it was not possible to identify a larger number of fragments due to the poor preservation of the charcoal fragments. This way, seven fragments were identified as Indeterminable and 17 as Indeterminate.

In the shell sector area, the only three charcoal fragments collected are damaged due to diagenesis and thus it was not possible to identify any anatomical features, being designated as Indeterminate.

**Table 6.2**
**Charcoal analysis from Tofo 1 (Hearth 1, Hearth 2 and Shell sector) – Taxonomy**

| Taxon | Hearth 1 | Hearth 2 | Shell Sector |
|---|---|---|---|
| *Diospyros* cf. *natalensis* | - | 46 | - |
| *Euclea* cf. *natalensis* | 91 | 30 | - |
| **Indeterminable** | 2 | 7 | - |
| **Indeterminate** | 7 | 17 | 3 |
| **Number of taxa** | **1** | **2** | **-** |
| **Total** | **100** | **100** | **-** |

Regarding the taphonomic processes in Hearth 1 (TABLE 6.3), the alteration present in most charcoal fragments (77) is the mineral inclusion (post-depositional alteration). Due to the combustion change, the second most present alteration in the fragments is the presence of vitrification, where 59 fragments had a vitreous aspect and, in 44 fragments cracks were observed. As for the alterations by microorganisms, 15 fragments were identified with cell decay. Finally, the less frequent alteration was due to changes in the morphological characteristics such as knots present (eleven fragments.).

**Table 6.3**
**Charcoal analysis from Tofo 1 - Hearth 1 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Euclea* cf. *natalensis* | **91** | 10 | 13 | - | 12 | 54 | 42 | 70 | **70** |
| **Indeterminable** | **2** | 1 | 1 | - | - | 1 | 1 | 2 | **2** |
| **Indeterminate** | **7** | - | 1 | - | - | 4 | 1 | 5 | **5** |
| **Total** | **100** | **11** | **15** | | **12** | **59** | **44** | **77** | **77** |

In Hearth 2 (TABLE 6.4), the alteration most common was mineral inclusion (post-depositional alteration) with 78 fragments present. The second alteration most present was vitrification due to combustion changes (49 fragments) followed by diagenesis (45 fragments). Cracks are present in 14 fragments. For the alterations by microorganisms, 24 fragments were identified with cell decay. Finally, only one fragment was identified as a knot.

**Table 6.4**
**Charcoal analysis from Tofo 1 - Hearth 2, taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Diospyros* cf. *natalensis* | **46** | - | 11 | | 26 | 26 | 9 | 40 | **40** |
| *Euclea* cf. *natalensis* | **30** | 1 | 10 | | 14 | 19 | 3 | 26 | **26** |
| **Indeterminable** | **7** | - | 2 | | 4 | 4 | - | 6 | **6** |
| **Indeterminate** | **17** | - | 1 | | 1 | - | 2 | 6 | **6** |
| **Total** | **100** | **1** | **24** | | **45** | **49** | **14** | **78** | **78** |

The three Indeterminate charcoal fragments analyzed from the Shell sector area have a strong presence of vitrification and mineral inclusions.

## Tofo 2

In Tofo 2, two taxa, *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis*, were identified. Of the 11 fragments collected and analyzed it was possible to identify eight fragments (TABLE 6.5). *Diospyros* cf. *natalensis* is the most frequent (six fragments) followed by *Euclea* cf. *natalensis* with two fragments identified. Just one fragment was identified as Indeterminable and 2 as Indeterminate. The alteration present in all the charcoal fragments analyzed was mineral inclusion (post-depositional alteration) with 11 fragments (TABLE 6.6). The second most common alteration is vitrification (ten fragments) due to the combustion change. The fragments show no alterations caused by microorganisms and only one fragment was identified a knot (morphological characteristics).

**Table 6.5**

**Charcoal analysis from Tofo 2 – Taxonomy**

| **Taxon** | |
|---|---|
| *Diospyros* cf. *natalensis* | 6 |
| *Euclea* cf. *natalensis* | 2 |
| **Indeterminable** | 1 |
| **Indeterminate** | 2 |
| **Number of taxa** | **2** |
| **Total** | **11** |

**Table 6.6**

**Charcoal analysis from Tofo 2 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Diospyros* cf. *natalensis* | **6** | 1 | - | - | 6 | 6 | - | 6 | **6** |
| *Euclea* cf. *natalensis* | **2** | - | - | - | 2 | 2 | - | 2 | **2** |
| **Indeterminable** | **1** | - | - | - | 1 | 1 | - | 1 | **1** |
| **Indeterminate** | **2** | - | - | - | 1 | 1 | - | 1 | **1** |
| **Total** | **11** | **1** | **-** | **-** | **10** | **10** | **-** | **10** | **10** |

## 6.2 - Praia da Rocha

Of the 315 charcoal fragments analyzed, 267 could be identified. Eleven woody taxa and eight families were present (TABLE 6.1). Woody taxa identified in four categories are, a mangrove cff. *Avicennia marina,* a shrub *Bauhinia* sp.*,* trees cff. *Harpephyllum, Burkea* cf. *africana, Combretum* sp.*, Diospyros* cf. *natalensis, Ekebergia* cf. *capensis, Mystroxylon aethiopicum* and shrubs or small trees of *Brachylaena* cf. *discolor, Catunaregam* cf. *obovata and Euclea* cf. *natalensis.*

Regarding their spatial distribution, as Table 6.1 shows, the most represented taxa in all the shell-middens studied in Praia da Rocha is *Euclea* cf. *natalensis* with 191 fragments analyzed followed by *Diospyros* cf. *natalensis* (25 frag.), although less frequent. They are present only in two shell-middens (PR1 and PR15).

### Praia da Rocha 1 (PR1)

In the burial area (PR1) of the 100 fragments selected and analyzed, 6 different taxa were identified (TABLE 6.7). The most representative taxa are *Euclea* cf. *natalensis* with 57 fragments, followed by *Diospyros* cf. *natalensis* (21 frag.) In smaller quantities five fragments were identified of *Burkea* cf. *africana*, followed by cff. *Harpephyllum* with two fragments and only one fragment identified as *Combretum* sp. and *Ekebergia* cf. *capensis*.

**Table 6.7**
**Charcoal analysis from PR1 – Taxonomy**

| **Taxon** | |
|---|---|
| *Burkea* cf. *africana* | 5 |
| *Diospyros* cf. *natalensis* | 21 |
| *Ekebergia* cf. *capensis* | 1 |
| *Euclea* cf. *natalensis* | 57 |
| cff . *Harpephyllum* | 2 |
| *Combretum* sp. | 1 |
| | |
| **Indeterminable** | 2 |
| **Indeterminate** | 11 |
| **Number of taxa** | **6** |
| **Total** | **100** |

In the sample, almost all the fragments were analyzed, except for six fragments (frags. 25, 77, 82, 90, 92 and 102) which present morpho-anatomical or taphonomic alteration. During the identification, four types of alterations were identified (TABLE 6.8).

**Table 6.8**
**Charcoal analysis from PR1 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Burkea* cf. *africana* | **5** | 1 | - | - | 3 | - | - | 5 | **5** |
| *Combretum* sp. | **1** | - | 1 | - | 1 | - | - | 1 | **1** |
| *Diospyros* cf. *natalensis* | **21** | - | 6 | 1 | 18 | 2 | 10 | 21 | **21** |
| *Ekebergia* cf. *capensis* | **1** | - | - | - | 1 | - | - | 1 | **1** |
| *Euclea* cf. *natalensis* | **57** | 1 | 10 | - | 45 | 2 | 5 | 54 | **54** |
| cff . *Harpephyllum* | **2** | - | - | - | 2 | - | - | 2 | **2** |
| **Indeterminable** | **2** | - | 2 | - | 2 | 1 | - | 2 | **2** |
| **Indeterminate** | **11** | - | 3 | - | 9 | 6 | - | 8 | **8** |
| **Total** | **100** | **2** | **22** | **1** | **81** | **11** | **15** | **94** | **94** |

In a general context, due to poor conservation of the charcoal where diagenesis did not allow the anatomical features to be viewed correctly. In two fragments (Indeterminable) from PR1 it was not possible to identify the species. In eleven fragments (Indeterminate) it was not possible to see any anatomical features due to the strong presence of vitrification (TABLE 6.8).

The alteration present in most of the set analyzed was the inclusion of minerals (post-depositional alteration), identified in 94 fragments. The second most obvious alteration is the diagenesis of the fragments due to the combustion change. 81 fragments were identified with the cell structure damaged, in 15 fragments cracks were observed and eleven fragments were vitrified. As for the alterations by microorganisms 22 fragments were observed with cell decay and just one fragment with an orifice. Finally, the less frequent alteration has to do with changes in the morphological characteristics such as knots present (two fragments).

**Praia da Rocha 14 (PR14)**

In PR14 of the 100 fragments selected and analyzed, two different taxa were identified (TABLE 6.9). The most representative taxon is, *Euclea* cf. *natalensis*, with 75 fragments. This is followed by only three fragments identified as *Catunaregam* cf. *obovata*. In five fragments (Indeterminable) it was not possible to identify the species due to poor conservation of the diagenesis that did not allow anatomical features to be viewed correctly and in 17 fragments (Indeterminate) it was not possible to see any anatomical features due to the strong presence of vitrification.

**Table 6.9**

**Charcoal analysis from PR14 – Taxonomy**

| **Taxon** | |
|---|---|
| *Catunaregam* cf. *obovata* | 3 |
| *Euclea* cf. *natalensis* | 75 |
| **Indeterminable** | 5 |
| **Indeterminate** | 17 |
| **Number of taxa** | **2** |
| **Total** | **100** |

In PR14 the alteration present in almost all the analyzed charcoal fragments was mineral inclusion (post-depositional alteration) with 86 fragments (TABLE 6.10). The second most common alteration is the combustion change causing cracks (44 fragments), vitrification (27 fragments), and 20 fragments with damaged cell structure. As for the alterations by microorganisms 38 fragments were identified with decay and just three fragments with an orifice. Finally, this set has no anatomical morphological changes such as the presence of knots.

**Table 6.10**

**Charcoal analysis from PR14 – Taphonomy**

| | | **Morphologycal Characteristics** | **Change by Microorganisms** | | **Combustion Change** | | | **Post-depositional** | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Catunaregam* cf. *obovata* | **3** | - | 2 | - | - | - | - | 3 | **3** |
| *Euclea* cf. *natalensis* | **75** | - | 27 | 2 | 15 | 18 | 34 | 63 | **63** |
| **Indeterminable** | **5** | - | 3 | 1 | 4 | 4 | 4 | 4 | **4** |
| **Indeterminate** | **17** | - | 6 | - | 1 | 5 | 6 | 16 | **16** |
| **Total** | **100** | - | **38** | **3** | **20** | **27** | **44** | **86** | **86** |

**Praia da Rocha 15 (PR15)**

In PR15 the total fragments collected (35 fragments) were analyzed and five different taxa were identified (TABLE 6.11). The most representative taxa are *Euclea* cf. *natalensis,* with 13 fragments identified followed by eight fragments of cff. *Avicennia marina*. The third most frequent taxa are *Brachylaena* cf. *discolor* (seven fragments). This is followed by only four fragments identified as *Diospyros* cf. *natalensis* and one fragment as *Mystroxylon aethiopicum*. Only two fragments were identified as Indeterminable and Indeterminate. In PR15, all fragments analyzed (35 fragments) present some morpho-anatomical or taphonomic alteration. During the identification, four types of alterations were identified.

**Table 6.11**
**Charcoal analysis from PR15 – Taxonomy**

| **Taxon** | |
|---|---|
| cff. *Avicennia marina* | 8 |
| *Brachylaena* cf. *discolor* | 7 |
| *Diospyros* cf. *natalensis* | 4 |
| *Euclea* cf. *natalensis* | 13 |
| *Mystroxylon aethiopicum* | 1 |
| **Indeterminable** | 1 |
| **Indeterminate** | 1 |
| **Number of taxa** | **5** |
| **Total** | **35** |

Combustion change is the alteration more visible and 35 fragments present evidence of damage by diagenesis and with cracks from the combustion process (TABLE 6.12). In this set just four fragments have been identified with some presence of vitrification. Follows post-depositional changes, 34 fragments have mineral inclusion. In seven fragments It was identified orifices in the diagenesis and in just one fragment cells decay, changes caused by microorganisms. Lastly, in six fragments the formation of knots can be observed, showing a morphological characteristic.

**Table 6.12**

**Charcoal analysis from PR15 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| cff. *Avicennia marina* | **8** | - | - | 1 | 8 | 1 | 8 | **7** | **8** |
| *Brachylaena* cf. *disc*olor | **7** | 3 | - | 1 | 7 | 1 | 7 | **7** | **7** |
| *Diospyros* cf. *natalensis* | **4** | - | - | 1 | 4 | - | 4 | **4** | **4** |
| *Euclea* cf. *natalensis* | **13** | 2 | 1 | 3 | 13 | 2 | 13 | **13** | **13** |
| *Mystroxylon aethiopicum* | **1** | - | - | - | 1 | - | 1 | **1** | **1** |
| **Indeterminable** | **1** | - | - | 1 | 1 | 1 | 1 | **1** | **1** |
| **Indeterminate** | **1** | 1 | - | - | 1 | - | 1 | **1** | **1** |
| **Total** | **35** | **6** | **1** | **7** | **35** | **5** | **35** | **34** | **35** |

## Praia da Rocha 4 (PR4)

In PR4 the total number of fragments collected (40 fragments) were analyzed and two different taxa were identified (TABLE 6.13). The most representative taxa are *Euclea* cf. *natalensis,* with 26 fragments identified, followed by four fragments of *Bauhinia* sp., six fragments were identified as Indeterminable and four fragments as Indeterminate.

**Table 6.13**

**Charcoal analysis from PR4 – Taxonomy**

| **Taxon** | |
|---|---|
| *Bauhinia* sp. | 4 |
| *Euclea* cf. *natalensis* | 26 |
| **Indeterminable** | 6 |
| **Indeterminate** | 4 |
| **Number of taxa** | **2** |
| **Total** | **40** |

The alteration present in 38 charcoal identified fragments was post-depositional mineral inclusion (TABLE 6.14). The second alteration most present, due to the combustion change, was the diagenesis of the fragments. 38 fragments were identified with cell structure damage, in 36 fragments the presence of vitrification and in 15 fragments the presence of cracks were observed. As for the alterations by microorganisms only two fragments were identified with cell decay and others two fragments with the presence of knots (morphological characteristics).

**Table 6.14**

**Charcoal analysis from PR4 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Bauhinia* sp. | **4** | - | - | - | 4 | 4 | 1 | 4 | **4** |
| *Euclea* cf. *natalensis* | **26** | 2 | 2 | - | 26 | 26 | 11 | 26 | **26** |
| **Indeterminable** | **6** | - | - | - | 5 | 4 | 2 | 5 | **5** |
| **Indeterminate** | **4** | - | - | - | 3 | 2 | 1 | 3 | **3** |
| **Total** | **40** | **2** | **2** | - | **38** | **36** | **15** | **38** | **38** |

**Praia da Rocha 7 (PR7)**

In PR7 the total number of fragments collected (40 fragments) were analyzed and two different taxa were identified (TABLE 6.15). With approximately the same representation, the taxa *Euclea* cf. *natalensis* has 20 fragments identified and *Catunaregam* cf. *obovata* 19 fragments. Only one fragment was identified as Indeterminate.

**Table 6.15**

**Charcoal analysis from PR7 – Taxonomy**

| **Taxon** | |
|---|---|
| *Catunaregam* cf. *spinosa* | 19 |
| *Euclea* cf. *natalensis* | 20 |
| **Indeterminate** | 1 |
| **Number of taxa** | **2** |
| **Total** | **40** |

The alteration present in the charcoal set was mineral inclusion (post-depositional alteration) with 40 identified fragments (TABLE 6.16). Due to the combustion change the second alteration most present is diagenesis, with 40 fragments were identified with the cell structure damaged and with the presence of vitrification. Only eight fragments have cracks present. Five fragments showed evidence of microorganism action with the presence of orifices.

**Table 6.16**

**Charcoal analysis from PR7 – Taphonomy**

| | | Morphologycal Characteristics | Change by Microorganisms | | Combustion Change | | | Post-depositional | |
|---|---|---|---|---|---|---|---|---|---|
| **Taxon** | **Nº of studied fragments** | **Knot** | **Cells Decay** | **Hole** | **Diagenesis** | **Vitrification** | **Cracks** | **Mineral Inclusion** | **Nº of alterated fragments** |
| *Catunaregam* cf. *spinosa* | **19** | - | - | 2 | 19 | 19 | 3 | 19 | **19** |
| *Euclea* cf. *natalensis* | **20** | - | - | 3 | 20 | 20 | 4 | 20 | **20** |
| **Indeterminate** | **1** | - | - | - | 1 | 1 | 1 | 1 | **1** |
| **Total** | **40** | - | - | **5** | **40** | **40** | **8** | **40** | **40** |

# 7. Discussion

The discussion of the results obtained with the anthracological analysis concerning the shell-middens of Praia do Tofo and Praia da Rocha are presented as follows: 1) interpretation and context of the anthracological analysis, 2) community interaction with the surrounding landscape and 3) fuel wood management and acquisition .

## 7.1 - Interpretation and context of the anthracological analysis

The anthracological analysis presented here comes from seven open-air shell-middens which are located on the coast of the Inhambane municipality. The analysis revealed the use of eleven taxa that were chosen by these late farming communities, around 300 years ago, that provided wood resources to carry out their tasks. The taxonomic list of species that would be exploited from Inhambane's landscape is as follows: a mangrove tree (cff. *Avicennia marina),* a shrub *(Bauhinia* sp.)*,* trees (cff. *Harpephyllum*.*, Combretum* sp*, Burkea* cf. *africana*, *Diospyros* cf. *natalensis, Ekebergia* cf. *capensis, Mystroxylon aethiopicum*) and shrubs or small trees (*Brachylaena* cf. *discolor, Catunaregam* cf. *spinosa* and *Euclea* cf. *natalensis*).

The anthracological record collected derives from two types of deposition, 1) those associated with specific activities called concentrated charcoals and 2) those scattered in the sediment, probably by some transport and showing the results from various activities. This way, concentrated charcoal refers to fragments that are in primary position (*in situ*), where combustion activities took place (*e.g.*, fireplace, burial), which could have a social or economic nature (Allué, 2002; Bentsen, 2013, 2014; Chabal, 1992, 1997; Monteiro, 2017; Thiébault, 1988; Théry-Parisot, 1998; Piqué & Huerta, 1999). Scattered charcoal is related to secondary depositions. They are charcoal accumulations that are not associated with a structure and result from the cleaning and transport of the original combustion location. These charcoal fragments are considered the result of various activities over time, having been cleared and further dispersed by natural or anthropogenic agents (Bentsen, 2013, 2014; Chabal, 1992, 1997; Thiébault, 1998).

According to the context from which the charcoal was taken, thus, it is possible to make different interpretations. Some authors consider that concentrated charcoals are important for paleoethnobotanical or paleoeconomic interpretations of the use of fire as they are associated with a specific functional context, important to infer about the type of paleoethnobotanic activities, including collection (Allué, 2002; Bentsen, 2013, 2014; Chabal, 1992, 1997; Monteiro, 2017; Piqué & Huerta, 1999; Prior & Price, 1985; Scholtz, 1986, Thiébault, 1988; Théry-Parisot, 1998; Tusenius, 1989). In turn, dispersed charcoal is more suitable for paleoenvironmental studies (Badal, 1992; Chabal, 1992, 1997; Chikumbirike, 2014; Chikumbirike *et al.*, 2016; Ekblom *et al.*, 2014; February, 1990, 1994; House & Bamford, 2019; Mazel, 1990; Smart & Hoffman, 1988), although important to know the surrounding landscape of the study area.

**Praia do Tofo and Praia da Rocha**

In Tofo 1 and Tofo 2 some charcoal specimens were exposed on the surface while others were collected in a stratigraphic natural cut. Both types were in the dune zone. Although no excavation has been carried out in the shell-midden Tofo 1, the two Hearths identified *in situ*, allow one to assign a probable domestic function at the site. Not far from the two hearths, an agglomeration of shells mixed with some scattered charcoal debris, designated as Shell Sector, leads one to think that this was a trash zone (Bentsen, 2013, 2014). The charcoal was possibly used and deposited afterwards. The Shell Sector was located in what could have been the outside limit of a shell-midden. Hearth 1 and Hearth 2 were located within the shell-midden, possibly suggesting some spatial organization of activities that occurred within the area of the shell-midden. In Tofo 2, the archaeological charcoal is probably associated with a trash zone.

Praia da Rocha differs from Praia do Tofo by the number of shell-middens identified, in a total of 15. Found along the dune coast, the macro-remains of plants were exposed (largely due to wind erosion) but limited to a small area. It is likely that after its use as a fuel, the charcoal was placed in trash zones and hence the association of the charcoal with unburned shells and some lithics. The exception is PR1 where human remains were identified on the surface. Of the five shell-middens under study, Praia da Rocha 1 has probably a funeral purpose and part of the charcoal could be associated with the burial. The remaining four (PR14, PR15, PR4 and PR7) were probably be the result of secondary deposition, due to anthropic action but also strongly influenced by the wind transport felt in coastal areas. The taxonomic diversity identified in PR15 (five taxa) compared to the number of fragments present in the shell-midden (35 fragments) may be the result of charcoals mixed by the action of the wind or simply by anthropic action.

This way, in PR1, the context of the human burial 1 probably represent a first moment as human burial (*c.* 423 – 286 BP.) and some charcoal could be associated with it. Other part of the studied charcoal could be associated to other moments of depositions and although not likely, be more recent (*c.* 304-149 BP.). In order to know if there was an association of the charcoal present there with the burial, a dispersion diagram was made indicating the location of all artefacts that were listed during excavation. FIGURE 7.1 (A and B) represents the position of all artifacts collected in PR1 and FIGURE 1.B represents the 100 charcoal fragments selected for analysis plus the taxonomic identification.

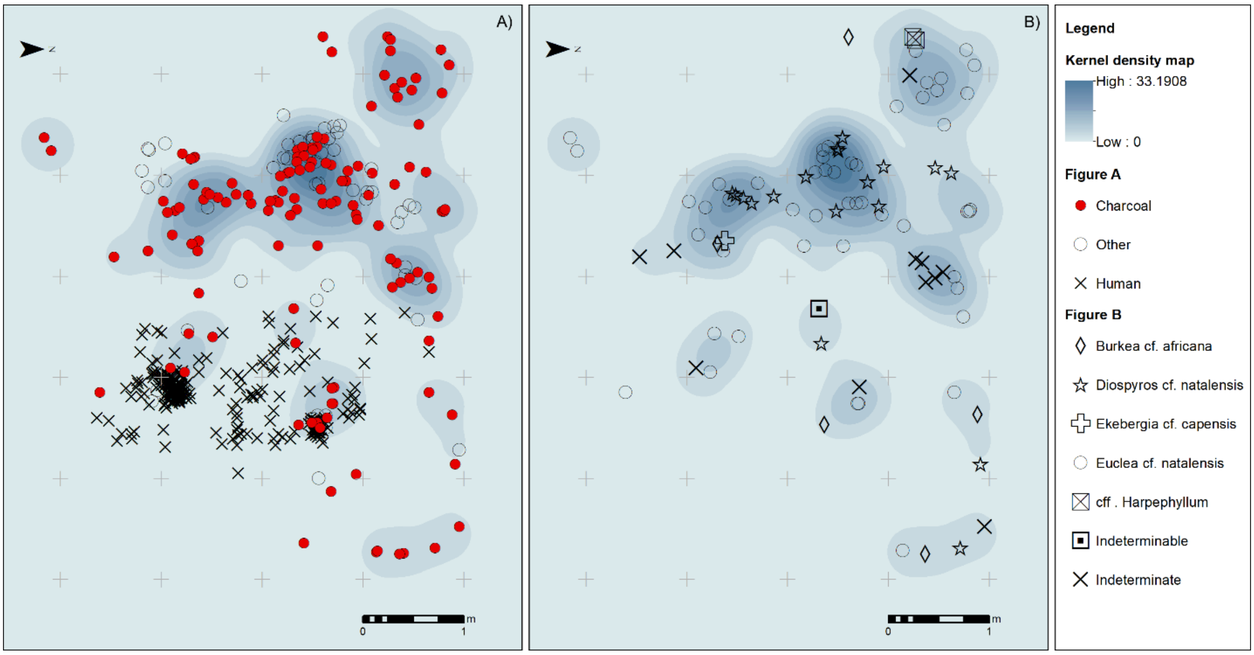



Figure 7.1 - A) Spatial distribution of all artifacts collected in PR1; B) Spatial distribution of the analyzed charcoals. Credits: Célia Gonçalves, ICArEHB.

In FIGURE 7.1A, the crosses represent the osteological remains, the red points represent all the charcoal and the circles the other artifacts found, namely, shells, and ceramics where the ceramic fragments were refitted to reveal a single large vase. However, other than the refitting, no other analysis has yet been made of ceramic pot that is associated with the burial context. This could provide more information about the context (Jeaimba, 2017). As for the anthracological remains, they have no obvious association with the burial other than the fact that most of the charcoal, including the analyzed fragments, are in the adjacent area to the osteological remains (FIGURE 7.1). The taxa identified in the context of the burial were relatively few compared to the remaining area of the shell-midden, with only three taxa identified there, *Diospyros* cf. *natalensis*, *Euclea* cf. *natalensis* and *Burkea* cf. *africana*, in addition some were unidentifiable. Thus, there may be no direct correlation between the burial and the arrangement of the identified taxa that are mixed all over the shell-midden, with no concentration zone of a specific taxon.

Most of the analyzed charcoal fragments come from surface collections, whose materials were exposed and confined to a small area. Here, the archaeological charcoal collected relates to scattered deposits. They are the result of activities and different combustion times over a period, transported after their use for trash deposits (Shell Sector, Tofo 2, PR14, PR15, PR4 and PR7). This type of occurrence of presence of charcoal in a context where there are no fire marks in the other materials may show a secondary deposition, that is, was deposited after combustion with the remaining artifacts and, this way, the combustion process took place in another location (Matias, 2016; Monteiro, 2017) . Other contexts examined (Hearth 1 and Hearth 2) may have had a specific function as a combustion feature. The charcoal specimens associated constitute concentrated charcoal, which may reflect specific or short-term activities. Finally, in addition to domestic charcoal use, some charcoal from a human burial (PR1) were also analyzed. Part of the charcoal collected there probably come from dispersed material by human action (likely a trash deposit) and some by wind transport and the concentrated charcoal from the human burial (funerary nature). This way, this shell-midden may present more than one moment of depositions and part of the anthracological presence may be associated with the burial 1.

Lastly, these shell-middens presented in this study, fall within the “Southern Mozambique Coastal Kitchen Midden Tradition” (Senna-Martinez, 1969) and are likely part of the second phase defined by Senna-Martinez (1968), related to the “First Farmer and Shepherd Communities”. The shell-middens presented here are part of the settlement system on Mozambique coast.

## 7.2 - Interaction of communities with the surrounding landscape

To corroborate the anthracological data presented in this study with the past vegetation it is important to integrate with other paleoclimatic studies that describe the climate changes occurring during the last millennium in southern Africa. Since the paleoeological reconstructions using anthracological analysis in Mozambique are still scarce, for the discussion of this chapter, other paleoclimatic proxies such as diatoms, lake sediments, phytoliths, pollen and speleothems will be presented as a complement proxy to describe the past vegetation and climatic conditions in coastal Mozambique. Paleoclimatic biomarkers and anthracological data from archaeological sites presented in Chapter 2 provide complementary information about Holocene landscape and climate changes in southern Africa.

Tyson *et al.* (2000) demonstrated two distinct events through the climate record, consisting of oxygen, carbon isotope and color density data, obtained from a well-dated stalagmite derived from Goil Air Cave in Makapansgat valley, South Africa. The climatic events are the Medieval warming event that took place from 900 to approximately 600 years ago (1000 to 1300 AD); and the Little Ice Age event from approximately 600 years BP to 100 years BP. With these results, the author correlated the data with other similar weather events that took place in other parts of the world and demonstrated that the cooling phase was a regional phenomenon of some consequence throughout the southern African subcontinent. As Tyson *et al.* (2000) mentioned: "The changes in rainfall (…) have influenced both settlement patterns and livelihoods of (…) African Iron Age agropastoral economies". Holmgren *et al.* (2003) and Lee-Thorp *et al.,* (2001) also demonstrated, through the detailed Makapansgat stalagmite record, wetter conditions in the summer rainfall areas of southern Africa during the mid-Holocene warming phase, correlating with the Medieval warming phase described by Tyson *et al.* (2000, 2002). Other researchers, notably Reinwarth *et al.* (2013) and Scott & Lee-Thorp (2005) made important contributions through pollen, geochemical and sedimentological analysis made in lakes and in archaeological contexts in South Africa for the Holocene. Once again, the paleoclimatic record seems to reinforce the idea that Holocene climate and environment in southern Africa varied on a scale regarding the last millennium, that carried significant implications for distribution of fauna, flora and for human settlement.

About the climate and landscape of the last millennium at Mozambique coast (Ekblom 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.* 2012; Norström *et al.,* 2017; Sitoe, 2017 and Sitoe *et al.,* 2017), palaeoecological data collected from several lakes allows to interpret the landscape of the past. The palaeoecological analysis made in Nhaucati, Nhauhache and Xiroche Lakes, located 7 km south of Vilankulos, in the Chibuene area in Inhambane Province, show that the coastal area 1600 years BP consisted of a mosaic of forests, Miombo woodlands and grasslands (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.,* 2012). The data also show that the area supported extensive forests in the past until about 500 to 300 years ago when the forests declined. The decline of forests appears to be temporally correlated with a prolonged period of repeated dry spells associated with the `Little Ice Age', which caused a shift in vegetation (Ekblom, 2008; Holmgren *et al.* 2012). Collected from Lake Chilau, near Inhambane, the phytolith, diatom and mineral magnetic properties in fossil sediments demonstrated temporal dynamics within grassland and Miombo woodland ecosystems in southern Mozambique during the late-Holocene period (Norström *et al.*, 2017). The paleoenvironmental record suggests that *Panicoideae* grasses and other mesophytic grasses were abundant between 700 and 600 years ago, related to the last phase of the Medieval warming phase. This is followed by an increase in drought adapted *Chloridoideae* grasses during the early phase of the Little Ice Age, around 500 to 450 years cal BP (Norström *et al.*, 2017). In the coastal lowlands of Mozambique, an expansion of savanna at the cost of forests has been attributed (in addition to anthropogenic factors), to a climatic event of relative short duration which may have caused long-lasting shifts in vegetation on the scale of centuries, as for different regions during this period in southern Africa.

The "Environmental history in Southern Africa" monograph (Sitoe *et al.,* 2017) includes a complete compilation of paleoclimates studies from lakes on the Mozambique coast and in the floodplains of lower Limpopo River. The paleoenvironmental analysis from lakes located between Xai-Xai (Gaza province) and Vilankulos (Inhambane province) reveal the climatic and landscape changes that occurred during the last millennium in southern Mozambican coast (Sitoe *et al*., 2017). Recent palaeoenvironmental studies in Mozambique (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.*, 2012; Norström *et al.*, 2017; Sitoe, 2017; Sitoe *et al.,* 2017) support the previous studies (Holmgren *et al.,* 2003; Lee-Thorp, 2001; Tyson *et al.,* 2000, 2002; Reinwarth *et al.,* 2013; Scott & Lee-Thorp, 2005), showing that the forest component of Miombo woodlands savanna in coastal Mozambique was favored by "Little Ice Age" dryness, rather than damaged by the development of agriculture and pastoralism.

The palynology from Nhaucati, Nhauhache and Xiroche lakes (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.,* 2012) which are located about 170 km north of the study area, in the Vilankulos region still on the coast of the Inhambane province, indicates the vegetation type in the landscape along the coast of Inhambane area (FIGURE 7.2). During the period between 400 to 200 cal BP, this coastal stretch was mainly represented by Miombo woodland savannah vegetation, with a large proportion of trees or shrubs (FIGURES 7.3, 7.4 and 7.5).

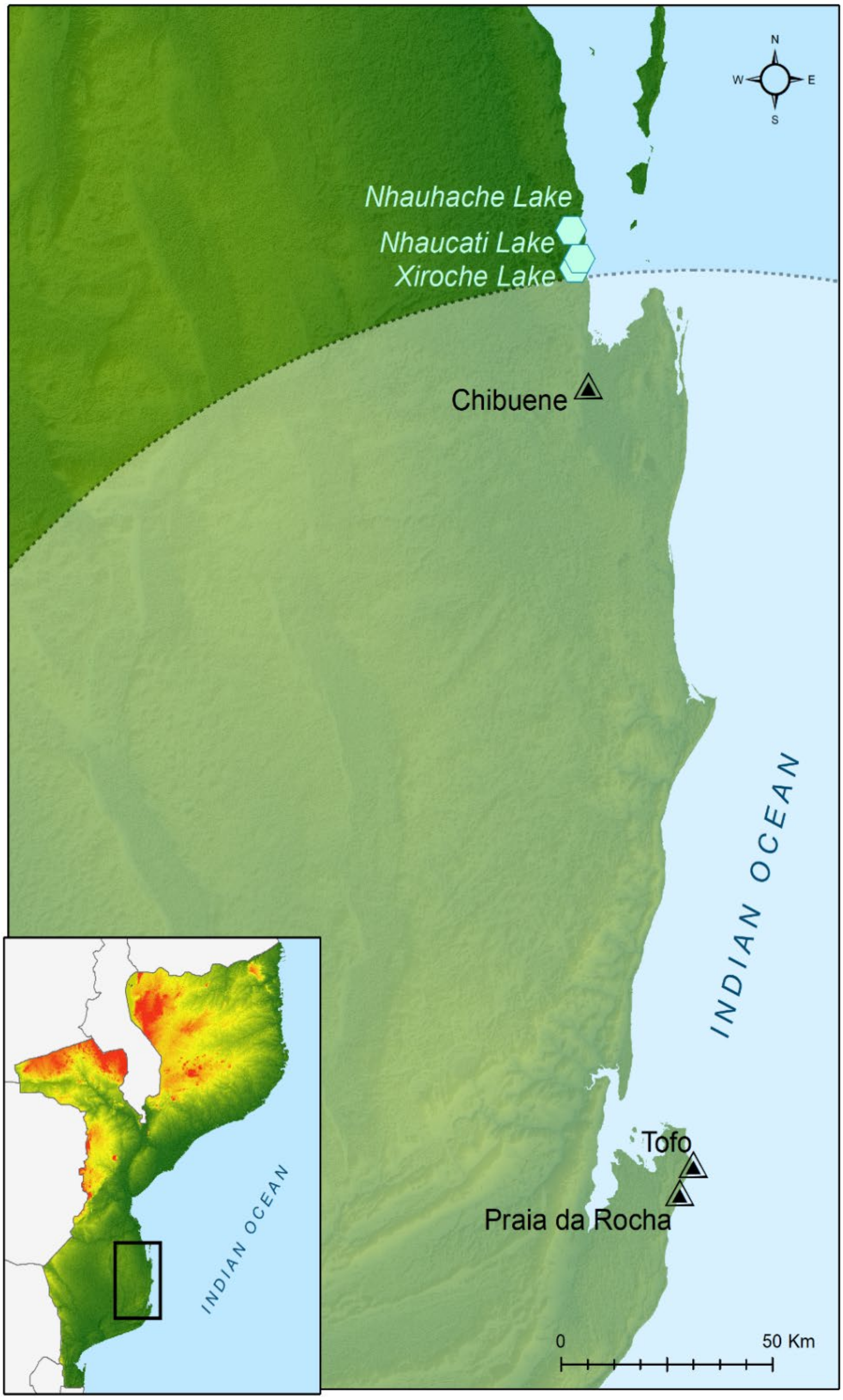



Figure 7.2 – Buffer showing the pollen spread zone (around 200km) with the location of the Archaeological sites under study and the lakes Nhauhache, Nhaucati and Xiroche with pollen analysis located about 170 km north of the study area, in the Vilankulos region. Credits: Célia Gonçalves, ICArEHB.

According to the pollen data of these three lakes, the most representative species and constant in the landscape are *Alchornea*, *Brachystegia, Cassine* – type*, Celasteraceae, Fagara*-type, *Myrtaceae*, *Phyllanthus*, *Sclerocarya*, cf. *Serophulariaceae* and cf. *Vitex.* Less representative but constant in the landscape, are the species *Acacia, Alcalypha, Brachylaena, Dialium* – type, *Grewia, Julbernardia* – type, *Myrica, Olea, Pseudolachnostylis, Rhamus, Rhus, Spirostachys,* and cf. *Peltophorum.* In much smaller representation with some vegetative oscillations, the pollen analyzes point to the presence of *Capparacaeae, Combretaceae*, *Corchurus, Crotolaria* – type*, Euclea*, *Millettia* – type*, Moraceae, Rhamnaceae, Sclerocarya, Stereospermum, Syzygium, Trema, Dirchrostachys, Uapaca* and cf. *Cordyla*, (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.,* 2012).

The pollen analysis of Ekblom (2004, 2008), Ekblom *et al.* (2014) and Holmgren *et al. (*2012), corroborated the climate and the kind of vegetation present today in the Inhambane coast. In paleoeological terms, it is pertinent to mention that all the taxa in the charcoal represented here, except for *Bauhinia* species and cff. *Harpephyllum* sp.*,* are still present in the landscape today. In this way, the hypothesis that the landscape in Inhambane study areas about 400 years BP until the present remained similar, is very likely correct.

As explained in Chapter 3, the current humid tropical climate of Inhambane municipality favors a type of vegetation characterized by open coastal forests, miombo woodland savanna, dunes shrubs and mangroves in the coastal zone. Also, riverine and gallery forests occur in the alluvial banks of the rivers and in the slopes of the lakes. These biomes provide the presence of the taxa identified in the anthracological analysis presented here and as mentioned, are present today in the Inhambane landscape, they are the mangrove tree, cff. *Avicennia marina,* species from Miombo woodland savannah, *Burkea* cf. *africana*, *Combretum* sp.*, Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis, deciduous trees,* cff. *Harpephyllum* sp.*, Ekebergia* cf. *capensis, Mystroxylon aethiopicum* and shrubs or small deciduous trees, *Brachylaena* cf. *discolor* and *Catunaregam* cf. *spinosa.* The only taxa that are not present today in the province are those identified as *Bauhinia* sp. (*Bauhinia galpinii*) and cff. *Harpephyllum* sp.*,* which is further inland in deciduous bushveld, in dry conditions, between the borders of Gaza, Inhambane and Maputo (Burrows *et al*., 2018).

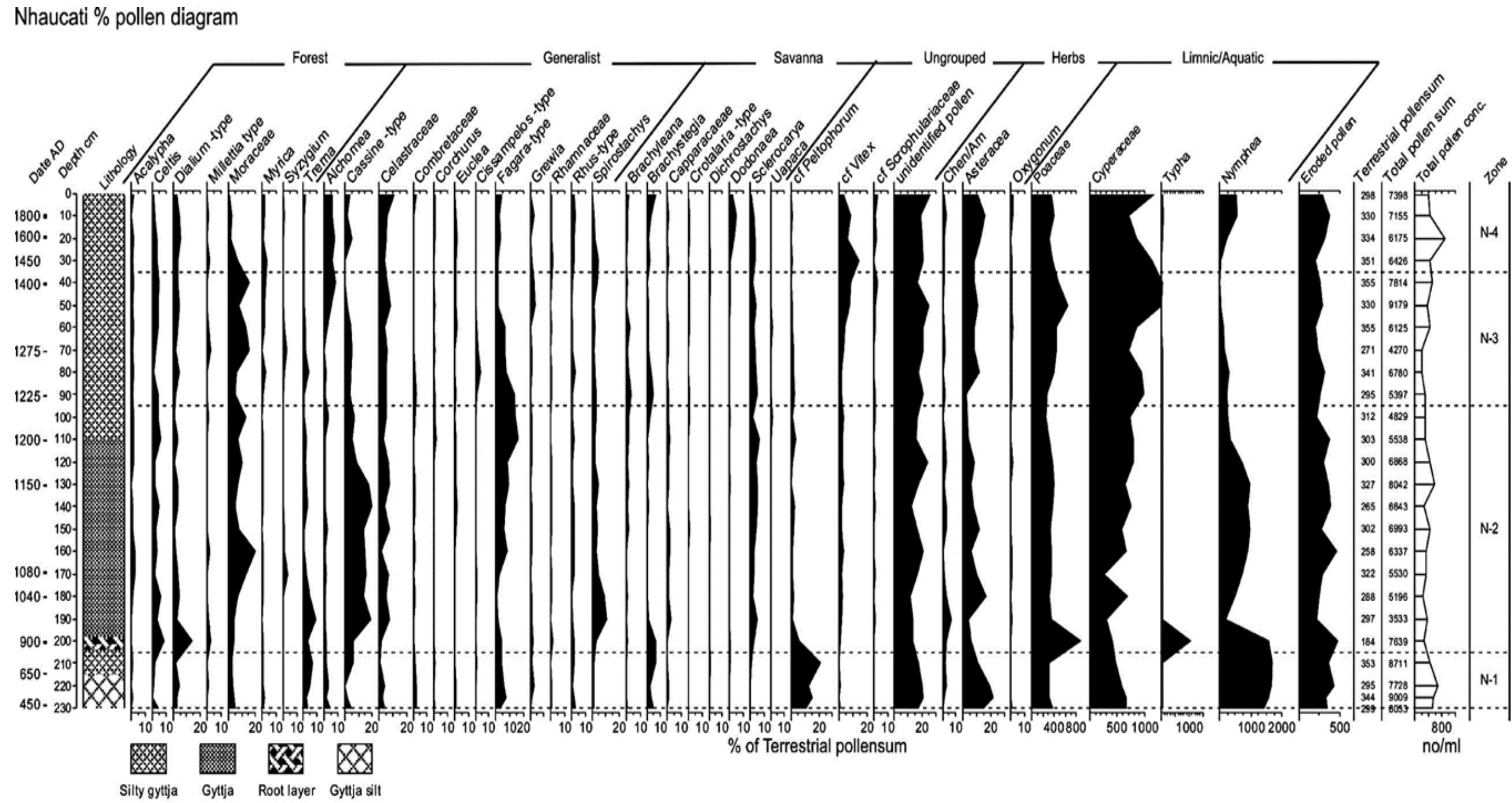



Figure 7.3 – Nhaucati Lake. Pollen diagram, with terrestrial pollen percentages grouped into arboreal types and savannah and generalist types. Credits: Ekblom *et al.*, 2014.

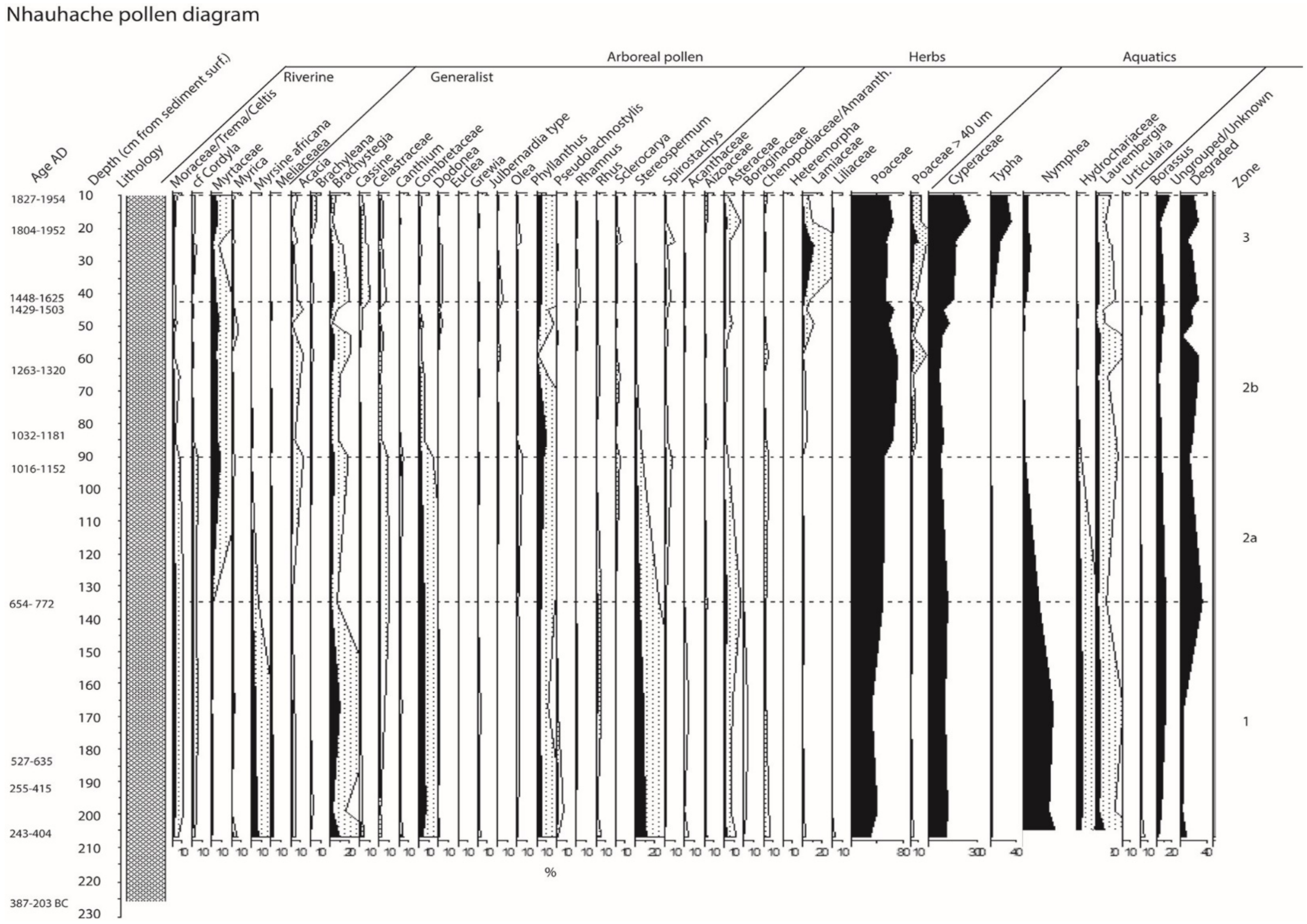



Figure 7.4 – Nhauhache Lake. Pollen diagram, with terrestrial pollen percentages grouped into arboreal types and savannah and generalist types. Credits: Ekblom *et al.*, 2014.

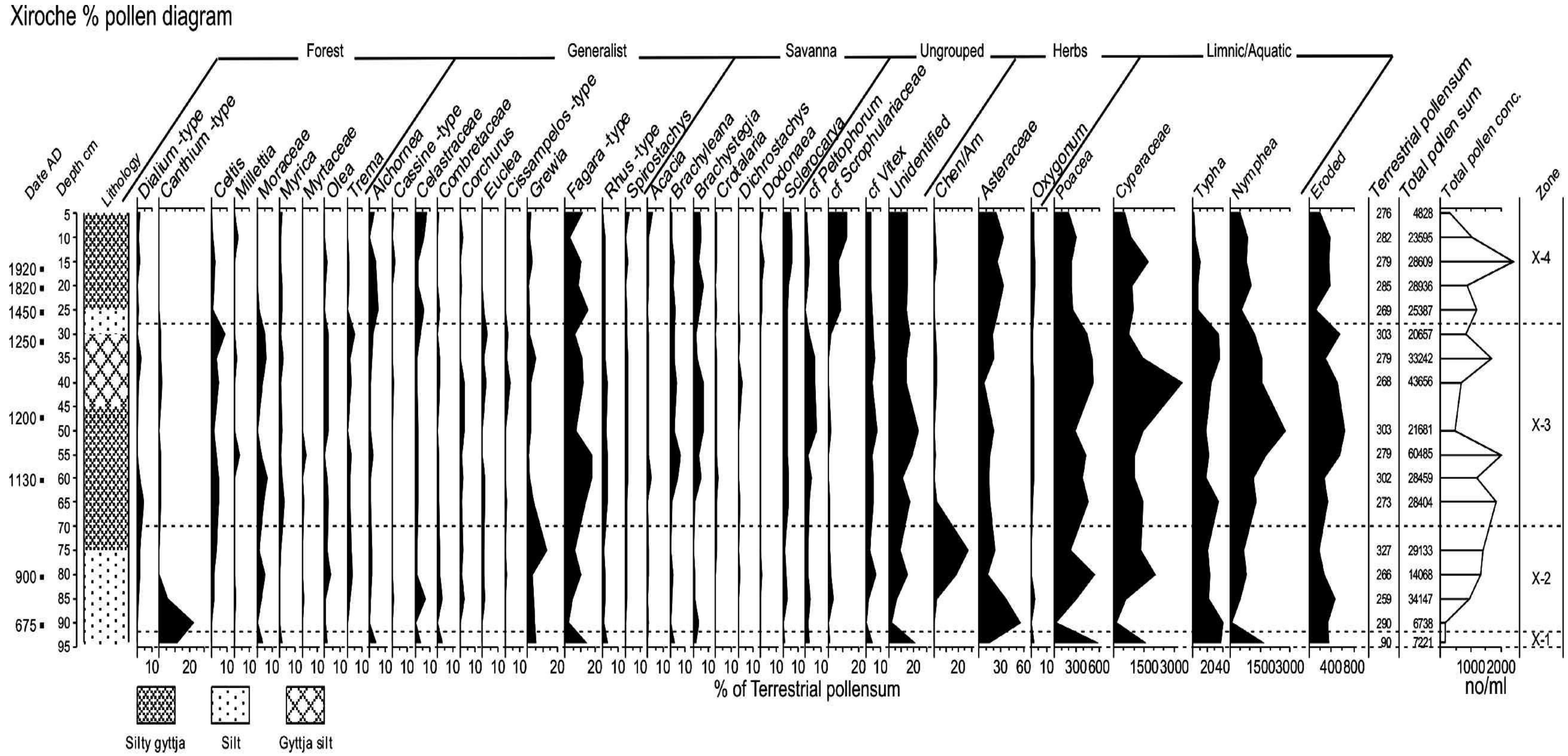



Figure 7.5 - Xiroche Lake. Pollen diagram, with terrestrial pollen percentages grouped into arboreal types and savanna and generalist type. Credits: Ekblom, 2008.

In taxonomic terms, since anthracological data have only two correlations (*Combretaceae* and *Euclea*) with the pollen record of Nhaucati, Nhauhache and Xiroche lakes (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.*, 2012), the identified taxa that are missing from the pollen record may be for different reasons. The main consideration is that the pollen register and the anthracological register have different origins. Thus, one represents a more regional reading and the other, is more local. Therefore, it allows one to consider these species as integral in the landscape, however the information is not provided by the pollen diagram. Another factor is that it could be due to the different pollination capacities of certain species, that influence pollen recordings over long distances, since the pollen diagrams do not refer to the underlying area of the shell-middens presented here. Although the pollen spectrum is spread over a circumference of about 200km, it is not fully representative of the landscape under study but it is essential to try to make inferences about the landscape, as there is still no pollen data from geological and archaeological contexts concerning the coastal zone of Inhambane Municipality (FIGURE 7.1). The results of the paleoeological studies carried out in lakes located a few kilometers off the coast of Inhambane municipality, by the InMoz Project (PTDC/HAR-ARQ/28148/2017), whose activities started in May 2019, in particular the pollen data, will be a great complement to corroborate and reinforce the presented data in this thesis.

Even without concrete pollen data for the area under study, the results obtained through anthracological analysis allow us to point out a similar relationship with the Miombo woodland savanna species present in the Vilankulos pollen diagram, especially with the presence of *Combretaceae* and *Euclea* in the landscape in the Mozambican coast since about 400 years ago. It is thought that the climate then was possibly very much like that of today in Inhambane region and thus, the ecology and environment of Late Iron Age communities present at Praia do Tofo and Praia da Rocha was likely identical to that seen presently in the region. The landscape would be perhaps characterized more by forests than by savanna, which decline was mainly due to climate change (Ekblom, 2004, 2008; Ekblom *et al.*, 2014; Holmgren *et al.,* 2012; Norström *et al.,* 2017; Sitoe, 2017) and in more recent periods accelerated by human interference. Starting about 400 years ago, the communities present in Praia do Tofo and Praia da Rocha would probably already lived in wetter conditions at today's temperatures. This hypothesis is supported by the paleoeological study carried out on Lake Chilau (Norström *et al.,* 2017), which revealed slight changes in vegetation with the end and the beginning of the Medieval warming and the Little Ice Age events occurred in the coast of Inhambane municipality.

In short, even without having carried out the complete anthracological analysis of some of the shell-middens under study (Hearth1, Hearth2, PR1 and PR14) the results obtained through the anthracological analysis allow us to point to a similar context seen in the Miombo woodland savanna species in the Vilankulos pollen diagram, especially with the presence of *Combretaceae* and *Euclea* in the landscape since about 400 years cal BP. This suggests that the surrounding landscape of Praia do Tofo and Praia da Rocha has not suffered major changes in terms of the vegetation composition, as the taxa identified remained the same over time. Plus, the scattered charcoals under study, these taxa represent the plant spectrum of the past. They are considered by some authors as useful tools for paleoenvironmental reconstructions (Chabal, 1991; Chabal *et al*., 1999, Vernet, 1973), both from the perspective of the evolution of a particular species over time (Figueiral & Terral, 2002), as well as, the characterization of the landscape during different climatic periods (Figueiral & Mosbrugerer, 2000).

### 7.3 - Fuel wood management and acquisition

The various functionalities of wood (protection, lighting, heating, cooking, wood tools, others activities) lead to the recollection of wood for fuel, would have been one of the daily activities of older societies (Bentsen, 2013; Carruso Fermé, 2012; Théry-Parisot, 2001). Thus, the way raw materials are managed (specifically the wood plant resources), through different acquisition strategies and types of use, are a good social and economic complexity indicator.

The question of mobility as several researchers have shown (Allott 2006; Bentsen, 2014; Binford, 1980; Cartwright & Parkington 1997; Cowling *et al*. 1999; Carruso Fermé, 2012; Monteiro, 2017; Théry-Parisot *et al.,* 2010) for woody resources is very important, especially in prehistoric hunter-gatherer societies. According to Shackleton & Prins (1992) the collection of woody resources is based on the "*Principle of least effort"*, that is, the least energy lost during the collecting phase. It is an exploration based on the most abundant and available local species and, thus, the environmental factor tends to determine the species exploited. Nevertheless, Hill *et al.* 1987 stated that the plants are not a static resource. Plant formations may vary from niche to niche, and, over time, and these variations can have profound implications for the mobility of communities and their strategies for exploiting landscape.

For the Iron Age period, as shown by many investigators, the communities have a most complex management and acquisition of the fuel wood. As mentioned by Chikumbirike *et al.*

(2016), the function of the settlement is most complex and can also dictate the gathering of the type of woody material. In the Great Zimbabwe Complex, Chikumbirike *et al*. (2016) proposes that fuel wood for domestic cooking and warming was different from wood used for industrial and construction purposes.

In addition to being influenced by the "*Principle of least effort"* (Shackleton & Prins, 1992) the state of wood (dead or mature wood and green wood) and the physicochemical properties of certain woods may be a selection factor for woody material. For example, dead wood can be obtained from branches fallen to the ground and green wood will have to be collected from the tree (Monteiro, 2017). That way, it is important to note that the wood dimensions and diameter may vary with the combustion properties of each species (Chabal *et al*., 1999; Théry-Parisot, 1998; Caruso Fermé, 2012; Monteiro, 2017). The relevance of these questions leads to the development of comparative and experimental studies to related taphonomic changes in the charcoal, allowing one to identify some discrimination that may be caused by the state of the wood before or during combustion.

The results obtained in the present analyses, will contribute to a deeper understanding of the fuel wood management and acquisition of the late farming communities in the coast of Inhambane, as well as to infer the kind of function that the species identified in this study could have had, further supported by taphonomic analysis. Finally, the last point of the discussion will be divided into two parts, 1) characterization of wood acquisition and fuel use mobilities and 2) contribution of the taphonomic changes.

### 7.3.1 - Characterization of wood acquisition and fuel use mobilities

The importance of the firewood for non-technological developed populations is well known (Bentsen, 2013; Esterhuysen, 1996; Marguerie & Hunot, 2007; Scholtz, 1986) and its importance for community contexts can be gauged by the fact that the proximity of a supply of firewood is important in deciding the location of the campsite. This way, considerable amounts of firewood are used, but the effort required to procure the firewood differs according to the environment and the pressure on the resources.

As mentioned before, the shell-middens under study in the Inhambane coast are strategically well located in a landscape with a variety of resources available, rich in mollusks, terrestrial fauna, and flora. All taxa identified in this study, except *Bauhinia* sp. (*Bauhinia galpinii*) and cff. *Harpephyllum* sp., are found today in the Inhambane landscape (TABLE 7.1). These are species of humid tropical climate, which mostly dwell in coastal, bushveld, savanna woodland, and in dunes, thickets and mangrove.

It is pertinent, thus, to mention that the occurrence of charcoal in the shell-middens depends of the transport of the wood onto them, not just for fuel, but also for use in construction as well as the production of wooden artifacts. In terms of combustion, they may select quite different species for uses as fuel, because of availability, durability, ease of reduction to small pieces or relative production of heat (Bentsen, 2013; Chikumbirike, 2014; Chikumbirike *et al*., 2016; Fern, 2014; Lennox *et al.*, 2015). Also, certain taxa may have had edible, economic, medicinal, or cultural purposes (TABLE 7.1). The possibility of collecting dead or green wood and taking advantage of fruits, cork, leaves, roots and flowers for specific purposes should be considered and despite the variety of uses a species may have, is clear that the wood can be re-used and its final use is often as fuel.

Combining data from ethnographic, paleoecological, anthracological studies (Allott, 2004, 2005, 2006; Bamford, 2015a.b; Bentsen, 2013, 2014; Burrows *et al*., 2018; Chikumbirike, 2014; Chikumbirike *et al*., 2016; Ekblom *et al.,* 2012; Fern, 2014; Hardwick, 2013; Lennox *et al.,* 2015, Lennox & Bamford, 2017; Prior & Price, 1985) and with online plant databases (Fern, 2014; Jodamus, 2003), there are several utilities that could have had the woody species exploited by these communities. TABLE 7.1 shows the possible function of each taxon identified in this study, allowing one to infer the wood acquisition mobilities and several activities possibly performed.

**Table 7.1**

**General list of anthracological species identified at Praia do Tofo e Praia da Rocha: Description, habitat and uses**

| FAMILY/ SPECIE/ COMMON NAME | MOZAMBIQUE REGION | DESCRIPTION | HABITAT | USES | REFERENCES |
|---|---|---|---|---|---|
| **ACANTHACEAE**<br>*Avicennia Marina*<br>(White mangrove) | Prsent in Inhambane | Evergreen shrub or small tree with an open branched, usually growing 1 - 10 meters tall and develops roots with many vertical breathing roots above soil level | Species of mangrove tree occurring in the intertidal zones of estuarine areas | Diet, economic firewood and medicinal uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **ANARCADIACEA**<br>*Harpephyllum caffrum*<br>(Wild plum) | Maputo Province, not present in Inhambane Province) | Medium to large evergreen tree to 25 m tall | Costal forest and scattered in riverine forest along the Lebombo Mts | Diet use | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **ASTERACEAE**<br>*Brachylaena discolor*<br>*(*Coast silver-oak) | From the Eastern Cape along the eastern coast of South Africa to Southern Mozambique (Present in Inhambane Province) | Evergreen shrub or tree, -10 m tall. Single or multi-stemmed tree. The trunk reaches 45 cm in diameter | Coastal forest and woodland, or dune thicket | Diet, Medicinal and economic uses | Burrows *et al*., 2018; Lennox, 2017; Van Wyk & Van Wyk, 2013 |
| **CELASTERACEAE**<br>*Mystroxylon aethiopicum*<br>(Bushveld koobooberry) | Southern parts of the Western and Eastern Cape | This is a small to medium-sized tree that may grow up to 12 m tall | Bushveld, forest margins, evergreen forests, and open woodland, riverine fringes | Diet, economic, firewood and Medicinal uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **COMBRETACEAE**<br>*Combretum apiculatum* subsp. *apiculatum*<br>(Red Bushwillow) | Mozambique north to tropical Africa (present in Inhambane province, in Vilankulos area) | Small deciduous tree, 3-9 m tall | Widespread in deciduous mixed woodland | Economic and firewood uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |

| | | | | | |
|---|---|---|---|---|---|
| *Combretum hereroense var. hereroense*<br><br>(Russet Bushwillow) | Mozambique to tropical Africa (present in Inhambane province) | Small deciduous tree, 3-5 m tall | Dense to open woodland types | Diet, economic, medicinal and cultural uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| *Combretum zeyheri*<br><br>(Large-frutted bushwillow) | Mozambique to tropical Africa (present in Inhambane province more inland close to Maputo Province) | Small to medium-sized deciduous tree to 10 m tall | Open woodland types, rocky hillsides and along rivers | Economic and medicinal uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **EBANACEAE** | | | | | |
| *Diospyros natalensis*<br><br>(Acorn Jackalberry) | South tropical Mozambique (Present in Inhambane Province) | Shrub or small tree up -10m<br><br>in height | Dune scrub or dune forest along the coast. | Diet, medicinal and cultural uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| *Euclea natalensis*<br><br>(Hairy guarri) | Northeastern parts of South Africa, through Mozambique (Present in Inhambane Province) | Evergreen shrub or small tree, up to 10 m high | In a wide variety of mixed woodland habitats, usually associated with dense thickets or riverine areas | Economic , medicinal and cultural uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **LEGUMINOSAE CAESALPINOIDEAE** | | | | | |
| *Bauhinia. galpinii*<br><br>(Red Bauhinia) | From South Africa into Mozambique and Zimbabwe (Absent in Inhambane province) | Scrambling shrub or small tree to 5 m | Across the moister bushveld areas of the country | Cultural uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| *Bauhinia burrowsii*<br><br>(Manyikeni Bauhinia) | Known only from Inhambane Province, in Vilankulos Municipality, Mozambique | Shrub to 5 m high | In mixed open coastal woodland and thicket mosaic on sands | - | Burrows *et al*., 2018 |
| *Burkea africana*<br><br>(Wild seringa) | Tropical Africa and in sub-tropical regions | Deciduous, medium-sized, spreading, flat- | Deciduous bushveld and woodlands | Diet, medicinal, firewood and | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |

| | | | | | |
|---|---|---|---|---|---|
| | | topped tree up to 15 m tall | | economic uses | |
| **MELIACEAE**<br>*Ekebergia capensis*<br>(Cape ash) | Eastern Cape of South Africa (Present in Inhambane Province) | large evergreen tree that grows to about 15 m in height | Different habitats: high altitude evergreen forests, riverine forests, and sea level | Diet, medicinal and cultural uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |
| **RUBIACEAE**<br>*Catunaregam obovata*<br>*(*Coastal bone-apple**)** | Southern Mozambique (Present in Inhambane Province) | Deciduous shrub, 2-6 m high | Costal thicket and woodland, or in dune scrub | Diet and medicinal uses | Burrows *et al*., 2018; Van Wyk & Van Wyk, 2013 |

**Economy and exploitation of woody resources**

As mentioned, the most represented and present taxa in all the shell-middens studied in Praia do Tofo and Praia da Rocha are *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis*. The combination of these two taxa seems to represent a pattern of utilization of wood mostly chosen as fuel over others. Since most of the charcoal analyzed comes from secondary deposits, containing scattered charcoals where these two taxa are the most representative, it is considered that the collection by these communities and the continued presence of *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis* in the archaeological records may be due to factors such as the strong nature of these species in the landscape, a preferential choice or the very quality of the wood. Hence, it should always be  in one's mind that although certain species were not present in the anthracological assemblage, they could in fact have been collected, but are not in the archaeological record due to the properties or quality of the wood and taphonomic processes that would turn to ash if the fire had more heat intensity (Bentsen, 2014).

However, what are the mobilities for acquisition and use of wood related to the identified taxa? Have these mostly been collected for their combustion quality or are these also present for being reused for fuel after having some domestic, economic or cultural functionality? Below is a discussion of the eleven taxa identified:

*Avicennia marina* grows a few kilometers from the archaeological sites under study. It is a species found in Inhambane Bay where the mangroves form. Inhambane mangrove originates on the shores of Inhambane Bay and extends for about 45km north towards Maputo. The eastern margin of the mangrove on the main road to Inhambane remains about 6 to 8 km to Praia do Tofo and Praia da Rocha. There, the predominant vegetation in the surroundings of the mangroves are the coconut trees and the fruit trees. Still on sandy soils there are *Momordica balsamina* (cacana) and *Manihot esculenta* (cassava) on vegetable gardens, as well as medicinal plants such as *Catharanthus roseus*. In the mud of the mangrove flourishes herbaceous vegetation and grass species of the *Poaceae* and *Cyperaceae* family that predominate. Of interest is that inside the mangrove are fishing activities (channels are built to catch fish trapped in basins). Two types of halophyte vegetation are dominant, *Sonneratia alba* and *Avicennia marina*. Cooked seeds of *Avicennia marina* are edible, the resin, leaf and bark are used for medicinal purposes and the wood is also used as firewood and for charcoal production. The smoke of burning wood is considered efficient as a mosquito repellent (Fern, 2014).

In southern Mozambique only two species of *Bauhinia* are present, *Baunhinia galpinii* and *Bauhinia burrowsii.* The first one is present in Maputo province and *Bauhinia burrowsii* occurs in Vilankulos municipality (Burrows *et al*., 2018). It should be noted that it was not possible to compare the sample with the species *Bauhinia burrowsii* because no microphotographs of the anatomical structure of that species is available. As mentioned, the anatomical structure of that specimen is not very clear due to taphonomic processes and needs to be better documented to enable interpretations about mobility and functionality of the wood. Little information about the uses of these two genera are available. *Bauhinia galpinii* was identified in charcoal in layer MOD dated to ~49ka from Sibudu (Lennox *et al*. 2015)

*Brachylaena discolor* is a shrub or small tree occurring in coastal bushveld. Present in the coast of Inhambane Municipality today, it flourishes from Maputo to the Vilankulos coast (Burrows, *et al*., 2018). This taxon has mainly economic and medicinal uses. The wood is used for construction purposes as boats, roofs and the branches can be used to fish. The leaves are used by some communities for medicinal purposes (Jodamus, 2003). Some anthracological works identified this taxon in archaeological contexts. Chikumbirike (2014) demonstrated that in Great Zimbabwe, some archaeological sites will have different functions for wood management. Presence / absence of some species in the archaeological sites delineate patterns of wood utilization. Of the various archaeological contexts present in Great Zimbabwe *Brachylaena discolor* has only been identified in one area, Barrier Hut. The author explains that probably that wood was "associated with the activities that took place in the hut or used in the construction of the hut itself" (Chikumbirike, 2014). In Chibuene area, more specifically in the Xiroche lake, the pollen diagram (Ekblom, *et al*., 2014) shows the presence of that species over the period 700 to 550 (1200 to 1450 AD) in the landscape. In hearths from Sibudu cave in South Africa, Lennox & Bamford (2017) identified *Brachylaena discolor* in the archaeological charcoal assemblage, showing that the taxon was collected as a useful firewood.

*Burkea africana* is a tree which dwells in various types of woodlands and bushveld often in deep sandy soils (Burrows *et al*., 2018). This vegetation can occur together with stands of *Combretum apiculatum* (Ekblom *et al*., 2012). This tree is present in all the coast of Inhambane province. It is mostly recognized for having multiple uses in medicine and construction (Chikumbirike, 2014; Chikumbirike *et al*., 2016; Fern, 2014, Lennox *et al.,* 2015). In edible terms, the gum produced from the stem and leaves is cooked as a vegetable. The bark, roots and leaves are commonly used in traditional medicine. Lastly, as the wood is hard, heavy, and durable it makes a good fuel and charcoal (Fern, 2014). Lennox *et al.* (2015) identified this species in Hearth 3 in layer MOD ~49ka from Sibudu cave, explaining that is a fuel wood associated with hot fires. As shown by Chikumbirike (2014; Chikumbirike *et al*., 2016), *Burkea africana* has been used commonly in metallurgical processing.

*Catunaregam obovata* are present today on the coast of the municipality of Inhambane in thickets or forest at stream sides (Burrows *et al*., 2018). Little information is available about the uses of this species. *Catunaregam obovata*, is a tree mainly used for edible uses. The cooked fruit is edible and in medicinal terms, it is common to use fruits, bark, roots and seeds (Fern, 2014).

*Combretum* spp. are trees commonly known as bushwillow, that have a variety of uses as edible, economic, medicinal, and culturally useful wood. *Combretum apiculatum* is a semi-deciduous tree flourishing in dry savanna and savanna woodland, especially in rocky places. Today it is mostly present in Vilankulos coast (Bamford, 2015a.b; Burrows *et al*., 2018; Prior & Price, 1985). This species has mainly economic and cultural purposes. In terms of economic uses, this species has properties required for smelting, because it is hard, burns slowly and retains heat for a long time (Chikumbirike, 2014; Chikumbirike *et al*., 2016; Fern, 2014; House & Bamford, 2019). For the cultural uses associated of that taxon, Hardwick (2013) in a PhD dissertation explains possible kinds of uses of archaeobotanical remains from sites in Limpopo province, South Africa. As he mentions, *Combretum apiculatum* is used in ceremonies, at funerals, or as a charm. *Combretum zehery* dwells in savannah woodland of *Brachystegia-Julbernardia*, dry forest, and woodland (Burrows *et al*., 2018; Fern, 2014), presently occurring in dry bushveld between Maputo, Gaza and Inhambane borders (Burrows *et al*., 2018). *Combretum zeyheri* is a deciduous shrub or tree having medicinal, economic (Fern, 2014) and cultural purposes. Bark and roots are used for medicine. The roots can be used to make shoes and it is also used by the *Inwala* community for ceremonial and funerary purposes (Hardwick, 2013). Last, *Combretum hereroense* is present today in the coast of Inhambane municipality. This is a deciduous shrub flourishing in mixed open or savannah woodland (Burrow *et al.*, 2018) with a variety of edible, medicinal and cultural purposes. The fruits and leaves are edible, the roots are used for medicine and the branches are used by traditional healers during healing ceremonies (Fern, 2014).

*Diospyros natalensis* is an evergreen, small tree typical in dune scrub or dune forest along the coast and present today on the coast of the Inhambane municipality (Burrow *et al*., 2018). Little information is available for that taxon, most *Diospyros* species produce edible fruits (Hardwick, 2013) and leaves have been used to a variety of herbal treatments (Fern, 2014).

*Ekebergia capensis*, is a large evergreen or semi-deciduous tree occurring in several different habitats, namely in riverine forests and at sea level. It is present today in Mozambique, mainly from the coastal Inhambane municipality to Maputo (Burrows *et al*., 2018). This species has edible, medicinal and cultural uses. The fruits are edible and in traditional medicine the bark, roots and leaves are widely used. In economic terms, the wood is medium weight to moderately heavy, soft and not very durable and generally used for light construction. The wood is also used as fuel and to make charcoal. The Zulu people have cultural beliefs that the wood facilitates childbirth (Fern, 2014).

*Euclea natalensis* is an evergreen shrub or tree flourishing in a wide variety of mixed woodland habitats, usually associated with dense thickets or riverine areas and is present today on the coast of Inhambane (Burrow *et al.*, 2018). That species has edible, economic, medicinal and cultural purposes. For the consumption of fruit, the fruit is edible but not very tasty (Boon, 2010). Lennox *et al.* (2015) report that the smoke of *Euclea* species can be poisonous. The wood produces copious amount of smoke and the smoke contains "diterpenes" which are toxic. Wood can be used in household crafts, as timber or as firewood. In medicinal terms twigs from some *Euclea* species can be used as dental care practices (Hardwick, 2013). Lastly, cultural beliefs avoid some *Euclea* species because they believe its burning will cause strife in the family (Chikumbirike, 2014).

*Harpephyllum* is a rare species in Mozambique, present only in Maputo province were the only genus present is *Harpephyllum caffrum*. This species is a medium to large deciduous evergreen tree in coastal forest (Van Wyk & Van Wyk, 2013) and scattered in riverine forest along the Lebombo Montains (Burrows *et al*., 2018). Lennox *et al*. (2015) identified this species in one of the Hearths found in Sibudu Cave. The fruits are edible (Lennox *et al*., 2015), leaves can be eaten raw or cooked (Fern, 2014), bark, leaves and roots have medicinal purposes and it is a heavy fuel (Lennox *et al*., 2015).

*Mystroxylon aethiopicum* is a shrub or small tree which grow in different habitats, from among them, coastal woodland or savannah woodland, at elevations from sea level to around 2,100 metres (Fern, 2014). This specie has three subspecies, of which only *M. aethiopicum* ssp. *schlechteri* occurs in Mozambique. In Inhambane, this specie is present in Vilankulos municipality (Burrows *et al.*, 2018). The fruits and raw are edible and the bark and leaves have medicinal purposes. In Kenya, the properties of that specie include frequently the use in medicinal practices (Fern, 2014). Lastly, the wood is also used for fuel. In Archaeological sites, this specie was identified from charcoal present in Sibudu (Allott, 2004; Lennox *et al.*, 2015), showing the use and the presence of *Mystroxylon aethiopicum* in the landscape

The species most present in the analyzed sets are *Disopyros* cf. *natalensis* and *Euclea* cf. *natalensis*. They were likely used for firewood, probably for domestic purpose, as it was mostly identified in Hearth1 and Hearth 2 and are also found in the smaller sets in secondary depositions. It is difficult, however, to discern other uses that these two species may have had. In terms of diet, it may be hypothesized that their fruits were probably consumed, since the great majority of *Diospyros* tree genera have edible fruits. As for other uses other than for fuel, it can only be said that these communities would have knowledge of the nature and their properties to not choose the species dangerous to human health.

In the burial area (PR1), in addition to the two taxa mentioned above, another four were identified: *Burkea* cf. *africana*, cff. *Harpephyllum* sp., *Combretum* sp. and *Ekebergia* cf. *capensis*. The discussed presence of the species *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis* will probably be associated with the secondary deposition. As for the remaining taxa identified, some may also be associated with trash context or are associated with the burial context and have a cultural nature or association with a funeral ceremony.

These species, except for cff. *Harpephyllum* are available in the landscape, thus the wood is accessible, easily and practically acquired. The presence of these taxa in the context under study may have several functions / activities and with the results obtained it is possible to discuss four types of wood management, they are edible, for firewood, medicinal and cultural uses. The fruits or the leaves of *Burkea africana*, *Ekebergia capensis*, *Combretum apiculatum*/*hereoense* and *Harpepyllum caffrum* can be eaten raw or cooked (Fern, 2014). As firewood, several authors (Chikumbirike, 2014; Fern, 2014; Lennox *et al.*, 2015) record the potential of these woods as being hard, heavy, durable or retain heat for a long time, making good fuel and charcoal. The species *Burkea africana*, *Combretum zeyheri* / *hereroense* and *Ekebergia capensis* which could also have been used has traditional medicine, since, the bark, roots and leaves have medicinal properties. Lastly, *Combretum apiculatum* / *zeyheri* and *Ekebergia capensis* can be associated to the burial context and, this way, be older that the other taxa identified there. Precisely, these species may be related to cultural beliefs or to certain types of funeral ceremonies. As mentioned by Hardwick (2003), *Combretum apiculatum* / *zehyeri* and *Ekebergia capensis* are used by *Incwala* and *Zulu* communities as charms or ceremonially, including funerals. Thus, the possible association of these three taxa with the burial context is supported by their presence only identified in PR1 and by being associated with various types of ceremonies (Hardwick, 2003). This hypothesis is plausible but it would be important to do the remaining anthracological analysis for two reasons, 1) the taxonomic list in this context will be increased by the taxonomic diversity already existing and by the amount of charcoals present in it, and 2) to reinforce the possibility that some taxa may have been used not for domestic purposes but for a funeral ritual. However, it needs to be considered that the use of *Combretum* sp. and possibly *Ekebergia capensis,* may have had a cultural nature.

Many microphotographs of the anatomy from woody species found in the current landscape of Inhambane are available in online databases and published in scientific studies. Nevertheless, no association was found with the available photomicrographs for the specimens identified as *Bauhinia* sp. and cff. *Harpephyllum.* Looking outside the Inhambane province, *Bauhinia galpinii* and *Harpephyllum caffrum*, as explained in Chapter 6, are the taxa with most similar anatomical features with the specimens in question. Thus, *Bauhinia* sp. *and* cff. *Harpephyllum* are a possible identification. Another factor that made the analysis difficult is the absence of microphotographs of certain species present in Inhambane, as *Bauhinia burrowsii*. In this way, the wood anatomy of these specimens is not very clear and needs to be better documented to enable interpretations about mobility and functionality of the wood. The difficulty in identifying both specimens can be due to the lack of anatomical microphotographs of the wood present in the area under study. In terms of acquisition, don't seem to be associated with any specific use that would justify such displacement. This is why the remaining analysis of the anthracological set collected in PR1 will be crucial in identifying other specimens like these identified with the taxon *Bauhinia* sp. and cff. *Harpephyllum* and complete the taxonomic list of the wood that has been collected, burned and deposited in this context.

The identification of the taxon cff. *Avicennia marina* suggest movement to the mangrove zone to acquire the wood, since this species is typical of these environments. *Avicennia marina* has several uses include edible (seeds), medicinal (resin, leaf and bark) and firewood. As mentioned, the wood is used as firewood, for charcoal production and the smoke of burning wood is considered efficient as a mosquito repellent (Fern, 2014).

*Brachylaena discolor* is a shrub or small tree occurring in the coast of Inhambane today (Burrows *et al*., 2018). The identification of this taxon in the anthracological set presented is corroborated by the pollen data of Lake Nhaucati, Nhauhache and Xiroche lakes (Ekblom, 2004, 2008; Ekblom *et al*., 2014; Holmgren *et al.,* 2012), whose species were in the Inhambane landscape in the studied chronological period. As the studies by Chikumbirike (2014; Chikumbirike *et al*., 2016) and Lennox & Bamford (2017) reveal, it appears to have been a prized wood for combustion as its presence has been identified in more than one archaeological site. Thus, it probably has been collected for its combustion properties (Chikumbirike, 2014; Lennox & Bamford, 2017) and wood quality that may have had construction purposes (Jodamus, 2003). It is noted that this species is also used for medicinal purposes (Jodamus, 2003).

Finally, *Mystroxylon aethiopicum* (PR15*)* and *Catunaregam obovata* (PR14 and PR7), are mainly used for edible and medicinal uses. If they collect fruits, bark, roots, seeds and wood for a function or simply from plants which are present in the landscape around the shell-middens, the wood harvested from these species should be considered as a wood resource exploited by these communities.

In general, the similarity of the taxonomic list in the different contexts of Praia do Tofo and Praia da Rocha, allows consideration of the hypothesis that the same species are being used as fuel for different activities/functionalities. There is a pattern of fuel acquisition and wood management during the late farming communities between Praia do Tofo and Praia da Rocha, satarting around 400 years ago (1600 AD). Among the charcoal presented in this study there is a clear intentionality in the collection of *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis*, to the detriment of other species present in the landscape. This fact reinforces the hypothesis that wood harvesting by these communities has responded to specific cultural and economic needs. As noted, the wood may have been harvested for various reasons or even preferences, both for the quality of the wood, the shape and size of the branches and for various uses of fuel for domestic, social and economic purposes. Lastly, other conclusions are the presence of taxa used for domestic purposes (fireplaces), the transport of the charcoal to a trash area after its use as fuel (secondary deposits) and the probable association of *Combretum* sp. and *Ekebergia* cf. *capensis* to the burial.

### 7.3.2 - Contribution of the taphonomic changes

Supported by the identification of taphonomic changes in the charcoal, it is possible to identify other characteristics of the wood and the combustion process, including changes caused by the state of the wood or during burning. These factors will also be important for interpreting the modalities of wood acquisition by these communities, not only based on species but also on other wood characteristics.

As mentioned earlier, the cellular structure of woody taxa affected by taphonomic changes can provide data for the type of wood burnt in the archaeological contexts under study (Allué, 2002; Allué *et al*., 2008, 2013; Bentsen, 2013; Euba, 2008; Caruso Fermé 2008, 2012, 2015; Théry-Parisot, 1998, 2001). The taphonomic process may be caused naturally or be associated with wood characteristics or exposure to combustion conditions, so the study may suggest an anthropogenic process or activity. Charcoal alteration and cause can suggest economy of collection and fire management, relevant when addressing archaeological questions, in terms of human behavior of wood selection and fuel management or occupation and spatial distribution of the activities of the shell-middens through the anthracological remains.

The taphonomic analysis presented noted the following types of changes, 1) morphological changes, 2) change by microorganisms, 3) combustion changes and 4) post-depositional changes related to the state of the wood (dead wood or green) and 5) the combustion process which is affected by species anatomy.

As shown in Chapter 6, almost all the analyzed charcoal fragments in all shell-middens from Praia do Tofo and Praia da Rocha show taphonomic alterations. Thus, of the 529 charcoal fragments analyzed the most common alteration in 458 charcoal fragments is caused by mineral incrustation, which makes taxonomic analysis difficult. Sediment grains subsequently incorporated into the fissures have caused further damage to the rays and other structures normally visible in radial and tangential sections. Probably, this contamination took place after carbonization (Chabal, 1992), possibly resulting from an anthropic factor (transport) or a natural factor (wind, sea erosion), exposure and contact of charcoal with sandy soils.

In turn, the changes caused by combustion are present in the analyzed set. 281 fragments with altered diagenesis, probably due to combustion, starting the process of deteriorating cells. This change affected all identified species. Some fragments present two types of diagenesis in transverse section, one more affected by combustion than another, as shown in FIGURE 7.6. It is considered that this difference in cell structure may be due to a portion having been more exposed to hot or prolonged fire. Vitrification (237 fragments) and cracks (175 fragments) are also present in the cellular structure of the analyzed charcoals. Regarding vitrification, cell damage is more frequent and easily identified by its "vitreous" aspect and the anatomical structures appear to have fused (FIGURE 7.7). However, as mentioned in Chapter 5, Methodology, the concrete causes of vitrification in charcoal diagenesis continue to be investigated. This may be a result of exposure to heat or prolonged fire and may indicate high silica content in the wood (Allott, 2006). Cracks also represent a good indicator of possible wood harvesting modalities. Cracks are caused by the natural process of wood moisture loss during combustion (Allott, 2006; Caruso Fermé, 2013; Henry & Théry-Parisot, 2014).

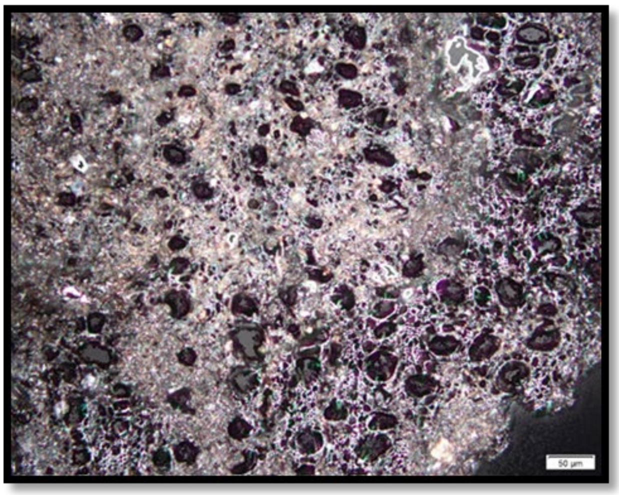


Figure 7.6 - *Catanuragem* cf. *obovata* (PR7 Frag. 37) showing how combustions affect the diagenesis of the charcoal. Credits: Roxane Matias, ICArEHB.

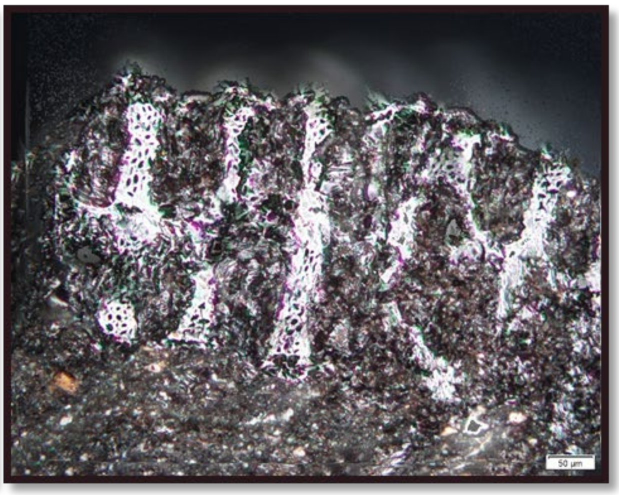


Figure 7.7 – Indeterminate type (PR7 Frag. 37) showing the vitreous aspect (white parts) of the diagenesis of the charcoal. Credits: Roxane Matias, ICArEHB.

Thus, the presence of cracks in some of the studied charcoal fragments could be indicative of the use of green wood as fuel and constitute a modality of wood acquisition by the Late Iron Age Inhambane communities. However, the varied causes associated with these two alterations may not indicate a specific cause in the anthracological complex of Praia do Tofo and Praia da Rocha. It should be noted that these two characteristics were not found in *Burkea* cf. *africana*, *Combretum* sp. and *Ekebergia* cf. *capensis* species. In the taxon *Mystroxtlon aethiopicum*, no vitrification was identified, only a crack in the fragment was found. The fact that they constitute very small anthracological sets, when compared with all fragments identified as *Euclea* cf. *natalensis* and *Diospyros* cf. *natalensis*, could be the explanation for the absence of these two characteristics. However, only four fragments were identified as *Bauhinia* sp. and all these reveal the presence of vitrification and cracks. Thus, it is likely that the absence of these two characteristics are related to the quality and properties of the wood rather than to the reduced sampling.

In terms of the changes by microorganisms, 102 fragments were identified with cell decay and only 16 fragments with a hole. The damage caused by meteorological agents or microorganism attacks culminating in the death of the tree or branches (Théry-Parisot *et al*., 2010) and cell decay, provide information about the wood quality, which shows bad wood and, this way, wood exploitation. As the percentage of wood affected by microorganisms in the anthracological complex under study is small, it is pertinent to hypothesize that the wood used as fuel by Inhambane communities would be mostly in good condition. Twenty-six fragments with knots were identified. As noted in Chapter 5, Methodology, it is a natural morphological change during the growth of woody species (Martín Seijo, 2013). It may be evident that small wood is collected, since the knots usually originate at the junction of the trunk with the branch or the branch with another branch. In this contact a distortion occurs and the anatomical sections of the wood are mixed. This hypothesis is still supported by the fact that it is *Euclea* cf. *natalensis* where the most knots were identified (16 fragments), remembering that it is the most representative and quantitative taxon of the analyzed shell-middens.

In short, although they sometimes make identification impossible, the taphonomic alterations are an important fact to acquire other information about the wood and its eventual manipulation. Taxonomic identification and taphonomic changes in the wood allowed us to identify the selection of wood for fuel and to consider the characterization of wood acquisition mobilities by the late farming populations of the coast of Inhambane, mainly focusing on two species, *Euclea* cf. *natalensis* and *Diospyros* cf. *natalensis*, probably based on selection criteria that would be determined by the economic needs of these societies, besides the availability in the landscape.

# 8. Conclusion

The anthracological analysis presented here comes from seven open-air shell-middens, located on the coast of the Inhambane municipality and revealed the use of eleven taxa used by these late farming communities starting about 400 years ago. In addition, the discovery of these shell-middens corroborates the idea of a "Southern Mozambique Coastal Kitchen Midden Tradition" defined by Senna-Martinez (1968) and they are the testimony about settlement pattern on Mozambique coast with these typical structures, the shell-middens.

The anthracological analysis of the 529 fragments suggests that species *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis* were collected as fuel for different activities / functionalities. This is a pattern of wood management and acquisition during the late farming communities between Praia do Tofo and Praia da Rocha, at least in the last 400 years.

Most of the analyzed charcoal fragments come from surface collections, where materials were confined to a small area. The collected archaeological charcoal relates to scattered charcoal deposits (Shell Sector, Tofo 2, PR1, PR14, PR15, PR4 and PR7), which are the result of activities and different combustion times over a period of time and transported after use for trash deposits (Bentsen, 2014). Other contexts studied (Hearth 1 and Hearth 2) may have had a specific function as a combustion structure. The concentrated charcoal present there may reflect specific or short-term activities. Finally, in addition to domestic charcoals, some charcoal comes from a human burial (PR1). The charcoal collected there come from dispersed material (trash deposits) as well as from specific contexts (a funerary nature), presenting two moments of deposit, with part of the archaeological charcoal possibly associated with the burial 1. Although there was no association between the charcoal and the osteological remains in terms of spatial distribution, some taxa identified in this context may have been used for ceremonial purposes.

Thus, through the taxonomic analysis, it is conclusive that some species will have had domestic purpose, such as those identified in Hearth1 and Hearth2 (*Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis*), that most of the charcoals analyzed come from secondary depositions (transported to a trash area after use as fuel) and the probable association of *Combretum* sp. and *Ekebergia* cf. *capensis* with the human burial. As for the taphonomic analysis of the charcoals under study, these supported the suggestions made earlier about the collection of wood. Regarding wood exploitation, since the percentage of wood affected by microorganisms in the anthracological complex studied is small, it is pertinent to hypothesize that the wood used as fuel by Inhambane communities would be mostly in good condition. In turn, the morphological changes, namely knots, can suggest that small wood was collected, supported by the fact that *Euclea* cf. *natalensis* is the taxon where more knots were identified which is the most representative and quantitative taxon of the analyzed shell-middens studied. Also, the presence of cracks in some of the studied charcoals could be indicative of the use of green wood as fuel and constitutes a possible modality of wood acquisition by the Inhambane communities. Vitrification can be associated with high temperatures. However, the varied causes associated with these two alterations are presently unknow.

Even without having analyzed all the fragments (Hearth1, Hearth2, PR1 and, PR14), the anthracological analysis of some of the shell-middens studied points to a similar context of the Miombo woodland savanna species in the Vilankulos pollen diagram, particularly *Combretaceae* and *Euclea* in the landscape since about 400 years ago, which is corroborated with the anthracological data presented here. This leads one to consider that the surrounding landscape of Praia do Tofo and Praia da Rocha will not have undergone major changes in terms of vegetative composition, as the taxa identified remain present over time. Thus, the charcoal assemblage describes the kind of landscape flourishing during the late farming communities, reflecting the distribution of trees and shrubs around the shell-middens studied in the Inhambane coast.

Further research and analysis of charcoal will be needed to complement the present findings in order to better understand the processes of the formation of shell-middens, taphonomic changes and the depositional and post-depositional processes of the charcoal. Further studies on experimentation and charcoal fragmentation are needed to understand the post-depositional processes (Braadbaart *et al.*, 2009; Chrzazvez *et al.*, 2014) in the charcoal analyzed at Praia do Tofo and Praia da Rocha. Despite fragment numbers could also depend on the type of wood because some burn to ash and others burn to fragments (Bentsen, 2014), the high number of charcoal fragments identified as *Diospyros* cf. *natalensis* and *Euclea* cf. *natalensis* in each shell-midden suggest that these were widely used and commonly present taxa in the landscape, since other experimental studies show that the amount of fragments tend to be proportional to the original ecology (Théry- Parisot & Chabal, 2010).

Lastly, to obtain more consistent data, it would be important to carry out the remaining analysis of the collected charcoals for three reasons: 1) to be able to make palaeoethnobotanical and paleoecological interpretations more reliable (at least 200 fragments of each set, number that was considered to be the minimum for the appearance of the vegetal spectrum (Chabal, 1989, 1997; Figueiral, 1992; Figueiral & Carcaillet, 2005), 2) the taxonomic list in PR1 and Hearth 1 will be increased by taxonomic diversity and by the amount of charcoals present in it and 3) to reinforce the possibility that some taxa in PR1 may have been used not for domestic purposes but for a funeral ritual or ceremony. Also the other artefacts found in the shell-middens, namely the malacological and ceramic remains, when related to the charcoal, complete the detailed analysis and interpretation of the shell-middens from late farming communities in the coast of Inhambane municipality starting 400 years ago (1600 AD).

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# APPENDIX

# APPENDIX 1

## LIST OF ANATOMICAL FEATURES OBSERVED IN THE IDENTIFICATION OF THE WOOD CHARCOALS WITH THE NUMERICAL CODES DEFINED BY IAWA (IAWA, 1989)

**Vessel arrangement:**

IAWA 6 – Vessels in tangential bands: vessels arranged perpendicularly to the rays and forming short or long tangential band (FIGURE 1)

IAWA 7 – Vessels in diagonal and/or radial pattern: Vessels arranged radially or intermediate between tangential bands (FIGURE 2).

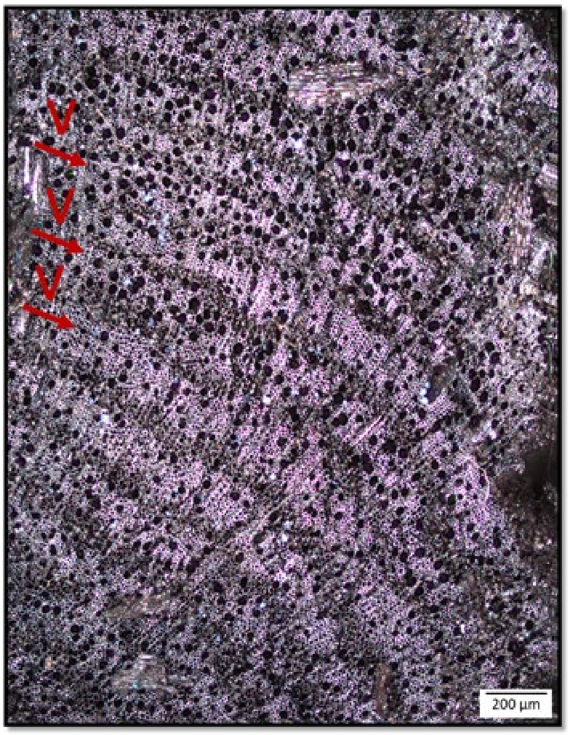



Figure 1 – PR15 20, TS x50 (*Mystroxylon aethiopicum*), showing vessels in tangential bands (IAWA 6). Credits: Roxane Matias, ICArEHB.

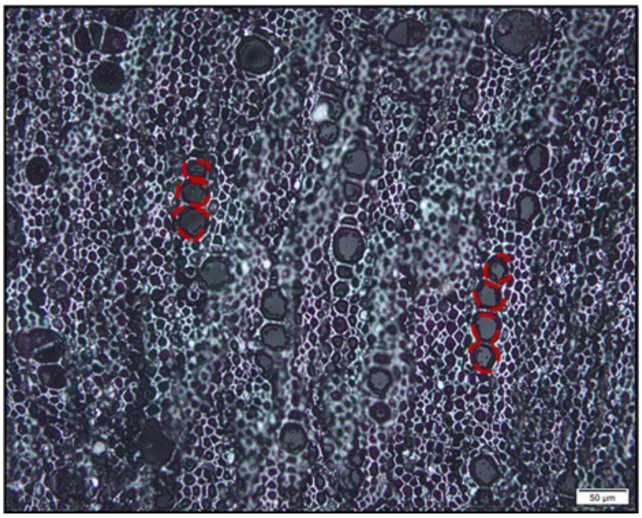


Figure 2 – Hearth2 132, TS x200 (*Diospyros* cf. *natalensis),* showing vessels in radial pattern (IAWA 7). Credits: Roxane Matias, ICArEHB.

**Vessel groupings:**

IAWA 9 – Vessels exclusively solitary (90% or more) – they are completely surrounded by other elements (FIGURE 3A)

IAWA 10 – Vessels in radial multiples of 4 or more common - radial files of 4 or more adjacent vessels of common occurrence (FIGURE 3B)

IAWA 11 – Cluster common – groups of 3 or more vessels having both radial and tangential contacts (FIGURE 3C).

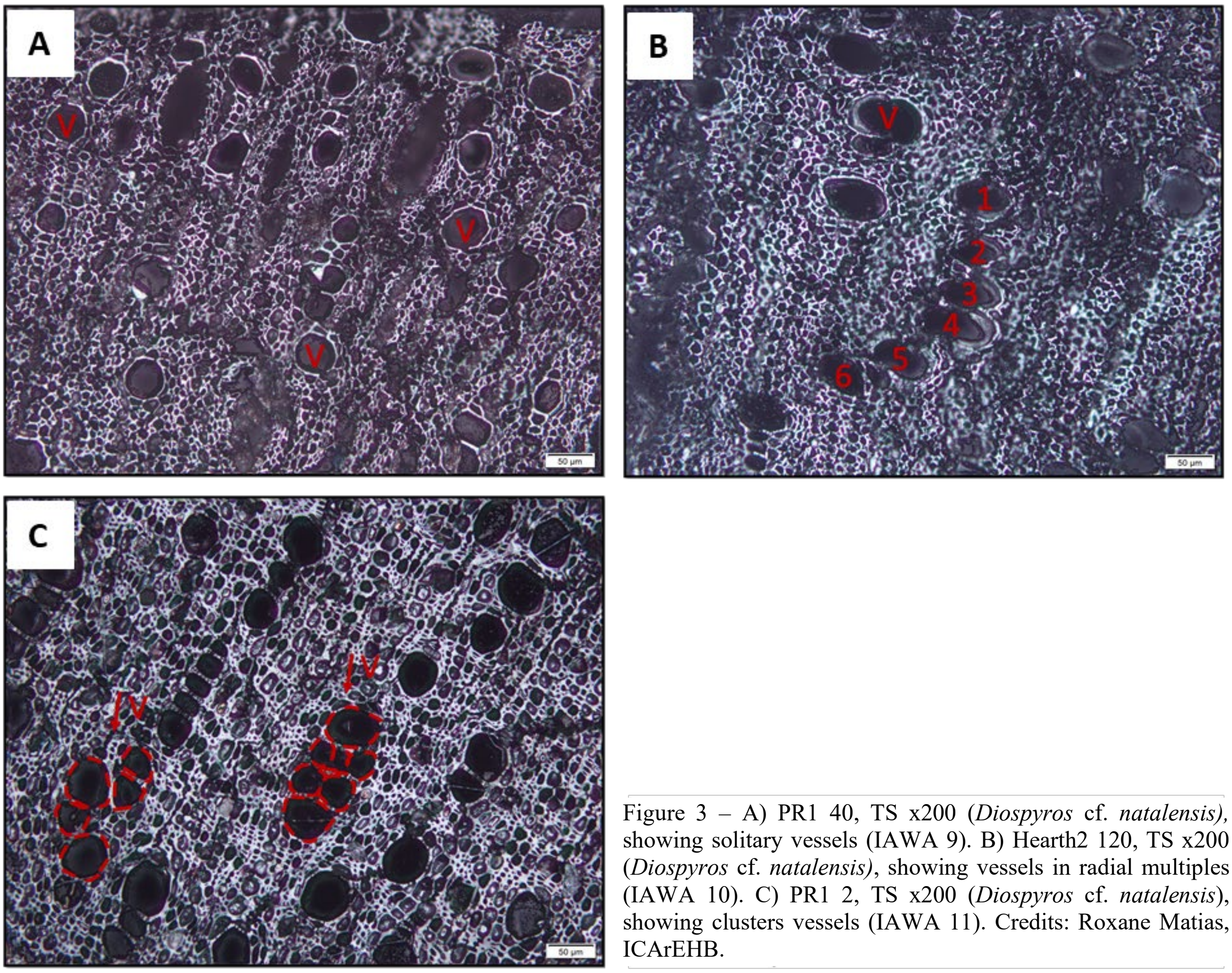



Figure 3 – A) PR1 40, TS x200 (*Diospyros* cf. *natalensis),* showing solitary vessels (IAWA 9). B) Hearth2 120, TS x200 (*Diospyros* cf. *natalensis)*, showing vessels in radial multiples (IAWA 10). C) PR1 2, TS x200 (*Diospyros* cf. *natalensis*), showing clusters vessels (IAWA 11). Credits: Roxane Matias, ICArEHB.

**Perforation plates:**

IAWA 13 – Simple perforation plate – a perforation plate with a single circular or elliptical opening (FIGURE 4).

**Intervessels pits arrangement and size:**

IAWA 22 – Intervessel pits alternate – they are arranged in diagonal rows (FIGURE 4 and 5):

IAWA 24 – Minute - ≤ 4µ

IAWA 25 – Small – 4 – 7µ

IAWA 26 – Medium – 7 – 10µ

IAWA 27 – Large - ≥ 10µ

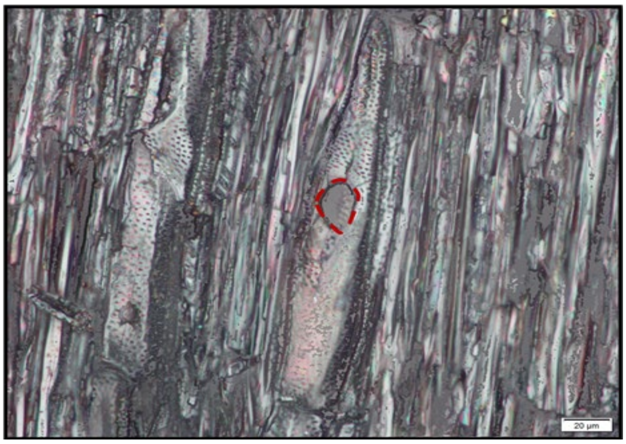


Figure 4 - Hearth2 132, TLS x500 (*Diospyros* cf. *natalensis*), showing a simple perforation plate (IAWA 13). Credits: Roxane Matias, ICArEHB.

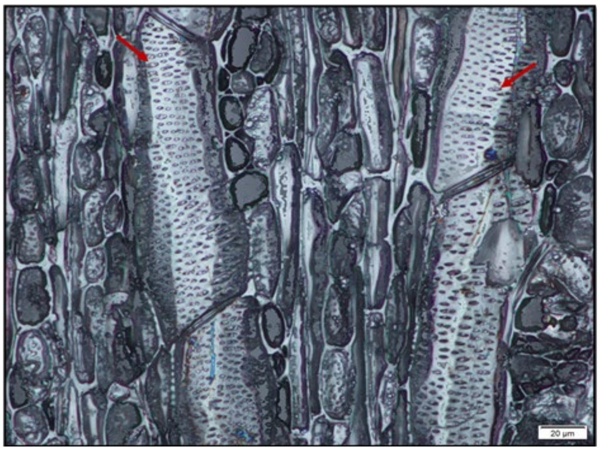


Figure 5 - PR1 53, TLS x500 (*Diospyros* cf. *natalensis*), showing intervessel pits alternate arranged in diagonal rows (IAWA 22). Credits: Roxane Matias, ICArEHB.

**Tangential diameter of vessel lumina:**

IAWA 40 - ≤ 50µm (Figure 6A)

IAWA 41 – 50 - 100µm (Figure 6B)

IAWA 42 – 100 - 200µm (Figure 6C)

IAWA 43 - ≥ 200µm

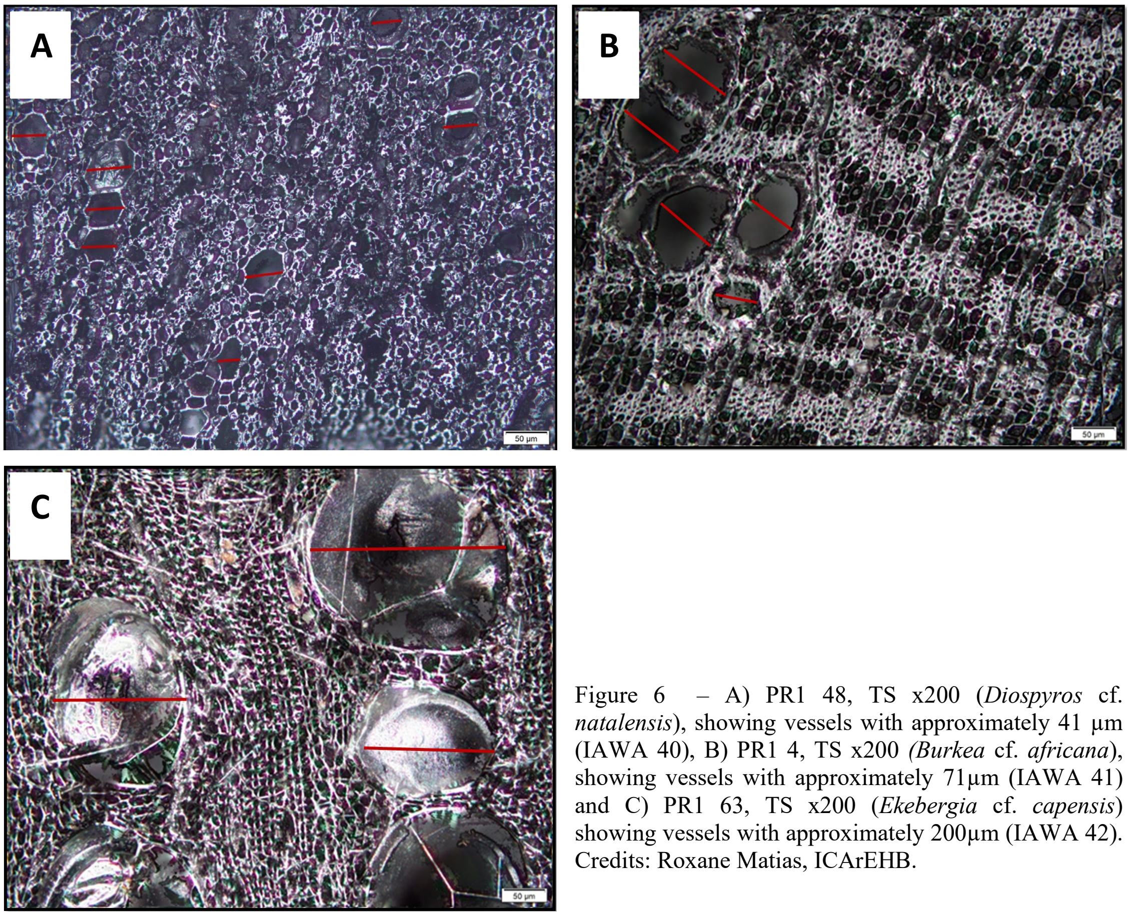



Figure 6 – A) PR1 48, TS x200 (*Diospyros* cf. *natalensis*), showing vessels with approximately 41 µm (IAWA 40), B) PR1 4, TS x200 (*Burkea* cf. *africana*), showing vessels with approximately 71µm (IAWA 41) and C) PR1 63, TS x200 (*Ekebergia* cf. *capensis*) showing vessels with approximately 200µm (IAWA 42). Credits: Roxane Matias, ICArEHB.

**Vessel per square millimeter:**

IAWA 46 - ≤ 5 (Figure 7A)

IAWA 47 – 5 – 20 (Figure 7B)

IAWA 48 – 20 – 40 (Figure 7C)

IAWA 49 – 40 – 100

IAWA 50 - ≥ 100 (Figure 7D).

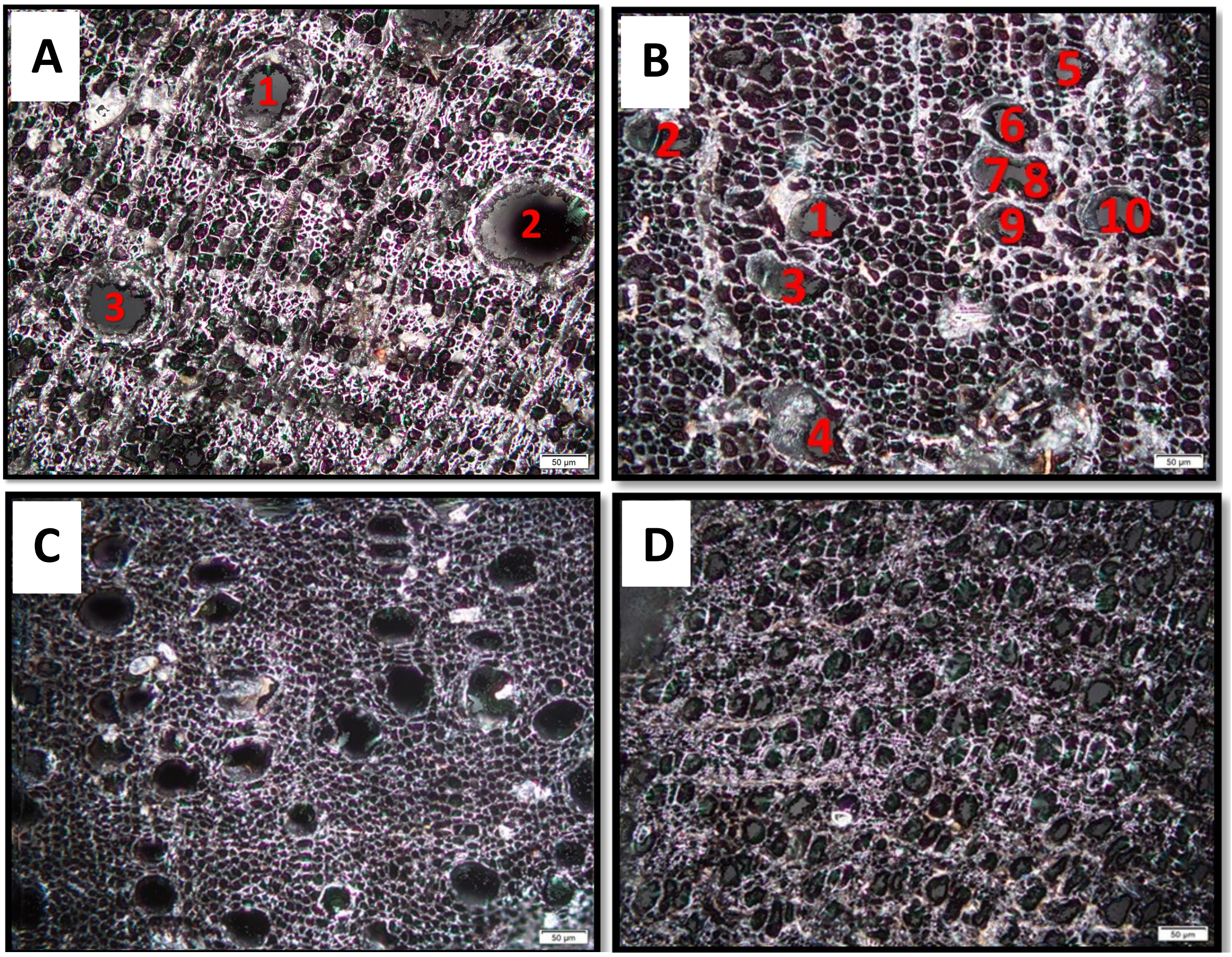



Figure 7 – A) PR1 4, TS x200 *(Burkea* cf. *africana*), showing 3 vessels per square millimeter (IAWA 46), B) PR15 23, TS x200 (*Brachylaena* cf. *discolor*), showing 10 vessels per square millimeter (IAWA 47), C) PR15 13, TS x200 (*Diospyros* cf. *natalensis*), showing 35 vessels per square millimeter (IAWA 48) and D) PR7 2 , TS x200 (Catunaregam cf. spinosa), showing ≥ 100 vessels per square millimeter (IAWA 50). Credits: Roxane Matias, ICArEHB.

**Tyloses and deposits in vessels:**

IAWA 56 – Tyloses common – outgrowths from an adjacent ray or axial parenchyma cell through a pit in a vessel wall, partially of completely blocking the vessel lumen (FIGURE 8A)

IAWA 58 – Gums and other deposits in heartwood vessels (FIGURE 8B).

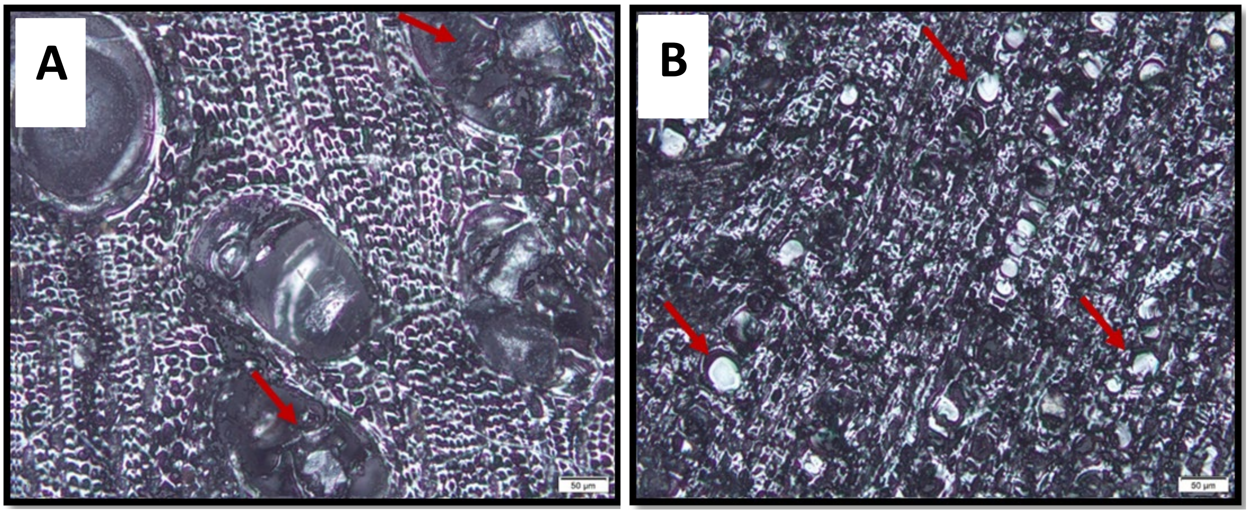



Figure 8 – A) PR1 63, TS x200 *(Ekebergia* cf. *capensis),* showing tyloses common (IAWA 56) and B) – Hearth1 116, Ts x200 (*Diospyros* cf. *natalensis*), showing gums and other deposits in heartwood vessels (IAWA 58). Credits: Roxane Matias, ICArEHB.

**Ground tissue fibers:**

IAWA 61 – Fibers with simple to minutely bordered pits (FIGURE 9).

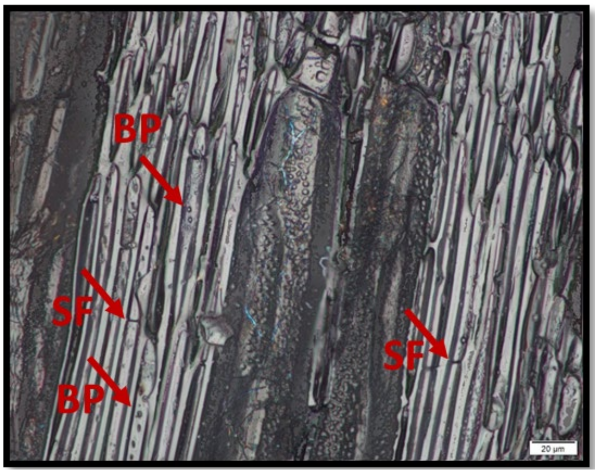



Figure 9 – PR4 24, TS x500 *(Euclea* cf. *natalensis),* BP = fibers with simple to minutely bordered pits fibers (IAWA 61) and SF = septate fibers (IAWA 65). Author: Roxane Matias.

**Septate fibers and parenchyma like fiber bands:**

IAWA 65 – Septate fibers present (FIGURE 9)

IAWA 66 – Non-septate fiber present.

**Fibers walls thickness:**

IAWA 68 – Fibers very thin walled – fiber lumina 3 or more times wider than the double wall thickness (FIGURE 10A);

IAWA 69 – Fibers thin to thick walled – fiber lumina less than 3 times the double wall thickness and distinctly open (FIGURE 10B);

IAWA 70 – Fibe rs very thick walled – fiber lumina almost completely closed (FIGURE 10C).

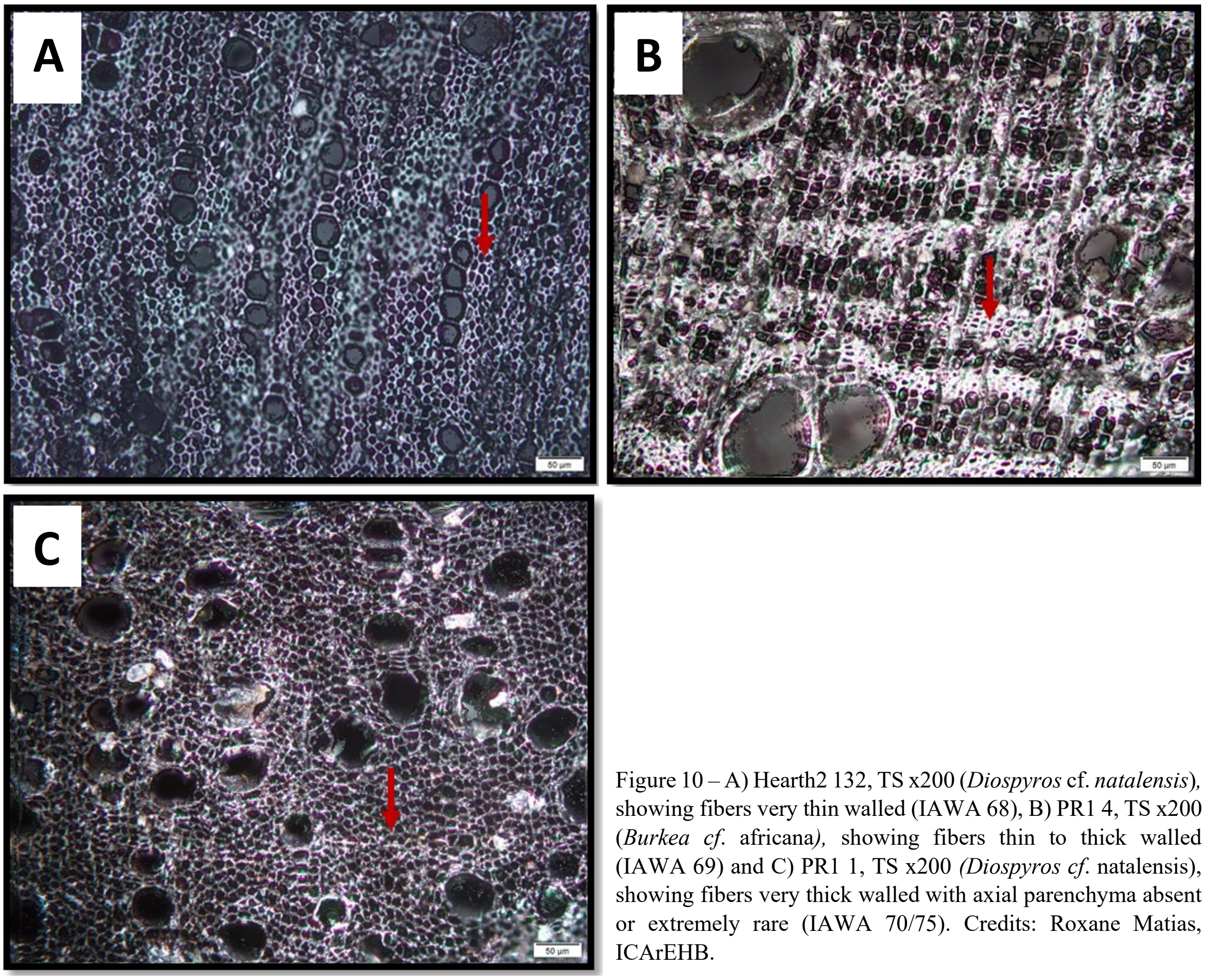



Figure 10 – A) Hearth2 132, TS x200 (*Diospyros* cf. *natalensis*), showing fibers very thin walled (IAWA 68), B) PR1 4, TS x200 (*Burkea cf.* africana*),* showing fibers thin to thick walled (IAWA 69) and C) PR1 1, TS x200 *(Diospyros cf.* natalensis), showing fibers very thick walled with axial parenchyma absent or extremely rare (IAWA 70/75). Credits: Roxane Matias, ICArEHB.

**Axial parenchyma:**

IAWA 75 – Axial parenchyma absent or extremely rare.

**Apotracheal axial parenchyma**:

IAWA 76 – Axial parenchyma diffuse – single parenchyma strands or pairs of strands distributed irregularly among the fibrous elements of the wood (FIGURE 11A);
IAWA 77 – Axial parenchyma diffuse in aggregates – parenchyma strands grouped into short discontinuous tangential or oblique lines (FIGURE 11B).

**Paratracheal axial parenchyma:**

IAWA 78 – Scanty – occasionally parenchyma cells associated with the vessels or an incomplete sheath of parenchyma around the vessels (FIGURE 11B);
IAWA 79 – Vasicentric – parenchyma cells forming a complete circular to oval sheath around a solitary vessel or vessel multiple (FIGURE 11C);
IAWA 83 – Confluent – coalescing vasicentric or aliform parenchyma surrounding or to one side of two or more vessels, and often forming irregular bands (FIGURE 11D).

**Banded parenchyma:**

IAWA 85 – Axial parenchyma bands more than three cells wide (FIGURE 11D);
IAWA 86 – Axial parenchyma in narrow bands or lines up to three cells wide (FIGURE 11D).

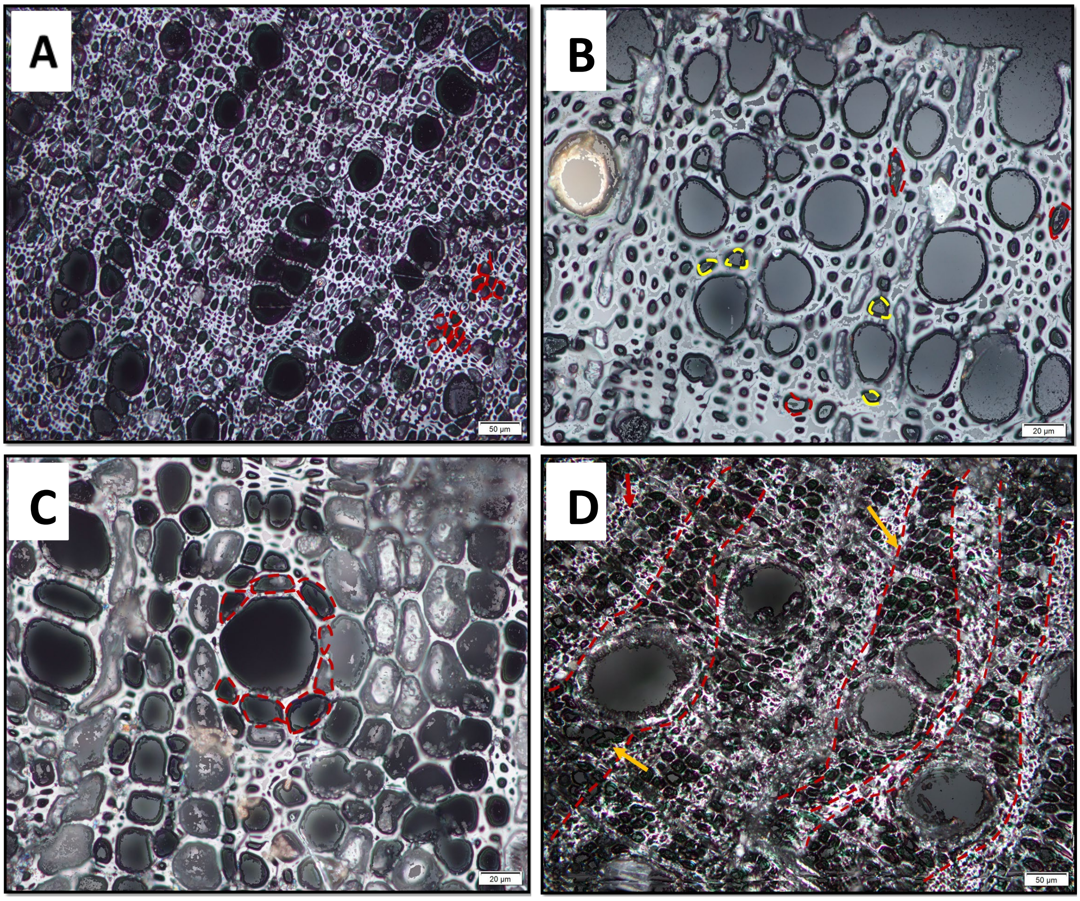



Figure 11 – A) PR1 12, TS x200 (*Diospyros* cf. *natalensis),* showing axial parenchyma diffuse (IAWA 76), B) PR7 26, TS x200 (*Catunaregam cf.* obovata*),* Red lines = Axial parenchyma diffuse in aggregates (IAWA 77) and Yellow lines = Scanty axial parenchyma (IAWA 78) , C) PR1 12, TS x200 (*Diospyros* cf. *natalensis),* showing axial parenchyma vasicentric (IAWA 79) and D) PR1 4, TS x200 (*Burkea* cf. africana*),* Red lines = Axial parenchyma confluent (IAWA 83) , Yellow arrow = Axial parenchyma bands more than three cells wide (IAWA 85) and Red arrow = Axial parenchyma in narrow bands or lines up to three cells wide (IAWA 86). Credits: Roxane Matias, ICArEHB.

**Rays width:**

IAWA 96 – Rays exclusively uniseriate (FIGURE 12A);

IAWA 97 – Ray width 1 to 3 cells (FIGURE 12B);

IAWA 98 – Larger rays commonly 4 to 10 seriate (FIGURE 12C);

**Ray height:**

IAWA 102 – Ray height > 1mm (FIGURE 12D).

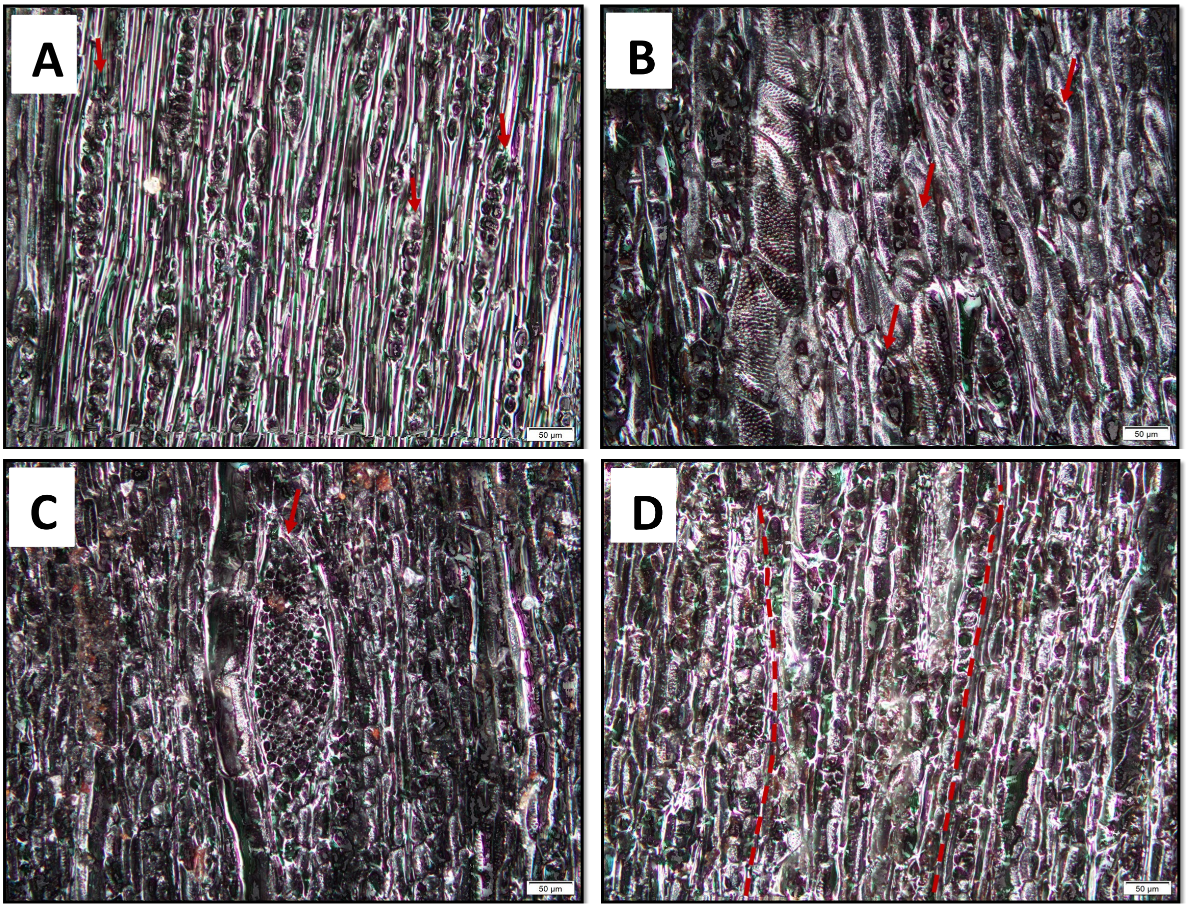



Figure 12 – A) PR1 63, TS x200 (*Ekebergia* cf. *capensis*) showing rays exclusively uniseriate (IAWA 96), B) PR15 34, TS x200 (*Brachylaena* cf. discolor*),* showing ray width 1 to 3 cells (IAWA 97), C) PR1 76, TS x200 *(Diospyros* cf. *natalensis*), showing larger ray commonly 4 to 10 seriate (IAWA 98) and D) PR1 51, TS x200 (*Euclea* cf. *natalensis*), showing rays height > 1mm (IAWA 102) . Credits: Roxane Matias, ICArEHB.

**Rays cellular composition:**

IAWA 104 – All ray cells procumbent – a ray parenchyma cell with its longest dimension radial as seen in radial section (FIGURE 13A);

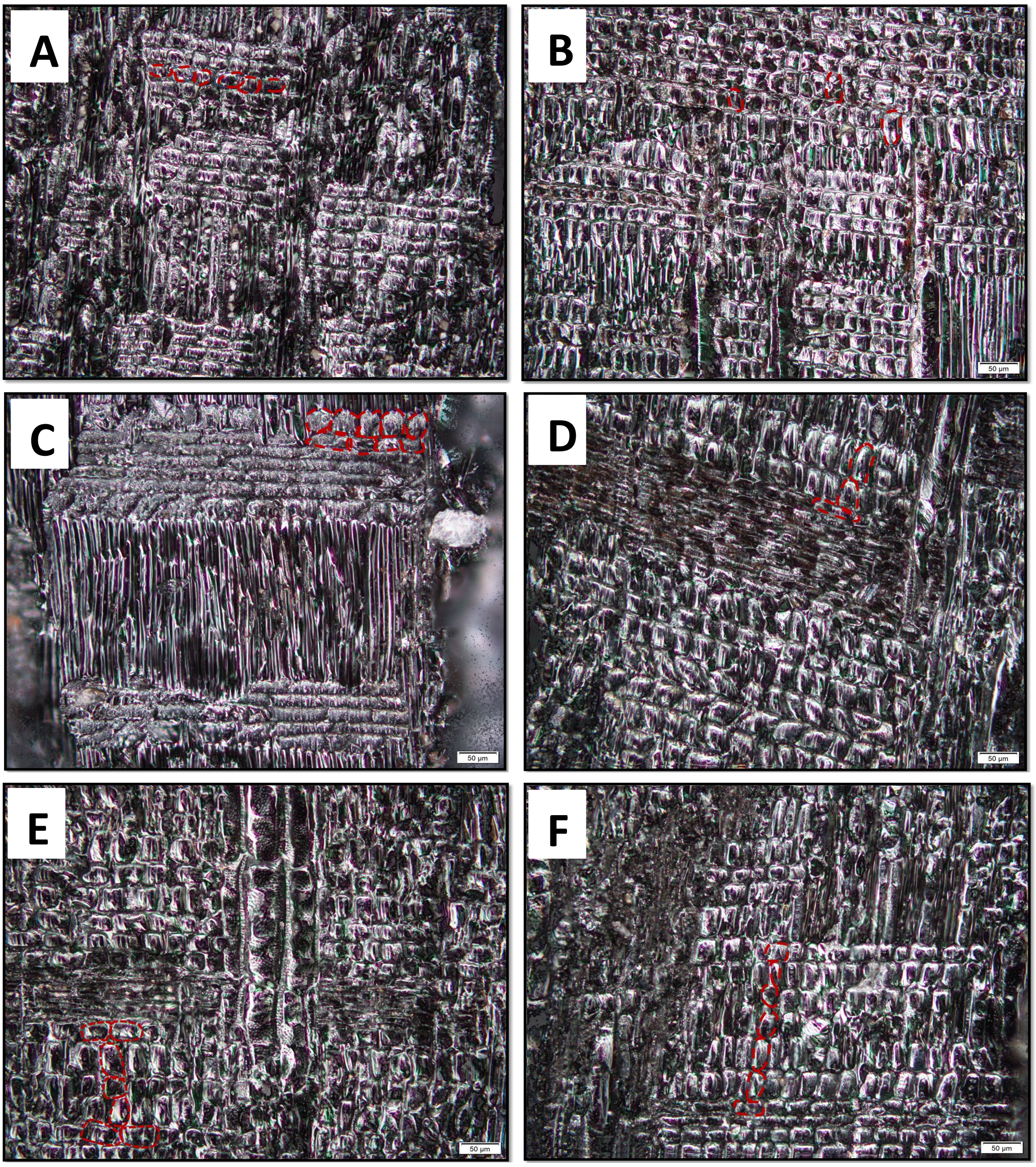
IAWA 105 – All ray cells upright and/ or square – a ray parenchyma cell approximately square as seen in radial section (FIGURE 13B).;

IAWA 106 – Body ray cells procumbent with one row of upright and/ or square marginal cells (FIGURE 13C);

IAWA 107 – Body cells procumbent with mostly 2 – 4 rows of upright and/ or square marginal cells (FIGURE 13D/E).;

IAWA 108 – Body ray cells procumbent with over 4 rows of upright and/ or square marginal cells (FIGURE 13F).;

IAWA 109 – Rays with procumbent, square and upright cells mixed throughout the ray (FIGURE 13G).



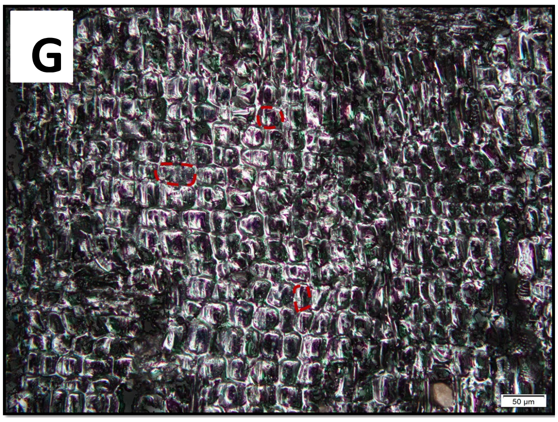


Figure 13 – A) PR1 4, TS x200 (*Burkea* cf. *africana*), showing all ray cells procumbent (IAWA 104), B) PR4 24, TS x200 (*Euclea* cf. *natalensis*), showing all ray cells upright and square (IAWA 105), C) PR1 53, TS x200 (*Diospyros* cf. *natalensis*), showing body ray cells procumbent with one row of upright marginal cells (IAWA 106), D and E) PR1 28/53, TS x200 (*Diospyros* cf. *natalensis*), (IAWA 107), F) PR1 12, TS x200 (Diospyros cf. *natalensis*), showing body ray cells procumbent with over 4 rows of upright and square marginal cells (IAWA 108) and G) PR1 53, TS x200 *(Euclea* cf. *natalensis*), showing Rays with procumbent, square and upright cells mixed throughout the ray (IAWA 109. Credits: Roxane Matias, ICArEHB.

**Rays per millimeter:**

IAWA 114 - ≤ 4/mm (FIGURE 14A);

IAWA 115 – 4 – 12/mm (FIGURE 14B);

IAWA 116 - ≥ 12/mm (FIGURE 14C);

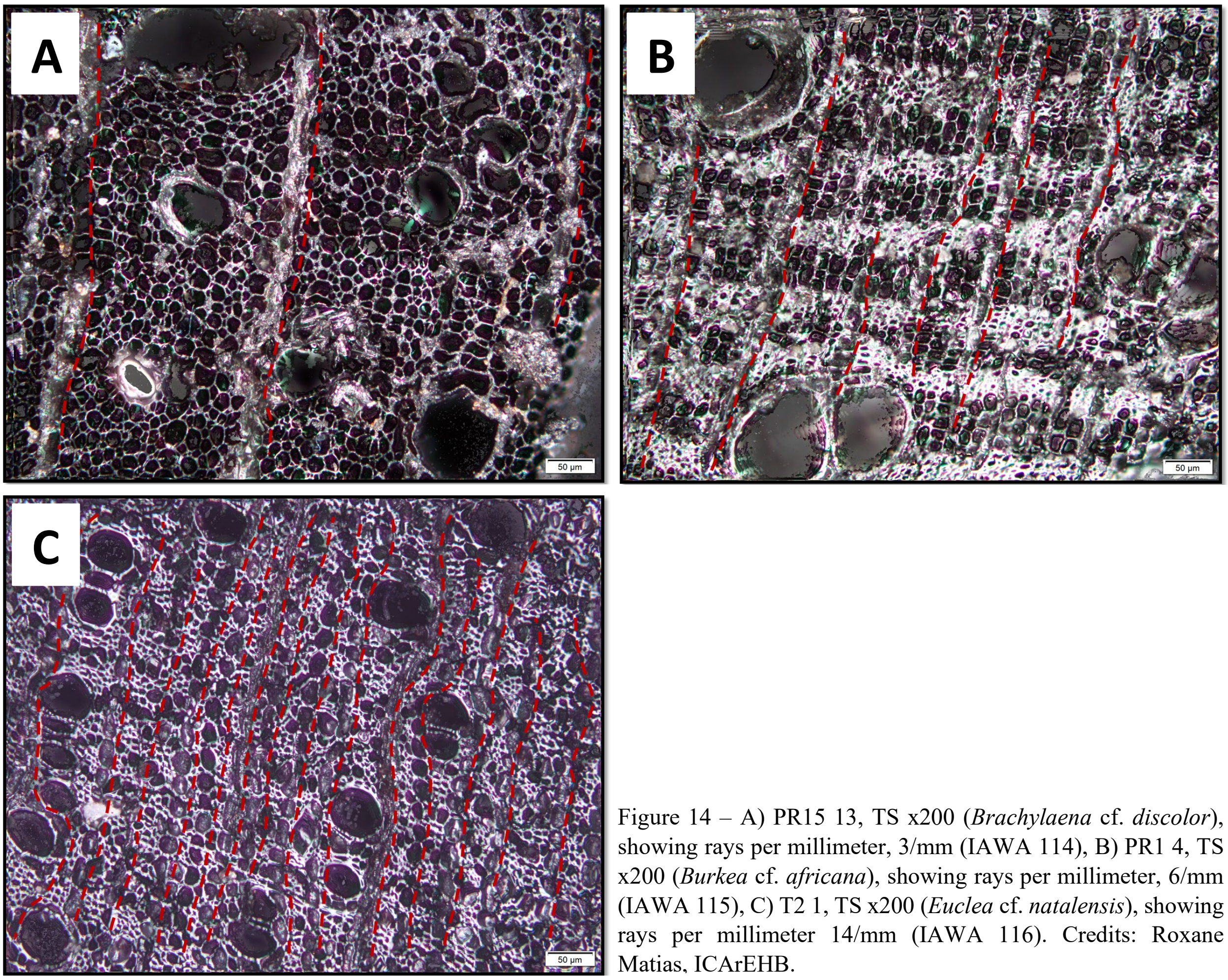



Figure 14 – A) PR15 13, TS x200 (*Brachylaena* cf. *discolor*), showing rays per millimeter, 3/mm (IAWA 114), B) PR1 4, TS x200 (*Burkea* cf. *africana*), showing rays per millimeter, 6/mm (IAWA 115), C) T2 1, TS x200 (*Euclea* cf. *natalensis*), showing rays per millimeter 14/mm (IAWA 116). Credits: Roxane Matias, ICArEHB.

**Mineral Inclusions:**

Prismatic crystal

IAWA 136 – Prismatic crystal present – solitary rhombohedral or octahedral crystals composed calcium oxalate (FIGURE 15.A);

IAWA 137 – Prismatic crystal in upright and/ or square ray cells (FIGURE 15.A);
IAWA 138 – Prismatic crystals in procumbent ray cells (FIGURE 15.A);

IAWA 139 – Prismatic crystals in radial alignment in procumbent ray cells (FIGURE 15.B);

IAWA 140 – Prismatic crystals in chambered upright and/ or square ray cells – an axial parenchyma cell or ray parenchyma cell subdivided by septa or by thick cell walls (FIGURE 15.C); IAWA 142 – Prismatic crystals in chambered axial parenchyma cells (FIGURE 15.D);
IAWA 143 – Prismatic crystals in fibers (FIGURE 15.D).

**Other diagnostics crystals features:**

Feature 154 – More than one crystal of about the same size per cell or chamber (FIGURE 15.C).

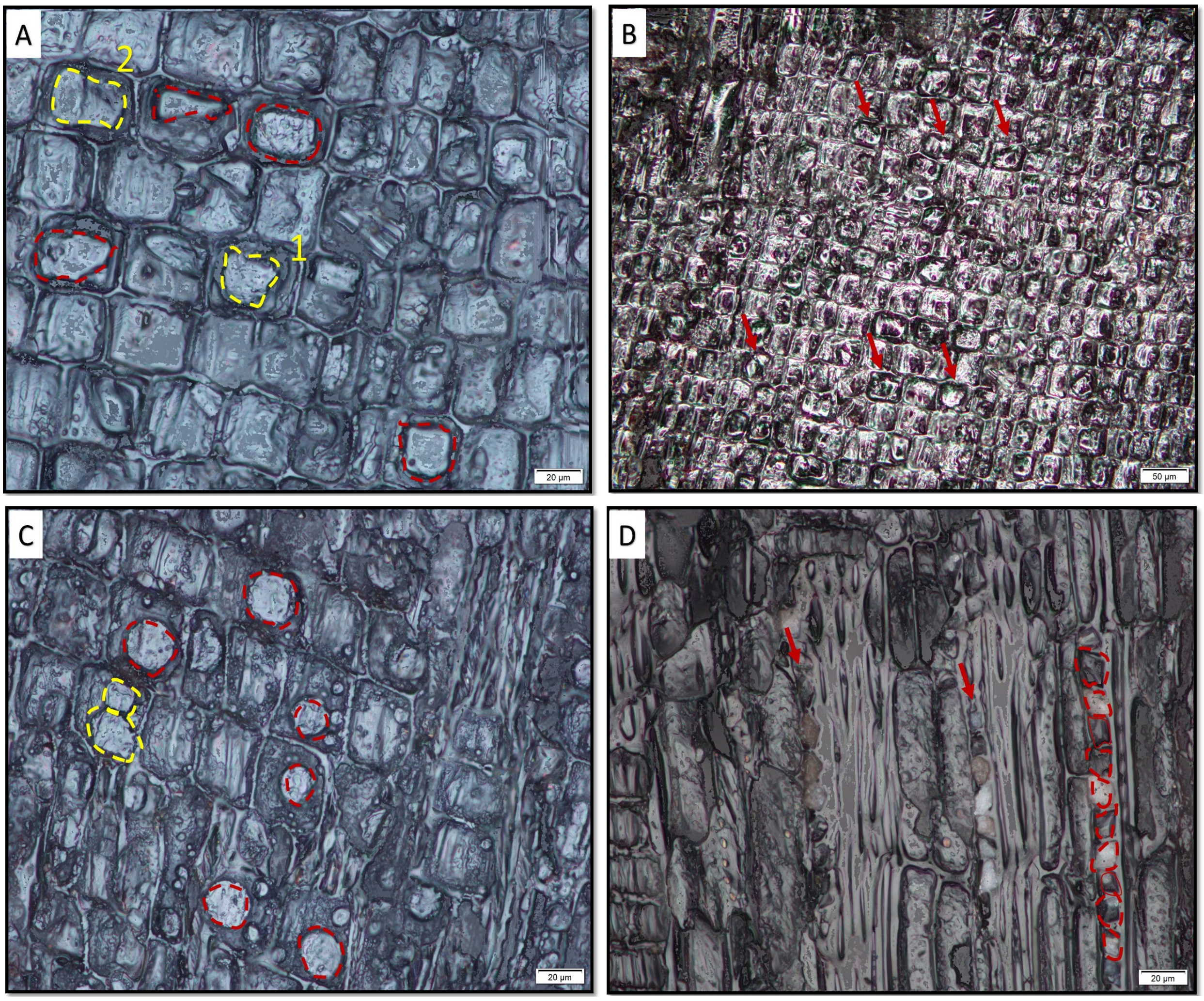



Figure 15 – A) Hearth1 41, TS x200 (*Diospyros* cf. *natalensis*), Red lines = prismatic crystal (IAWA 136), Yellow lines 1 = prismatic crystal in upright ray cell (IAWA 137), and Yellow line 2 = prismatic crystals in procumbent ray cells (IAWA 138), B) Hearth1 41, TS x200 (*Diospyros* cf. *natalensis*), showing prismatic crystals in radial alignment in procumbent ray cells (IAWA 139), C) Hearth1 2, TS x200 (*Diospyros* cf. *natalensis*), Red lines = prismatic crystals and Yellow lines = prismatic crystals in chambered upright ray cell and (IAWA 140/154) and D) PR1 4, TS x200 (*Burkea* cf. *africana*), showing prismatic crystals in chambered axial parenchyma cells or prismatic crystals in fibers (IAWA 142/143). Credits: Roxane Matias, ICArEHB.

# APPENDIX 2

## ANATOMICAL FEATURES (IAWA CODES) IDENTIFIED IN THE CHARCOAL AT PRAIA DO TOFO AND PRAIA DA ROCHA

List of abbreviations: I.V.P = Intervessel pits; G.T.F = Ground tissue fiber; H = Heterogeneous; H.T = Helical thickenings; T.D.V = Tyloses and other deposits in vessels; S.P.P = Simple perforation plate.

**Archaeological Site:** Praia da Rocha 1 (PR1)

**Collection type:** Manual collection and sieve

**Charcoal specimen:** Frag. 43 (Type 1), Frag. 12 (Type 2), Frag. 4 Type 3), Frag. 3 (Type 4), Frag. 65 (Type5), Frag. 109 (Type 6)

**Table 1**

**Summary of wood anatomical features of the archaeological charcoal analyzed from PR1 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGMENTS | VESSESLS GROUPING | IVP | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Diospyros natalensis* – LFA 50 | *N* | 7 | 10 | 22/24 | 61 | N | 40 | 49 | N | 70 | 66 |
| | *Euclea natalensis* – LFA 54 | *N* | 7 | 10 | 22/24 | ? | N | 40/41 | 49 | 58? | 69 | 65? |
| **EBENACEAE** | **Praia da Rocha 1: Type 1 - frag. 43** | ***N*** | **7** | **10/11v** | **22/24** | **N** | **N** | **40/41v** | **47v/48** | **58** | **70** | |
| | *Euclea divinorum* – Tw 28287 | N | 7 | 10/11v | 22/24 | N | N | | 48 | | 69 | 65 |
| | **Praia da Rocha 1: Type 2 - frag. 12** | **N** | **7** | **10 /11V** | **22/24** | **N** | **N** | **40** | **48/49** | **58** | **69** | |
| **LEGUMINOSAE CAESALPINIOIDEAE** | *Afzelia quanzensis* – **LFA 183** | 5 | 7 | 9/10v | 22/25 | N | | 41 | 47 | N | 69 | 66 |
| | *Burkea africana* – LFA 185 | 5 | | 9/10v | 22/26 | 61 | | 42 | 47 | 58 | 69 | 66 |
| **LEGUMINOSAE PAPILIONOIDEAE** | *Xeroderris stuhlmanni* - Detienne unpublished | 5 | | 9/10v | 22/27 | 61 | | 42 | 46 | N | 69 | |
| | **Praia da Rocha 1: Type 3 – frag 4** | | **7** | **9/10v/11v** | **22/27** | **61** | | **42** | **47** | **58** | **69** | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **LEGUMINOSAE CAESALPINOIDEAE** | *Bauphinia galpinii* – LFA 184 | 7 | 9/10v | 22/24/ 25/26 v | 61 | 41 | 48? | 56 | 69 | 65?/ 66 |
| | *Ekebergia capensis* – LFA 89 | 7 | | | ? | 42 | 46v/47 | 56?/58 | 69 | 65/66v |
| **MELIACEAE SAPINDACEAE** | *Bligia unijugata* – PROTA, 1988 | 7 | | 22/25 | 61 | 42 | 46/47 | 58 | 69 | 65 |
| | **Praia da Rocha1. Type 4 – frag. 63** | **7** | **10/11** | **22/24** | | **42** | **46** | **56/58?** | **68** | |
| ***ANACARDIACEA*** **LEGUMINOSAE MIMOSOIDEAE** | *Harpephyllum caffrum* – LFA 2 | | 10 | 22/25 ? | 61 | 41V | 49 | 56/58 | 68 | 66 |
| | *Protorhus longifólia* – LFA 5 | | 10v | 22/24 | 61 | 41 | 49 | 58 | 68 | 66 |
| | *Dichrostachys cinera* – LFA 200 | | 10 | 22/24 ? | | | 49 | 58 | 68 | |
| | **Praia da Rocha 1: Type 5 – frag. 65** | | **10** | | | **41** | **48** | **58** | | |
| **COMBRETACEAE** | *Combretum apiculatum* - LFA 40 | 7 | 9 | 22/24 | 61 | 40 | 48 | | 70 | |
| | *Combretum hereroensi* – LFA 42 | 7 | 9 | 22/24 | ? | 41 | 47 | | 70 | |
| | *Combretum zeyheri* – LFA 43 | 6?/7 | 9 | 22/24 | 61? | 41 | 48 | | 70 | |
| | **Praia da Rocha 1: Type 6 – frag. 109** | **7** | **9** | **22/24** | | **41** | **46** | | **70?** | |

**Table 1 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAY WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFRENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 79 | Y (1/2 – ser) | **N** | 97(1-2) /$<1mm^2$ | | 108 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1/2 – ser) | **N** | 97(1-2) /$<1mm^2$ | | 105 | 116 | 136 | Allott, 2005 |
| **75** | **76** | **N** | **N** | **96//$<1mm^2$** | | **108** | **115V/116V** | **136/137/138** | |
| 77 | 79 | Y (1 – ser) | 86? | 96/97V/102 | | 108 | 116 | 136/137/138/139 | Insidewood, 2014 |
| **77** | **79** | **Y (1 – ser)** | **86?** | **96/97V/102** | | **108** | **115/116** | 136/137/138 | |
| 75 | 79/80/83 | Y (> 4 - ser) | 85/90 | 97/$<1mm^2$ | | 104 | 115 | | Allott, 2005 |
| 75 | 79/80/81/83 | | 85v/86v/89/91v92 | 97/98V/$<1 mm^2$ | | 104/106V | 115 | 136/142v/143v | Allott, 2005 |
| 75 | 79 | Y (> 4 - ser) | 85/89V91/92 | 97/98V | | 104 | 115 | 136/142 | Insidewood, 2014 |
| **75** | **79/83** | **Y (> 4 - ser)** | **86** | **97/98V/102** | | **104/108** | **115** | **136/142?/143?** | |
| 75 | 79? | | | 96/$<1mm^2$ | | 108 | 115 | | Allott, 2005 |
| | 78/79V | | 91/92/93 | 97/98V/$<1 mm^2$ | | 104/106 | 115 | | Allott, 2005 |
| 75 | 78 | | 92V/ | 96/97V/$<1 mm^2$ | | 104 | 115/116 | 136v/137v/138v/ 142 /145/154v | Insidewood, 2014 |
| **75** | **79** | | | **96/97V/$<1 mm^2$** | | **104/106v** | **115** | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 75 | 79 | | 96//<1$mm^2$ | 106/107 | 115 | Allot, 2005; Insidewood, 2014 |
| | 79 | | 96/97V/102 | 104/106V | 115 | Allot, 2005 |
| | 79 | | 96/97V//<1 $mm^2$ | 104? | 115 | Allott, 2005 |
| | | | | | **115** | |
| | 79/80/83 | | 96 | H | 115/116 | Allot, 2005 |
| | 79/80/83 | | 96 | H | 115/116 | Allott, 2005 |
| | 79/80/83 | | 96 | H | 115 | Allott, 2005 |
| **76** | **79/80/81/83** | | **96** | | | |

**Archaeological Site:** Praia da Rocha 4 (PR4)

**Collection type:** Sieve

**Charcoal specimen:** Frag. 1 (Type1), Frag. 18 (Type 2)

**Table 2**

**Summary of wood anatomical features of the archaeological charcoal analyzed from PR4 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGMENTS | VESSESLS GROUPING | I.V.P | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EBENACEAE** | *Diospyros natalensis* - LFA 50 | N | 7 | 10 | 22/24 | 61? | N | 40<br>40/41 | 49 | N | 70 | 66<br>65? |
| | *Euclea natalensis* - LFA 54 | N | 7 | 10 | 22/24 | 61/63 | N | | 49 | 58? | 69 | 65 |
| | **Praia da Rocha 4: Type 1 – frag. 16** | | **7** | **10/11v** | **22/24** | | | **40** | **47/48** | **58** | **69** | |
| **LEGUMINOSAE CAESALPINOIDEAE** | *Bauhinia galpinii* – LFA 184 | | 7 | 9/10v | 24 | | | 41 | 48? | 56 | 69 | 65? |
| | **Praia da Rocha 4: Type 2 – frag. 18** | | **7** | **9?/10v** | **22/24** | **61?** | | **41** | **47/48** | | **69** | |

**Table 2 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAY WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFRENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 79 | Y (1/2 – ser) | N | 97 (1-2) <1mm$^2$ | 13 | 108 | 116 | 136 | Allot, 2005 |
| 77 | 79 | Y (1/2 – ser) | N | 97 (1-2) <1mm$^2$ | | 105 | 116 | 136 | Allott, 2005 |
| **77** | **79** | **N** | | **97 (1-3)** <1mm$^2$ | | **108** | **115/116?** | **136/137/138/139** | |
| 75 | 79? | | | 96 <1mm$^2$ | 13 | 108 | 115 | | Allott, 2005 |
| **75** | **79?** | | | **97** <1mm$^2$ | | **108** | **114?** | **136/137** | |

**Archaeological site:** Praia da Rocha 7 (PR7)

**Provenience:** Sieve

**Charcoal specimen:** Frag. 40 (Type 1), Frag. 18 (Type 2)

**Table 3**

**Summary of wood anatomical features of the archaeological charcoal analyzed from PR7 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGMENTS | VESSESLS GROUPING | I.V.P | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OLACEAE** | *Ximenia caffra – LFA 105* | | 7 | 9 | 22/24 | 61 | N | 40 | *49* | N | *69* | *66* |
| **RUBIACEAE** | *Catanuragem spinosa – LFA 130*<br>*Gardenia volsenkii – LFA 131* | | 7 | 9/10V | 22/24 | 61? | | 40 | *49* | N | *69* | *65?*<br>*66* |
| **SAPOTACEAE** | *Vitellariopsis marginata – LFA 157* | | 7 | 9 | 22/24 | 61? | | 40 | *49* | N | *69* | *66* |
| | **Praia da Rocha 7: Type 1 – frag. 40** | | 7 | 10 | 22/24 | N | | 40 | *49* | N | *69* | ***65*** |
| | | | **7** | **10** | **22/24** | **61** | | **40** | **49** | **58?** | ***69*** | |
| **EBANACEAE** | *Diospyros natalensis – LFA 50* | N | 7 | 10 | 22/24 | 61 | N | 40 | 49 | N | 69 | 66<br>65? |
| | *Euclea natalensis – LFA 54*<br>*Euclea divinorum - IAWA* | N | 7 | 10 | 22/24 | ? | N | 40/41 | 49 | 58? | 69 | 65 |
| | **Praia da Rocha 7: Type 2 – frag. 18** | | 7 | 10/11V | 22/24 | N | N | 40 | 48 | 58 | 69 | 65 |
| | | | **7** | **10/11V** | **22/24** | **61/63** | | | **47/48** | | **69** | |

**Table 3 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAY WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFRENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 78 | | | 97/<1mm$^2$ | 13 | 108 | 115 | N | Allott, 2005 |
| 77 | 79 | | | 96/97v/ <1mm$^2$ | 13 | 108 | 116 | N | Allott, 2005 |
| 75/76? | 78 | | | 97/<1mm$^2$ | 13 | 108 | 115 | N | Allott, 2005 |
| 75 | 78 | | | 96/97v/<1mm$^2$ | 13 | 108 | 116 | | Allott, 2005 |
| **77?** | **79** | | | **97**/<1mm$^2$ | | **108** | **115?** | **136/137/138** | |
| 75 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | 13 | 108 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | | 105 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1-ser) | 86? | 96/97v/102 | | 107/108/109 | 116 | 136/137/138/139 | Allott, 2005 |
| **77** | **79** | | | **97/98/102** | | **107/108/109** | **116** | **136/137/138** | |

**Archaeological Site:** Praia da Rocha 14 (PR14)

**Collection type:** Sieve

**Charcoal specimen:** Frag. 1 (Type1), Frag. 95 (Type 2)

**Table 4**

**Summary of wood anatomical features of the archaeological charcoal analyzed from PR14 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGMENTS | VESSESLS GROUPING | I.V.P | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EBANACEAE** | *Diospyros natalensis - LFA 50* | N | 7 | 10 | 22/24 | 61? | N | 40 | 49 | N | 69 | 66 |
| | *Euclea natalensis* - LFA 54 | N | 7 | 10 | 22/24 | 61/63 | N | 40/41 | 49 | 58? | 69 | 65? |
| | **Praia da Rocha 14: Type 1 – frag. 1** | | **7** | **10/11v** | **22/24** | | | **40** | **47/48** | **58** | **69** | **65** |
| **RUBIACEAE** | *Catanuragem spinosa – LFA 130* | | 7 | 9/10v | 22/24 | 61? | | 40 | 49 | N | 69 | 65? |
| | **Praia da Rocha 14: Type 2 – frag. 95** | | **7** | **10v** | **22/24** | **61** | | **40** | **49** | | **69?** | |

**Table 4 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAYS WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFRENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | 13 | 108 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | | 105 | 116 | 136 | Allott, 2005 |
| **75** | **79** | **N** | | **97 (1-3)/<1mm$^2$** | | **108** | **115/116?** | **136/137/138/139** | |
| 77 | 79 | | | 96/97v/<1mm$^2$ | 13 | 108 | 115 | | Allott, 2005 |
| **77** | **79/84** | | | **96/<1mm$^2$** | | **106/107/108** | **115** | | |

**Archaeological Site:** Praia da Rocha 15 (PR15)

**Collection type:** Sieve

**Charcoal specimen:** Frag. 8 (Type 1), Frag. 28 (Type 2), Frag.  25 (Type 3), Frag. 26 (Type 4), Frag. 20 (Type 5)

**Table 5**

**Summary of wood anatomical features of the archaeological charcoal analyzed from PR15 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGMENTS | VESSESLS GROUPING | I.V.P | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EBANACEAE** | *Diospyros natalensis* – LFA 50 | N | 7 | 10 | 22/24 | 61 | N | 40 | 49 | N | 69 | 66 |
| | *Euclea natalensis* – LFA 54 | N | 7 | 10 | 22/24 | ? | N | 40/41 | 49 | 58? | 69 | 65? |
| | *Euclea divinorum* – IAWA | | **7** | 10/11v | 22/24 | N | N | | 48 | | 69 | 65 |
| | **Praia da Rocha 15: Type 1: Frag. 8** | | **7** | **10** | **22/24** | **61/63** | | **40** | **47/48** | **58** | **69** | **65** |
| | **Praia da Rocha 15 – Type 2: Frag. 28** | | **7** | **10/11v** | **22/24** | | | **40** | **48/49** | **58** | | |
| **ASTERACEAE** | *Brachylaena discolor* – LFA 26 | | 7 | 10/11v | 22/24 | N | N | 40 | 48 | N | 69 | N |
| | **Praia da Rocha 15 – Type 3: Frag. 25** | **N** | **7** | **10/11v** | **22/24** | **61** | **N** | **40/41** | **47** | **58** | **69** | **N** |
| **OLEACEAE** | *Olea capensis* – PROTA, 1988 | 5 | 7 | 10 | 22/24 | 61 | | 40v/41 | 48v/49 | 58 | 70 | 66 |
| **RUBIACEAE** | *Psydrax obovata* subsp. *obovate* - Pearson, 1932 | 5 | | 9v | 22/23v /24v/2 5v | 62/63 | | 41 | 48v/49 | 58v | 69V/70 | 66 |
| **SANTALACEAE** | | 5 | 7 | 10v | 22/24 | 61 | | 41 | 48 | 58 | 69/70 | 66 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Avicennia Marinna* - Fahn, *et al.*, 1986 | | | | | | | | | | | |
| | **Praia da Rocha 15 – Type 4: Frag- 26** | | **7?** | **10?** | **22/24** | | | **40?** | **47?** | **58** | | **69?** |
| CELASTERACEAE | *Gymnosporia Senegalensis* – Détienne unpublished | 5 | | | 22/24 | 61/62/63 | N | 40/41v | 48/49 | 58 | 68/69 | 65/66/67 |
| MYRTACEAE | *Mystroxylon aethiopicum* – LFA 39 | 5 | | | 22/24 | 61 | N | 40 | 49 | N | 70 | 65 |
| | *Syxygium cordatum* - LFA 104 | 5 | | 10v/11v | 22/24 | ? | N | 40 | 49 | N | 70 | 65? |
| | **Praia da Rocha 15 – Type 5: Frag. 20** | **5** | **6** | **9/11v** | **22/24** | | | **40** | **49** | **58** | **69** | |

**Table 5 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAYS WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFERENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 79 | Y (1/2 – ser) | N | 97 (1-2)/$<1mm^2$ | 13 | 108 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1/2 – ser) | N | 97 (1-2)/$<1mm^2$ | | 105 107/108/109 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1-ser) | 86? | 96/97v/102 | | | 116 | 136/137/138/139 | Allott, 2005 |
| **75** | **79** | | | **96/97v/102** | | **107/108** | **115** | **136/137** | |
| **77** | **79** | | | **97/102** | | **107/108** | **116** | **136/137/138** | |
| N | 79/80/83 | N | N | 96 (1-2)/$<1mm^2$ | 13 | 104 | 115/116 | N | Allott, 2005 |
| **?** | **79/83** | **N** | **N** | **96 (1-2)/$<1mm^2$** | **?** | **104/106v** | **115/116v** | **On TS rays** | |
| | 78/79v | | | 97/98v/$<1mm^2$ | 13 | 106 | 115/116 | 150v/152v | InsideWood, 2004 |
| 76/77v | 78 | 80v/81v | 86v | 97/102 | 13 | 106/107/108v | 115 | | InsideWood, 2004 |
| | 78/79 | | | 97v/98v/$<1mm^2$ | 13 | 109 | 115 | 144v/145v/152/154 | InsideWood, 2004 |
| | | | | **96/97v/$<1mm^2$** | **13** | **104/106/107** | **116** | **136/137** | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 75 | 78 | 85 | 97 | 12/13 | 105/108/109 | 115/116 | 136/137/138 | InsideWood, 2004 |
| 75 | | 86 | 97(1-3) | 13 | 106/107 | 116 | | Allott, 2005 |
| N | 79/80/83 | 85 | 96(1-2) | 13 | 104/106 | 116 | | Allott, 2005 |
| **75** | **79** | | **96?** | | **104/106** | **115** | **136** | |

**Archaeological site:** Tofo 1 (Hearth 1 and Hearth 2) and Tofo 2 (Lower level)

**Collection type:** Manual collections

**Charcoal specimen:** Frag. 13 (Type 1 – Heart 1); Frag. 39 (Type 1 – Hearth 2); Frag. 31 (Type 2 – Hearth 2); Frag. 1 (Type 1 – Lower level)

**Table 6**

**Summary of wood anatomical features of the archaeological charcoal analyzed from Tofo 1 and Tofo 2 and comparable references collections with modern and archeological woods**

| FAMILY | TAXON AND CHARCOAL SPECIMEN | VESSELS POROSITY | VESSELS ARRANGEMENTS | VESSESLS GROUPING | I.V.P | G.T.F | H.T | VESSELS DIAMETER | VESSELS DENSITY | T.D.V | FIBERS WALLS | SEPTATE FIBERS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **EBANACEAE** | *Diospyros natalensis* – LFA 50 | N | 7 | 10 | 22/24 | 61? | N | 40 | 49 | N | 69 | 66 |
| | *Euclea natalensis* – LFA 54 | N | 7 | 10 | 22/24 | | N | 40/41 | 49 | 58? | 69 | 65? |
| | **Tofo 1 (Hearth 2: Type 2 – frag. 31)** | **N** | **7** | **10/11v** | **22/24** | | | **40** | **48/49** | **58** | **69** | |
| | **Tofo 2 (Lower Level: Type 2 – frag.6)** | **N** | **7** | **10/11v** | **22/24** | | | **40** | **47** | **58** | **69** | |
| **EBANACEAE** | *Euclea natalensis* - IAWA | | 7 | 10 | 22/24 | ? | N | 40/41 | 49 | 58? | 69 | 65? |
| | **Tofo 1 (Hearth 1: Type 1 - frag. 13)** | **N** | **7** | **10/11v** | **22/24** | | | **40** | **48/49** | **58** | **69** | |
| | **Tofo 1 (Hearth 2: Type 1 – frag. 39)** | **N** | **7** | **10/11v** | **22/24** | **N** | **N** | **40** | **47/48/49** | **58** | **69** | |
| | **Tofo 2 (Lower level: Type 1 – frag. 1)** | **N** | **7** | **10/11v** | **22/24** | **N** | **N** | **40** | **47** | | **69** | |

**Table 6 continued**

| PARENCHYMA APOTRACHEAL | PARENCHYMA PARATRACHEAL | BANDED PARENCHYMA | AXIAL PARENCHYMA | RAYS WIDTH/ WEIGHT | S.P.P | RAY CELLULAR COMPOSITION | RAY FREQUENCY | MINERAL INCLUSIONS | REFERENCES |
|---|---|---|---|---|---|---|---|---|---|
| 75 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | 13 | 108 | 116 | 136 | Allott, 2005 |
| 77 | 79 | Y (1/2 – ser) | N | 97 (1-2)/<1mm$^2$ | | 105 | 116 | 136 | Allott, 2005 |
| **75** | **79** | **N** | | **97 (1-2)/**<1mm$^2$ | | **108** | **116** | **136/137/138/152/154/155** | |
| **75** | **79** | | | **97 (1-2)/**<1mm$^2$ | | **108** | **116** | **136/137/138** | |
| 77 | 79 | Y (1-ser) | | 97 (1-2)/<1mm$^2$ | | 105 | 116 | 136 | Allott, 2005 |
| **77** | **79** | **N** | N | **97/102** | **13** | **108** | **116** | **136/137/138/154** | |
| **77** | **79** | **N** | N | **97/102** | | **108** | **116** | **136/137/138/152/154** | |
| **77** | **79** | **N** | N | **97/102** | | **108** | **116** | **136/137/138** | |

# APPENDIX 3

## TAXONOMIC LIST

**ANARCADIACEAE**

**cff. *Harpephyllum*** – Wild plum

**Specimen: PR1 65**

**Sample description:** Vessel arrangement is in radial lines (IAWA: 7/10). The vessel density is medium ≥ 26-29/mm$^2$ (IAWA: 48). The vessel diameter is between ≥ 61-63 µm (IAWA: 41). The vessels have gums or other deposits in heartwood vessels (IAWA: 58). The ray frequency is ≥ 9/mm (IAWA: 115).

**Identification:** For the taxonomic identification of that Type, only 2 fragments have been identified. Moreover, the fragments are very minute and they are not totally carbonized. For these reasons it was not possible to observe correctly all the features of the three anatomical sections. Having only the transverse plane as a comparison, the taxa with similar anatomical characteristics are: *Acacia ataxacantha, Avicennia marina, Azanza garckeana, Brachystegia spiciformis, Combretum zeyheri, Dichrostachys cinerea* sp.*, Ficus natalensis, Pemphis acidula, Sonneratia alba, Sophora tomentosa* subsp. *tomentosa and Syzygium cordatum.* However, they cannot be any of these species because they have additional anatomical features not present in the sample, such as: axial parenchyma winged-aliform; axial parenchyma confluent (IAWA: 83) and axial parenchyma bands more than three cells wide (IAWA: 85). Looking for other species outside the province, *Harpephyllum caffrum*, located in Maputo province, presents a very similar transversal section with the sample (APPENDIX 2 – TABLE 1). That taxon has in common; vessel arrangement in radial lines; a medium density of vessels; abundant gums or other deposits in heartwood vessels and the ray frequency is less than 12/mm (FIGURE 1). Therefore, the poor conservation of the anatomical structure does not allow all the main sections to be observed and the species identified with certainty. Also, the fact that taxon (*Harpephyllum cafrum)* is not present in the region today led to considering the fragments as cff. *Harpephyllum*.

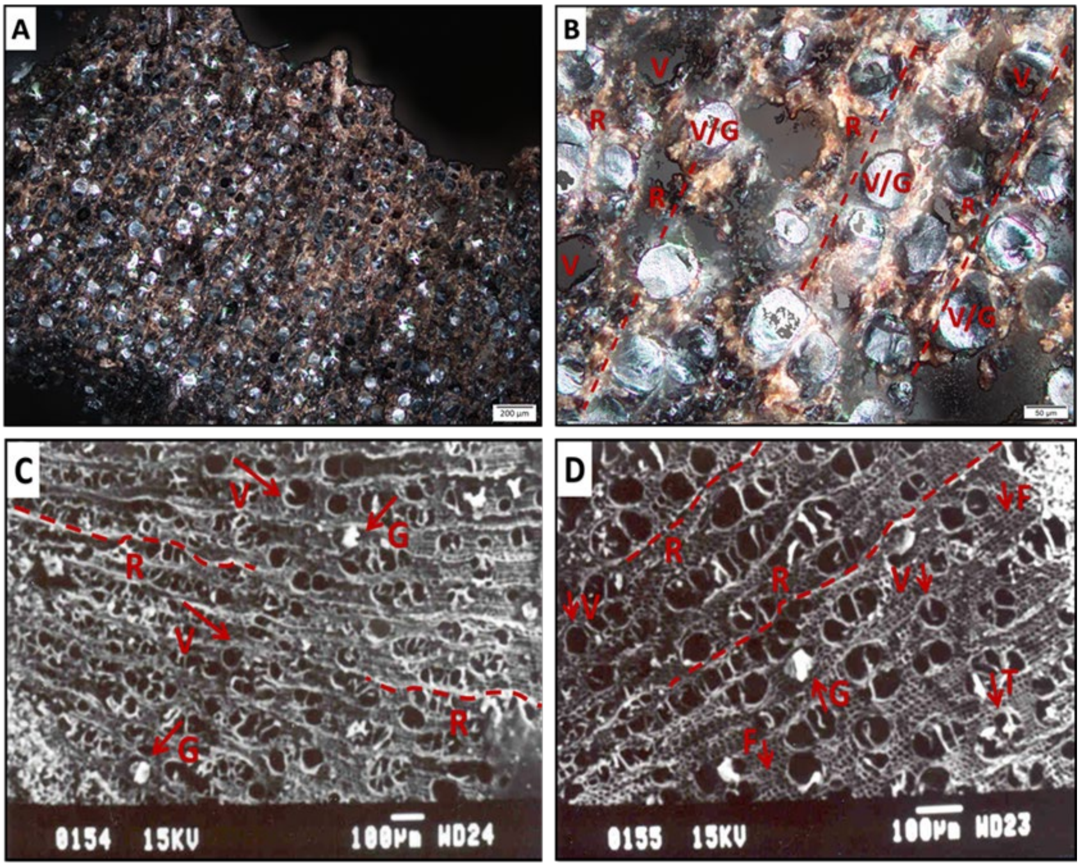



Figure 1 – A and B: PR1 65 (cff. *Harpephyllum*), C and D: LFA 2 – Allott 2005 (*Harpephyllum cafrum*); **A)** TS x200, **G** = Gum or other deposits in the hardwood vessels, **R** = Ray, **V** = Vessel, **C)** TS x50, **G** = Gum or other deposits in the hardwood vessels, **R** = Ray, **V** = Vessel and **D)** TS x200, **F** = Fiber, **G** = Gum or other deposits in the hardwood vessels, **R** = Ray, **T** = Tyloses common, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

## ASTERACEAE

***Brachylaena* cf. *discolor*** – Coast silver oak

**Specimen: PR15 34**

**Sample Description:** Vessel arrangement is in radial lines with some clusters (IAWA: 7/10 /11v). The vessel density is low $\geq$ 10 - 19/mm$^2$ (IAWA: 47). The vessels diameters are between $\geq$ 37 - 69µm (IAWA: 40/41). The intervessel pits are alternate and minute (IWAW: 22/24). They have gums or other deposits in heartwood vessels (IAWA: 58). They have bordered pits on fibers (IAWA: 61). The fiber walls are medium thick (IAWA: 69). The rays are very short and mostly uniseriate and biseriate, as a variation (IAWA: 96). The ray frequency is between $\geq$ 3 - 10/mm (IAWA: 115/116v). The ray type is homocellular. The ray cellular composition is mostly with body procumbent or can be one row of upright marginal cells as a variation (IAWA: 104/106v). On transverse section, rays with prismatic crystals was observed (IAWA: 136). The apotracheal axial parenchyma seems scanty (IAWA: 75) and the paratracheal axial parenchyma is vasicentric and confluent (IAWA: 79/83).

**Indentification:** Inhambane region have a very low density of Asteraceae family trees or shrubs. According to Burrows *et al*., (2018) eight species occur in Mozambique: *Brachylaena discolor*, *Brachylaena huillensis, Chrysanthemoides monilifera* subsp. *Rotundata, Helichrysum kraussii, Pluchea dioscoridis, Vernonia amygdalinaand, Vernonia colorata* subsp. *colorata*. However, these species have different anatomical characteristics compared to the sample except, *Brachylaena discolor* (APPENDIX 2 – TABLE 5). That species has the most anatomical features similar with the sample (FIGURE 2). The similarities observed were the density of vessels, fibers walls medium thick, very short rays, mostly uniseriate and biseriate, rays cellular composition with body procumbent or can be one row of upright marginal cells, as a variation and the paratracheal axial parenchyma vasicentric and confluent (Allott, 2005). To consolidate my data, on Inside wood database (InsideWood, 2004-onwards**)** that species has more feature descriptions matching with the charcoal samples, like bordered pits on fibers and scanty apotracheal axial parenchyma.

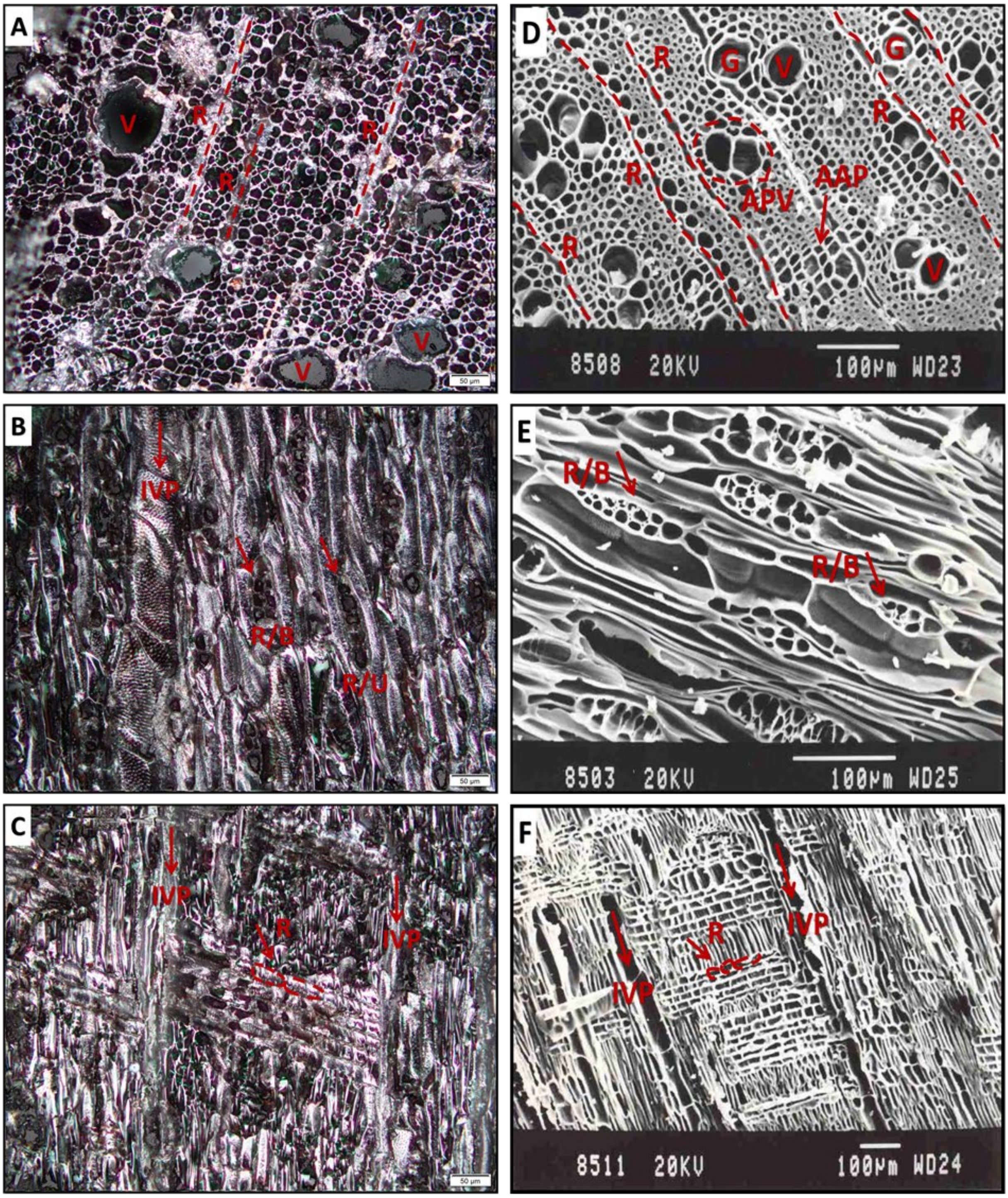



Figure 2 – A, B and C: PR15 34 (*Brachylaena* cf. *discolor*), D E and F: LFA 26 – Allott 2005 (*Brachylaena discolor*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200; **IVP** = Intervessel pit, **R** = Ray, **R/B** = Biseriate ray, **V** = Vessel, **D)** TS, **E)** TLS and **F)** RLS; **AAP** = Apotracheal axial parenchyma, **APV** = Axial parenchyma vasicentric, **G** = Gum or other deposits in the hardwood vessels, **IVP** = Intervessel pit, **R** = Ray, **R/B** = Biseriate ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

## CELASTRACEAE

***Mystroxylon aethiopicum*** – Spoonwood

**Specimen: PR15 20**

**Sample description:** The vessel arrangement is in tangential bands, solitary and with some radials (IAWA: 6/9/10). The vessel density is approximately more than 40/mm$^2$ and the vessel diameter has approximately 29 µm (IAWA: 40/49). They have gums or other deposits in heartwood vessels (IAWA: 58). The intervessel pits are alternate and minute (IAWA: 22/24). The intervessels are long and narrow. The fibers are thin to thick walled (IAWA: 69). The axial parenchyma is absent or extremely rare and the paratracheal axial parenchyma is vasicentric (IAWA: 75/79). Axial parenchyma bands were more than three cells wide (IAWA: 85). The rays are probably short and uniseriate (IAWA: 96?). The ray frequency is between $\geq$ 4-12/mm (IAWA: 115). The ray type is heterocellular. The ray cellular composition is body procumbent with 1-2 rows upright/square (IAWA: 106/107). They have prismatic crystals (IAWA: 136).

**Identification:** Vessel porosity, diameter arrangement, the fibers walls, the ray cellular composition and the axial parenchyma with bands are the principal features for that type. Among the tree and shrub species present in Inhambane, those with the greatest anatomical similarity are *Gymnosporia senegalensis, Mystroxylon aethiopicum* and *Syxygium cordatum* (APPENDIX 2 – TABLE 5). However, the vessel size of *Gymnosporia senegalensis* is large (50-100µm - Détienne 2004-onwards) *Syxygium cordatum* has mostly homocellular rays, different from the sample. Notwithstanding, *Mystroxylon aethiopicum* (LFA 104 – Allott, 2005), has the fibers walls very thick and on the sample was observed fibers walls thin to thick. However, this is the one that present more anatomical features in common with the specimen (FIGURE 3). The main feature comparable between the sample and that specie is the axial parenchyma banded with more than three cells wide (IAWA: 85).

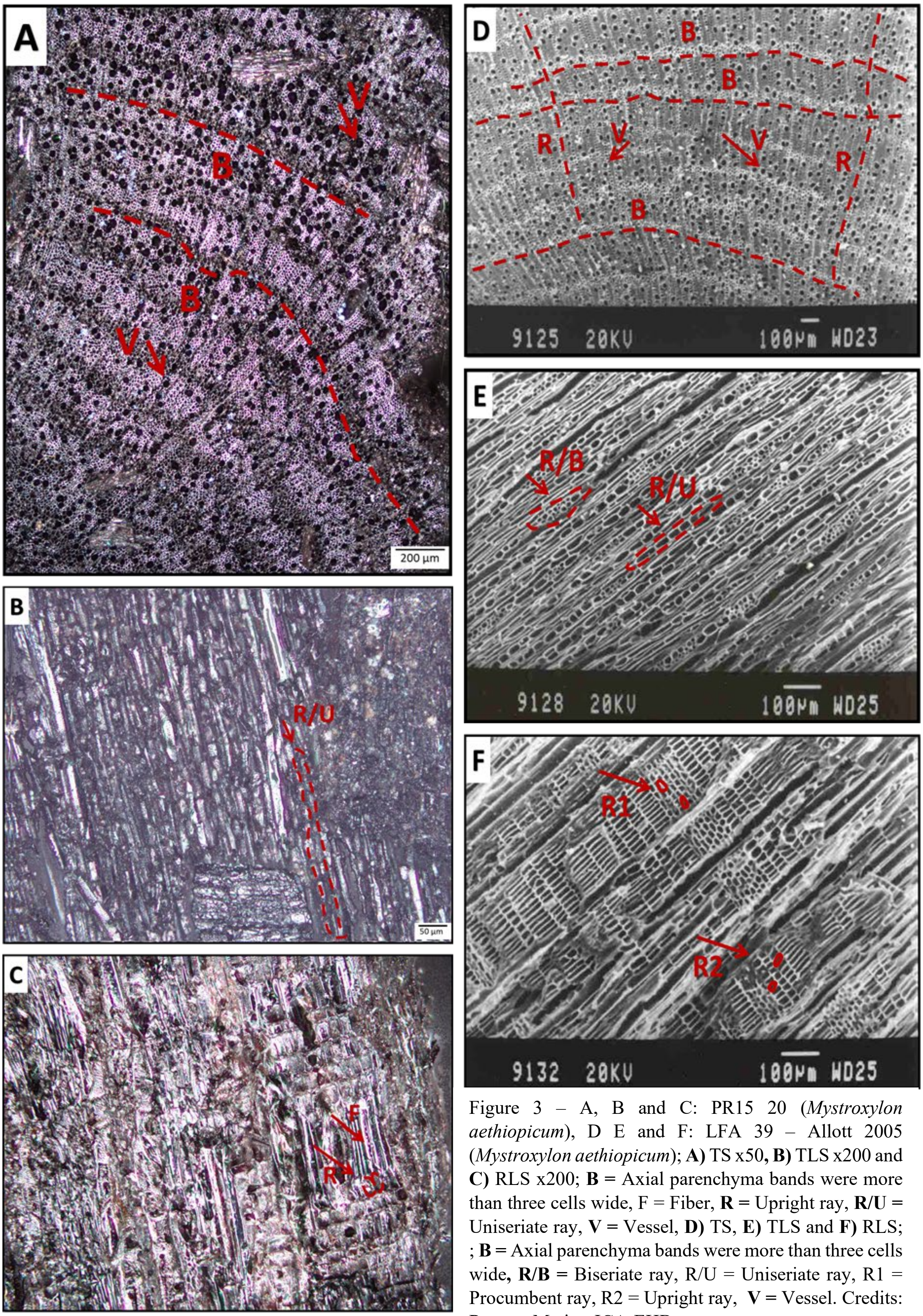



Figure 3 – A, B and C: PR15 20 (*Mystroxylon aethiopicum*), D E and F: LFA 39 – Allott 2005 (*Mystroxylon aethiopicum*); **A)** TS x50**, B)** TLS x200 and **C)** RLS x200; **B =** Axial parenchyma bands were more than three cells wide, F = Fiber, **R =** Upright ray, **R/U =** Uniseriate ray, **V =** Vessel, **D)** TS, **E)** TLS and **F)** RLS; ; **B =** Axial parenchyma bands were more than three cells wide**, R/B =** Biseriate ray, R/U = Uniseriate ray, R1 = Procumbent ray, R2 = Upright ray, **V =** Vessel. Credits: Roxane Matias, ICArEHB.

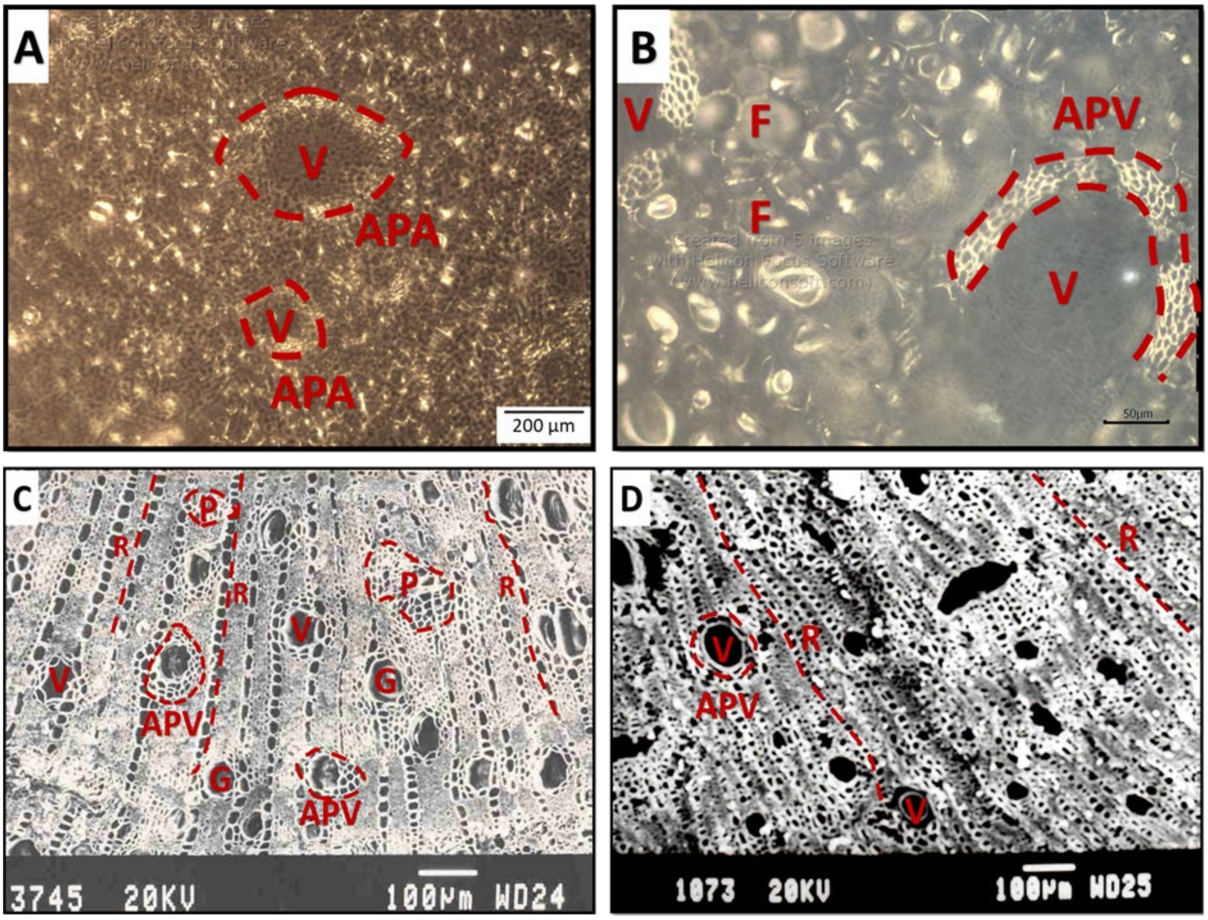
**COMBRETACEAEA**

***Combretum* sp.**

**Specimen: PR1 109**

**Sample description:** The vessel arrangement is in tangential bands (IAWA: 6), mostly solitary (IAWA: 7; 9). The vessel density is mostly very low ≥ 2-3/mm² (IAWA: 46). The vessel diameter is < 100 µm (IAWA: 41?). The fibers walls are very thick-walled (IAWA: 70?). The rays are uniseriate (IAWA: 96?). The apotracheal axial parenchyma is diffuse (IAWA: 76) and the paratracheal axial parenchyma is vasicentric, aliform and confluent (IAWA: 79/80/81/83).

**Identification:** The taxonomic identification was limited due to the anatomic structure which was badly damaged and the fact that just one fragment of that type had been analyzed. The main feature present in this taxon is the fibers which are very thick-walled (IAWA: 70?) The TLS are badly damaged and seem to have exclusively uniseriate rays surrounded by high fibers (FIGURE 4). Due to the size of the fragment it was not possible to observe the RLS section. Among the species present in Inhambane region, there are mainly species of the Combretaceae family that have the most similar anatomical features. Among them is *Combretum apiculatum* supbs. *apiculatum*, *C. hereroensi* and *C. zeyheri* the most similar taxon with the sample (APPENDIX 2 – TABLE 1). *C. apiculatum* supbs. *apiculatum* has a transverse section which is very similar to the sample, especially the vessels and the paratracheal axial parenchyma. *C. hereroensi* and *C. zeyheri* also have similarities but the vessels do not resemble the study sample. However, *C. apiculatum* supbs. *apiculatum* has vessels less than 100 µm but have about 20 to 40 vessels/mm$^2$. This was, due to the poor condition of the sample and the fact that it was not possible to see all the anatomical features and it was not possible to identify the genus with certainty. So it was decided to classify this taxon as *Combretum* sp. and because just one fragment was identified which are badly damaged, mostly due to taphonomic processes.



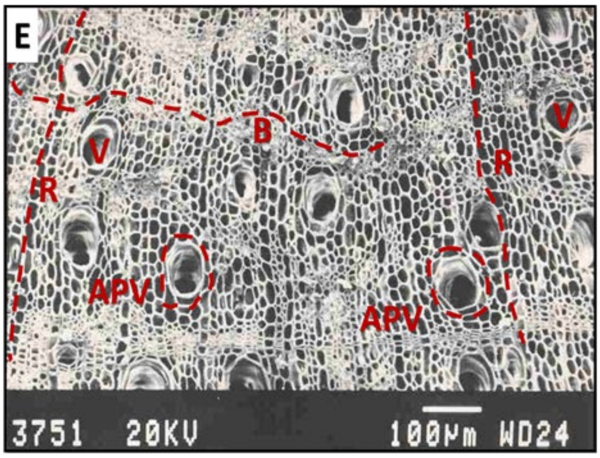




Figure 4 – A, B and C: PR1 109 (*Combretum sp.*), D, E and F: LFA 40, 42 and 45 – Allott 2005 (*Combretum apiculatum, Combretum hereroensii and Combretum zeyheri*); **A)** TS x10, **B)** TS x50; **APA** = Axial parenchyma aliform, **APV** = Axial parenchyma vasicentric, **F** = Fiber, **V** = Vessel, **C)** TS, **D)** TS and **E)** TS; **APV** = Axial parenchyma vasicentric, **B** = Axial parenchyma bands were more than three cells wide, **G** = Gum or other deposits in the hardwood vessels, **P** = Diffuse phloem, **R** = Ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

**EBENACEAE**

***Diospyros* cf. *natalensis*** – Maba natalensis

**Specimen: Hearth1 58**

**Specimen Description:** Vessel arrangement is in radial lines with some clusters (IAWA: 7; 10; 11v). The intervessel pits are alternate and minute (22/24). The vessel density is medium to numerous ≥ 20-55/mm$^2$ (IAWA: 48; 49). The vessel diameter is between ≥ 33.1/ 45.2 µm (IAWA: 40). They have gums or other deposits in heartwood vessels (IAWA: 58). The fiber walls are medium thick (IAWA: 69). The rays are short, (< 1mm) and mostly uniseriate and some are biseriate (IAWA: 96/ 97v (1-2)). The ray frequency is between ≥ 13-21/mm (IAWA: 116). The ray type is heterocellular. The ray cellular composition is mostly body procumbent with over four rows upright/square marginal cells (IAWA: 108). They have prismatic crystals (IAWA: 136; 137; 138), crystals of other shapes (IAWA: 152), some have more than one crystal of about the same size per cell or chamber (IAWA: 154) and others have two distinct sizes of crystals per cell or chamber (IAWA: 155). The axial parenchyma is absent (IAWA: 75) and the paratracheal axial parenchyma is vasicentric (IAWA: 79).

**Identification:** Among the species of Ebenaceae family present in Inhambane region, the sample analyzed is probably a *Diospyros* and possibly *Diospyros natalensis* (FIGURE 5). This taxon has the most anatomical features similar to the sample (APPENDIX 2 – TABLE 1). The similarities observed were the diameter and density of the vessels, fiber walls are medium thick. Short rays are mostly uniseriate with some biseriate and the ray cellular composition is mostly body procumbent with over four rows upright/square marginal cells. In Burrow's book *et al*. (2018), the Ebenaceae tree species present in Mozambique are *Diospyros inhacaensis*, *Diospyros mespiliformis*, *Diospyros natalensis*, *Diospyros retundifolia, Diospyros villosa* car. *Villosa, Diospyros loureiriana* subsp. *Loureiriana, Euclea divinorum, Euclea natalensis and Euclea racemosa* subsp. *sinuate*. Of this set, *Euclea natalensis* subsp. *natalensis* and *Diospyros natalensis* have many similar features with the sample. Therefore, *Euclea natalensis* cannot be because it presents vessels with different diameters and densities and, the apotracheal parenchyma is in narrow bands of more than three cells wide. These features are not present on the sample.

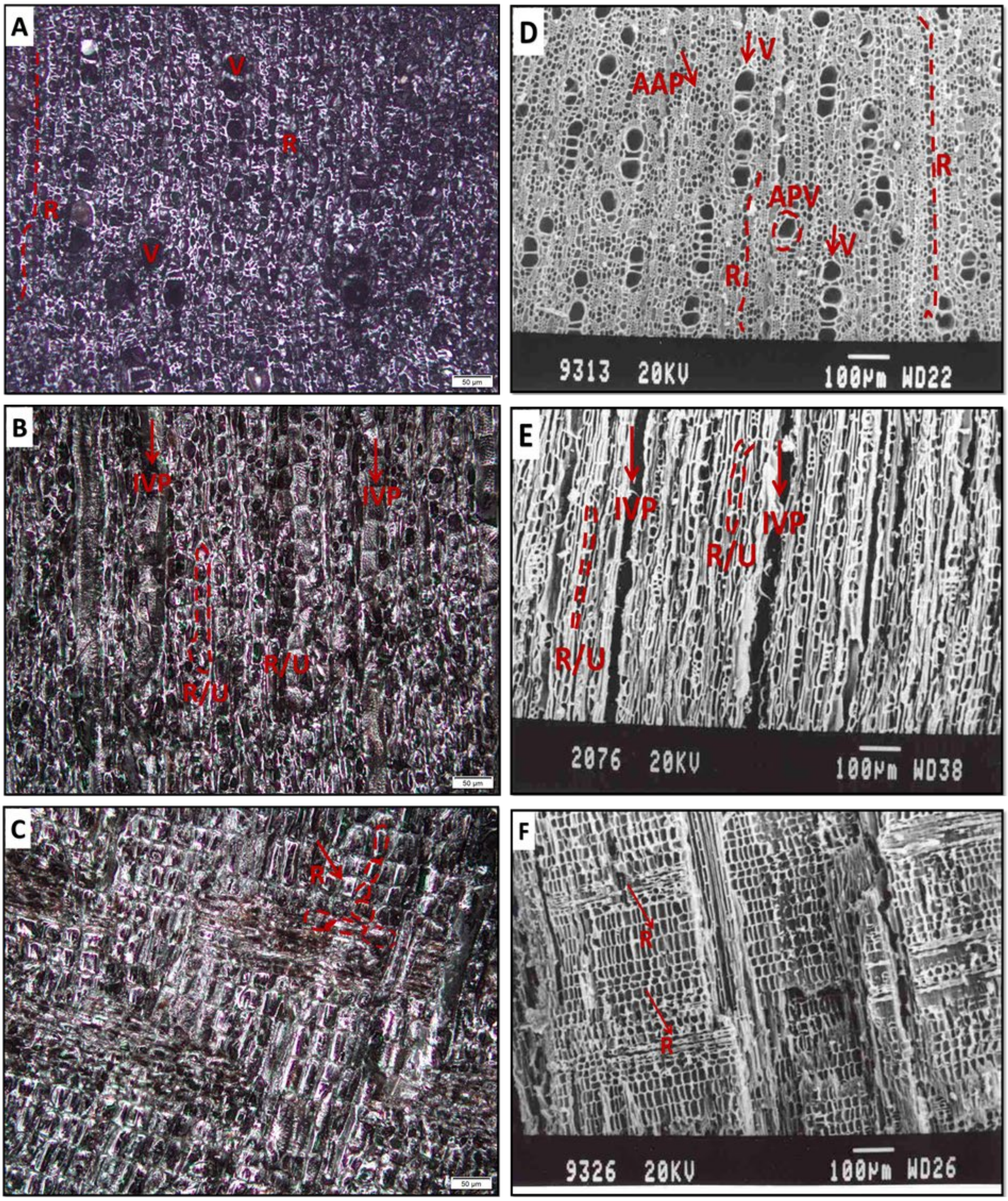



Figure 5 – A, B and C: Tofo 2 Hearth1 58 (*Diospyros cf. natalensis*), LFA 50 – Allott 2005 (*Diospyros natalensis*); **A)** TS x10**, B)** TS x50; **IVP** = Intervessel pit, **R** = Ray, **R/U** Uniseriate ray, **V** = Vessel; **D)** TS, **E)** TLS and **F)** RLS; **AAP** = Axial apotracheal parenchyma, **APV** = Axial parenchyma vasicentric, **IVP** = Intervessel pit, **R** = Ray, **R/U** = Uniseriate ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

*Euclea* **cf.** ***natalensis*** – Magic guarri

**Specimen: PR1 26**

**Sample description:** Vessel arrangement is in radial lines (IAWA: 7/10/11V). The vessel density is low to medium ≥ 9-35/mm$^2$ (IAWA: 47/48). The vessels diameters are between ≥ 27/50 µm (IAWA: 40). They have gums or other deposits in heartwood vessels (IAWA: 58). The intervessel pits are alternate, minute and circular (AWA: 22; 24). The fiber walls are medium thick (IAWA: 69). The rays are high, ≥ 1mm$^2$ (IAWA: 102) and mostly biseriate, triseriate and multiseriate as a variation (IAWA: 97/98). The ray frequency is mostly ≥ to 12/mm (IAWA: 115). They have bordered pits on fibers (IAWA: 61) and some septate fibers (IAWA: 65). The ray type is heterocellular. The ray cellular composition is mostly body procumbent with over four rows upright/square marginal cells (IAWA: 108). They have prismatic crystals (IAWA: 136; 137; 138). The apotracheal axial parenchyma is diffuse-in-aggregates (IAWA: 77) and the paratracheal axial parenchyma is vasicentric (IAWA: 79).

**Identification:** The samples analyzed are probably *Euclea* and possibly *Euclea natalensis* (FIGURE 6). That species has the most anatomical features similar to the samples (APPENDIX 2 – TABLE 1). The similarities observed were the density of vessels, fiber walls medium thick, apotracheal axial parenchyma diffuse-in-aggregates and in narrow bands more than three cells wide, high rays, mostly biseriate and the rays cellular composition are mostly with body procumbent over four rows upright/square (InsideWood, 2004-onwards). Another species present in that region could be match with the charcoal samples is *Euclea divinorum and Diospyros natalensis* (Allott, 2005). Therefore, they have some differences. *D. divinorum* has homocellular rays (IAWA: 105) and short rays (≤ 1 mm$^2$ high). *Diospyros natalensis* has vessels with different density and diameters and without apotracheal axial parenchyma diffuse-in-aggregates or narrow bands of more than three cells wide.

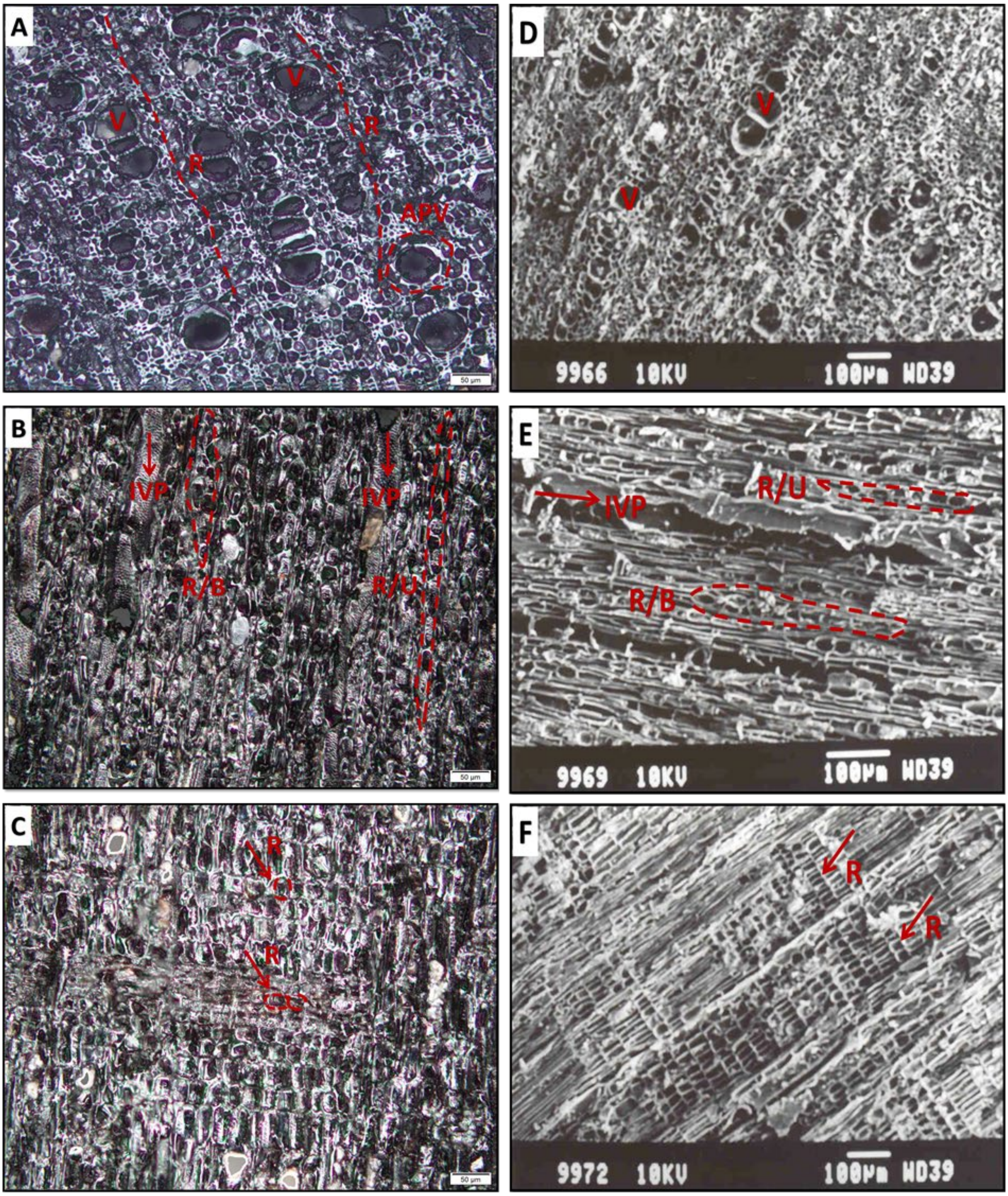



Figure 6 – A, B and C: PR1 26 (*Euclea* cf. *natalensis*), D, E and F: LFA 54 – Allott 2005 (*Euclea natalensis*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200; **APV** = Axial parenchyma vasicentric; **IVP** = Intervessel pit, **R** = Ray, **R/B** = Biseriate ray, **R/U** Uniseriate ray, **V** = Vessel; **D)** TS, **E)** TLS and **F)** RLS; **IVP** = Intervessel pit, **R/B** = Biseriate ray, **R/U** = Uniseriate ray, **V** = Vessel. Author: Credits: Roxane Matias, ICArEHB.

**LEGUMINOSAE CAESALPINOIDEAE**

***Bauhinia* sp.**

**Specimen: PR4 18**

**Sample Description:** Vessel arrangement is in radial lines (IAWA: 7/10). The vessel density is low to medium ≥ 12-27/mm$^2$ (IAWA: 47; 48). The average of the vessels diameter is between 54- 71 µm (IAWA: 41). The fibers are thin to thick walled (IAWA: 69). The vessel is very large and the Intervessel pits are minute and alternate (IAWA: 22/24). The rays are short and uniseriate with some biseriate, as a variation (IAWA: 96/97v). The ray frequency is low ≥ 3/mm (IAWA: 114). The ray type is heterocellular. The ray cellular composition has ray cells upright with body procumbent marginal cells (IAWA: 108). They have prismatic crystals (IAWA: 136; 137). The axial parenchyma is absent or rare (IAWA: 75) and the paratracheal axial parenchyma is vasicentric (IAWA: 79).

**Identification:** Identified as a possible genus of Leguminosae Caesalpinioideae family in Inhambane dwell (Burrows *et al*., 2018 and Wyk & Wyk, 2013): *Afzelia quanzensis, Bauhinia burrowsii, Brachystegia torrei, Brachystegia spiciformis, Burkea africana, Caesalpinia decapetala, Cassia afrofistula, Chamaecrista paralias, Dialium schlechteri, Erythrophleum lasianthum, Guilandina bondue, Julbernardia globiflora, Parkinsonia aculeata, Peltophorum africanum, Piliostigma thonningii, Pterolabium stellatum, Schotia capitate, Senna petersiana* and *Tamarindus indica.* Either the anatomical features are absent in the sample, or the reference material is unavailable. From outside the province, *Bauhinia galpinii*, located in Maputo, Sofala and Manica provinces, presents anatomical structure similar to the sample (FIGURE 7). The similarities observed are mainly the vessel arrangement in radial lines with the vessels mostly solitary (IAWA: 7/9/10v). The vessel diameter and the density of vessels present in 1mm$^2$ are comparable (IAWA: 41/47/48). The parenchyma apotracheal and paratracheal is very similar and the cellular ray composition is body rays cells procumbent with mostly two to four rows of upright marginal cells (APPENDIX 2 – TABLE 2). In Inhambane province there is another genus present, *Bauhinia burrowsii*, but it cannot be compared because there is no anthracological record. Thus, the term sp. was used due to the existence of more than one genus with similar characteristics and because the sample have just four fragments identified which are badly damaged, mostly due to

vitrification.

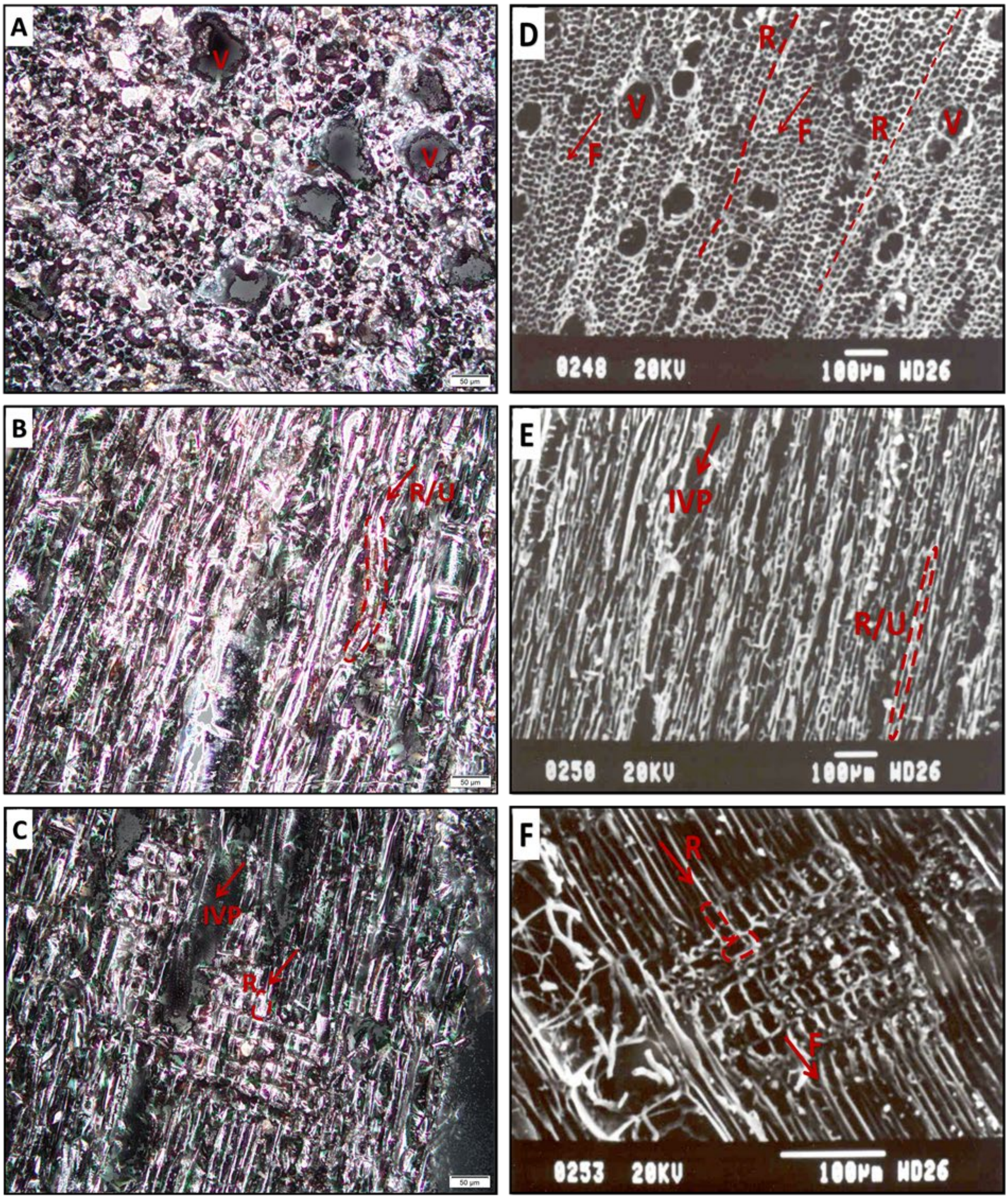



Figure 7 – A, B and C: PR4 18 (*Bauhinia* sp.), D, E and F: LFA 184 – Allott 2005 (*Bauhinia galpinii*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200; **IVP =** Intervessel pit, **R =** Ray, **R/U** Uniseriate ray, **V =** Vessel; **D)** TS, **E)** TLS and **F)** RLS; F = Fiber, **IVP =** Intervessel pit, **R =** ray, **R/U =** Uniseriate ray, **V =** Vessel. Credits: Roxane Matias, ICArEHB.

***Burkea* cf. *africana*** – Wild seringa

**Specimen: PR1 4**

**Sample description:** The vessel arrangement is in tangential bands (IAWA: 6). They are mostly solitary, some are in radial lines and few are clustered (IAWA: 9/10/11v). The vessel density is low ≥ 5-7/mm² (IAWA: 47). The vessel diameter is between 56 ≥ 77 µm (IAWA: 42). The ground tissue fibers have bordered pits (IAWA: 61). They have gums or other deposits in heartwood vessels (IAWA: 58). The intervessel pits are alternate. The pits are large (IWAW: 22; 27). The fiber walls are medium thick (IAWA: 69). The rays are high, > 1mm$^2$ (IAWA: 102) and mostly uniseriate with some biseriate as a variation (IAWA: 96; 97v). The ray frequency is between ≥ 6-9/mm (IAWA: 115). The ray type is mostly homocellular. The ray cellular composition is mostly body procumbent and some with three or more rows marginal upright/square (IAWA: 104/108). The paratracheal axial parenchyma is vasicentric and confluent (IAWA: 79; 83) with banded parenchyma in narrow bands up to three cells wide (IAWA: 86). They have prismatic crystals (IAWA: 136; 138) and crystals in fibers (IAWA: 143).

**Identification:** The three taxa presented, *Burkea africana, Afzelia quanzensis* and *Xeroderris stuhlmannii (*InsideWood, 2004-onwards and Allott, 2005*.),* have the most similar anatomical features with the fragments analyzed (APPENDIX 2 – TABLE 1). In common is vessel porosity (diffuse-porous), vessels are mostly solitary, some are in radial lines and few are clustered, the vessel density is low ≥ -5-7/mm². The ground tissue fibers have bordered pits and the intervessel pits are alternate with large pits. All have fiber walls which are medium thick, paratracheal axial parenchyma is vasicentric and confluent. The rays are uniseriate and some are biseriate and triseriate as a variation and their frequency is between ≥ 6-9/mm. They have prismatic crystals, in fibers or in chambered axial parenchyma cells. Therefore, comparing with the sample, *Xeroderris stuhlmannii* has larger vessel, no presence of gums or other deposits in heartwood vessels and, according with the Inside wood database features *(*InsideWood, 2004-onwards), this genus has no banded parenchyma in narrow bands up to three cells wide. In turn, comparing *Burkea africana* and *Afzelia quanzensis*, both Leguminosae Caesalpiniodeae family, with the sample, *Burkea africana* has more similar features, such as the greater presence of uniseriate rays, paratracheal axial parenchyma is vasicentric or confluent, prismatic crystals are in fibers (FIGURE 8). The term cf. was used due to the existence of more than one species with similar characteristics and because the sample has just five fragments identified as *Burkea* cf. *africana.* Inhambane region has a high density of Leguminous species. In the region 19 different species of Caesalpinioideae occur (Burrows *et al*., 2018 and Wyk & Wyk, 2013). *Xeroderris stuhlmannii,* appertain to the Papilionoideae sub family, which occur in the Inhambane region in dry bushveld.

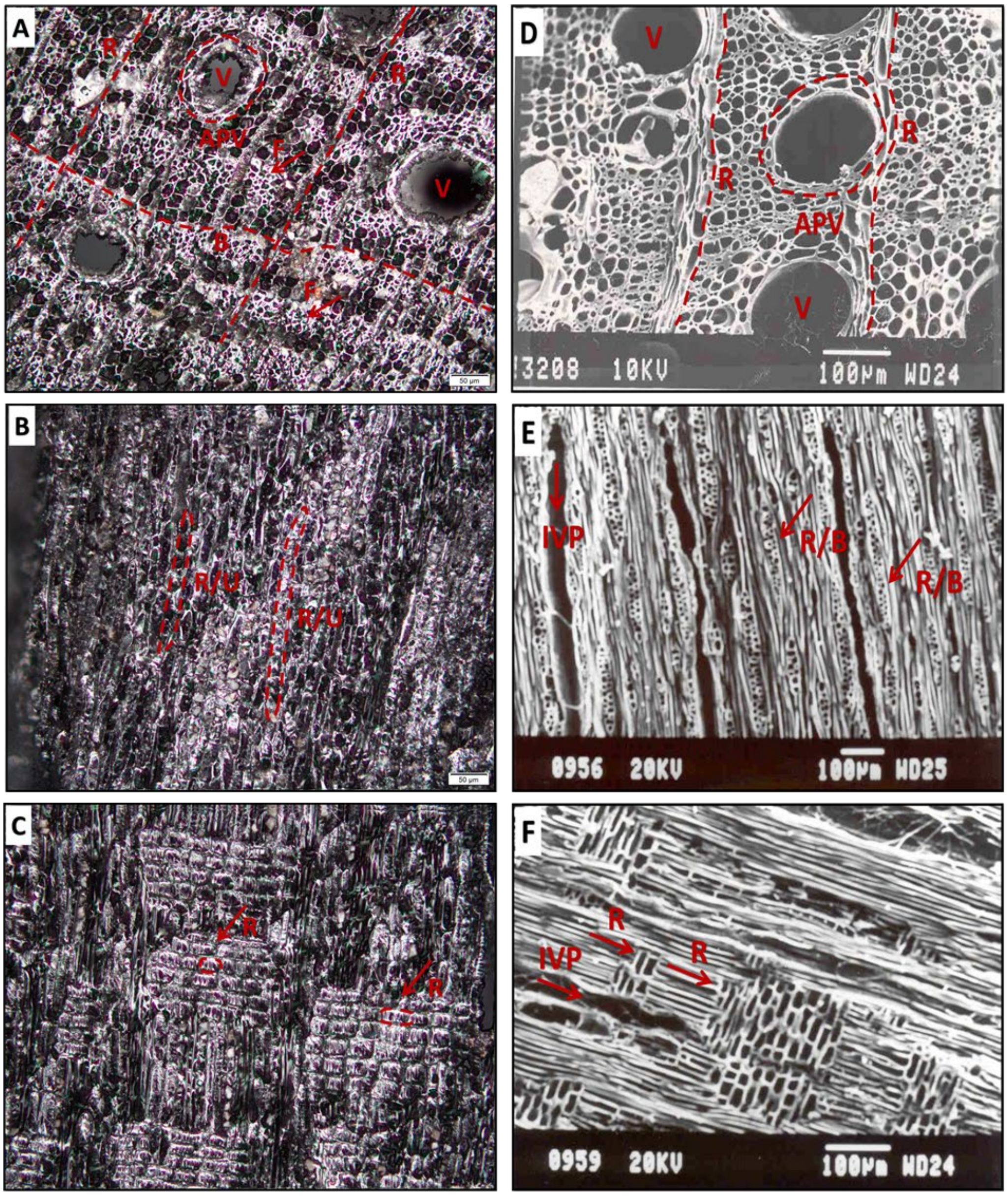



Figure 8 – A, B and C: PR1 4 (*Burkea* cf. *africana*), D, E and F: LFA 185 – Allott 2005 (*Burkea africana*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200; **B** = Axial parenchyma bands were more than three cells wide, **F** = Fiber, **IVP** = Intervessel pit, **R** = Ray, **R/U** Uniseriate ray, **V** = Vessel; **D)** TS, **E)** TLS and **F)** RLS; **APV** = Axial parenchyma vasicentric, **IVP** = Intervessel pit, **R** = ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

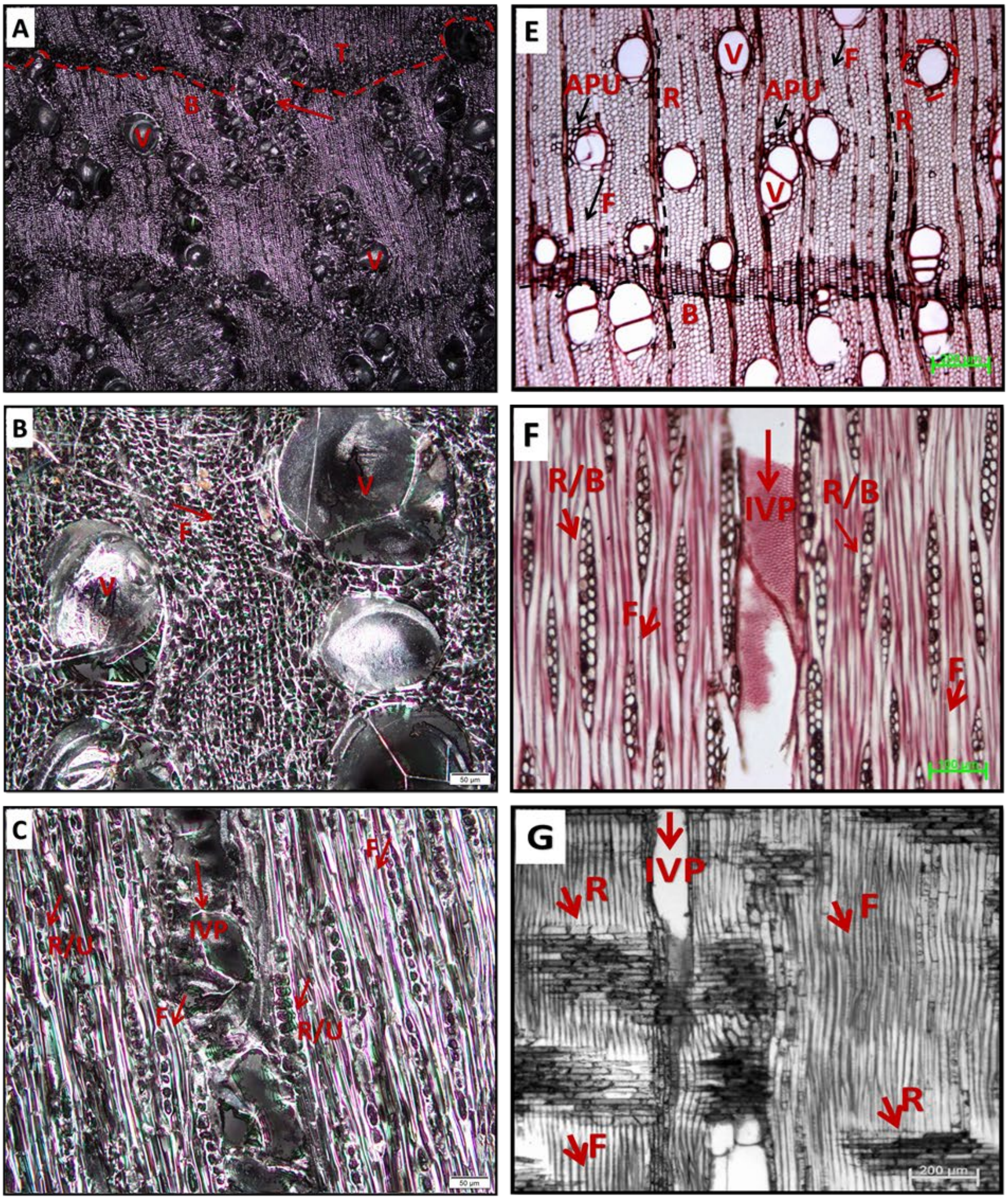
**MELIACEAE**

***Ekebergia* cf. *capensis*** – Cape ash

**Specimen: PR1 63**

**Sample description:** Vessel arrangements are in radial lines with clusters (IAWA: 7; 10; 11). Intervessel pits are minute in size (22/24). The vessel density is mostly very low $\geq$ 2-5/mm² (IAWA: 46). The vessel diameter is between $\geq$ 151/193µm (IAWA: 42). The vessels have common tyloses (IAWA: 56) and they have gums or other deposits in heartwood vessels (IAWA: 58). The fibers walls are very thin (IAWA: 68). The rays are short and mostly uniseriate with some biseriate as a variation (IAWA: 96; 97v). The ray frequency is $\geq$ 10/mm (IAWA: 115). The ray type is homocellular. The ray cellular composition is mostly body procumbent with 1 row upright (IAWA: 104; 106v). The axial parenchyma is absent or scanty (IAWA: 75) and the paratracheal axial parenchyma is vasicentric (IAWA: 79).

**Identification:** Large vessels, less than five vessels/mm², mostly uniseriate rays, with body ray cells procumbent and common tyloses are the principal features of the sample. Among the tree and shrub species present in Inhambane, those with the greatest anatomical similarity are *Blighia unijugata* and *Ekebergia capensis* (APPENDIX 2 - TABLE 1). *Blighia unijugata* do not have common tyloses, one of the principal features. *Ekebergia capensis* is the one that presents more anatomical resemblance with the samples (FIGURE 9), absent from Inside wood (2004-onwards), but common tyloses, axial parenchyma absent or extremely rare, axial parenchyma vasicentric and mostly uniseriate rays completed the description (Allott, 2005). The term cf. was used because the sample has many anatomical features very close to the indicated species and because the sample just has one fragment identified. In the Meliaceae family, from the Inhambane region there are *Entandrophragma caudatum, Khaya anthotheca, Pseudobersama mossambicensis, Trichilia capitate, Trichilia emetica, Turraea nilotica, Turraea wakefieldii* and *Xylocarpus granatum*.



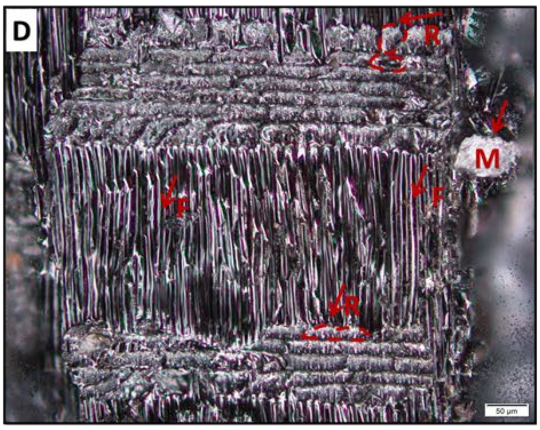




Figure 9 – A, B and C: PR1 63 (*Ekebergia*cf. *capensis*), D, E and F: InsideWood, 2004-onwards (*Ekebergia capensis*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200; **B** = Axial parenchyma bands were more than three cells wide, **F** = Fiber, **IVP** = Intervessel pit, **M** = Mineral inclusion, **R** = Ray, **R/U** Uniseriate ray, **T** = Tyloses common, **V** = Vessel; **D)** TS, **E)** TLS and **F)** RLS; **APU** = Axial parenchyma unilateral paratracheal, **APV** = Axial parenchyma vasicentric, **F** = Fiber, **IVP** = Intervessel pit, **R** = ray, **R/B** = Biseriate ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

**RUBIACEAE**

***Catunaregam* cf. *obovata (= Catunaregam spinosa)*** – Mountain pomegranate or common emetic nut

**Specimen: PR7 40**

**Sample Description:** Vessel arrangement is in radial lines (IAWA: 7; 10). The vessel density is medium to numerous ≥ 40 - 100/mm² (IAWA: 49). The vessels diameters are between ≥ 13-42 µm (IAWA: 40). They have gums or other deposits in heartwood vessels (IAWA: 58). The intervessel pits are alternate. The pits are minute and circular (IWAW: 22; 24). The ground tissue fibers have bordered pits (IAWA: 61). The fibers are thin to thick walled (IAWA: 69). The rays are short and mostly uniseriate and some are biseriate and triseriate (IAWA: 97). The ray frequency is between ≥ 3-8/mm (IAWA: 115). The ray type is heterocellular. The ray cellular composition is mostly body procumbent with over four rows upright/square marginal cells (IAWA: 108). They have prismatic crystals (IAWA: 136; 137; 138). The apotracheal axial parenchyma is diffuse-in-aggregates (IAWA: 77) and the paratracheal axial parenchyma is vasicentric (IAWA: 79).

**Identification:** Identified as a possible genus of Rubiaceae family in Inhambane 51 different genera occur (Burrows *et al*., 2018 and Wyk & Wyk, 2013), of which either anatomical features are absent or reference material is limited. The samples analyzed are probably a *Catunaregam* and possibly *Catunaregam obovata (=Catunaregam spinosa)* (FIGURE 10). That species has the most anatomical features similar with the samples. The similarities observed are mainly the vessels arrangement in radial lines with the vessels mostly solitary. The vessel diameter and the density of vessels present/ mm$^2$ are comparable (IAWA: 40/49) and the cellular ray composition is body ray cells procumbent with mostly two to four rows of upright marginal cells. Comparing the samples with LFA 130 (Allott, 2005), another matching feature is the presence of septate fibers (IAWA: 65). The term cf. was used due to the existence of more than one species with similar characteristics and because almost all the fragments are damaged by diageneses or by the taphonomic process making it difficult to correctly observe all the features, principally in the tangential longitudinal section. Therefore, uniseriate rays were observed and some biseriate and triseriate. Other species that have the anatomical structure similar with the sample are *Gardenia volsenkii*, *Ximenia caffra* and *Vitellariopsis marginata* (Appendix 2 – TABLE 3). *Gardenia volsenkii* has mostly biseriate and triseriate rays and absence of septa fibers. The other two have absence of septate fibers. *Ximenia caffra* has mostly biseriate rays (Allott, 2005).

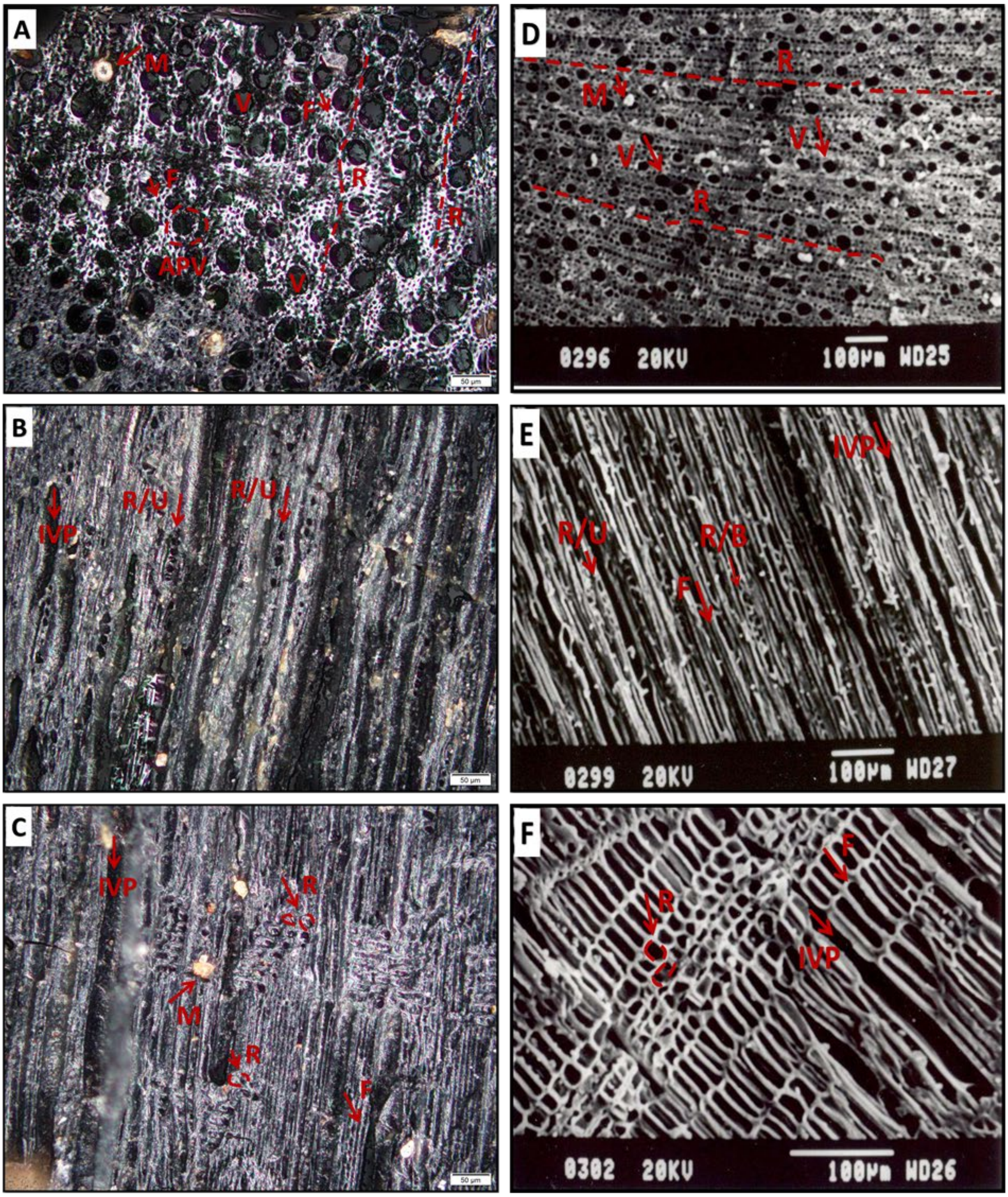



Figure 10 – A, B and C: PR7 40 (*Catanuragem cf. obovata)*, D, E and F: LFA 130 – Allott 2005 (*Catanuragem spinosa*); **A)** TS x200**, B)** TLS x200 and **C)** RLS x200;APV = Axial parenchyma vasicentric, **F** = Fiber, **IVP** = Intervessel pit, **M** = Mineral inclusion, **R** = Ray, **R/U** Uniseriate ray, **V** = Vessel; **D)** TS, **E)** TLS and **F)** RLS; **F** = Fiber, **IVP** = Intervessel pit, **M** = Mineral inclusion, **R** = ray, **R/B** = Biseriate ray, **R/U** = Uniseriate ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

## AVICENNIACEAE

### cff. *Avicennia marina*

**Specimen: PR15 26**

**Sample description:** Vessel arrangements are in radial lines (IAWA: 7? /10?). The vessel density is low ≥ 10-19/mm² (IAWA: 47?) and the vessels diameter is between ≥ 21 - 44µm (IAWA: 40?). The intervessel pits are alternate and minute (IWAW: 22/24). The vessels are short, with simple perforation plates (IAWA: 13). They have gums or other deposits in heartwood vessels (IAWA: 58). The fiber walls are medium thick (IAWA: 69?). The rays are short and mostly uniseriate and some are biseriate, as a variation (IAWA: 96/97v). The ray frequency is between ≥ 4-10/mm (IAWA: 116?). The ray type is heterocellular. The ray cellular composition is body procumbent with 1-3 rows upright/square marginal cells (IAWA: 104/106/107). They have prismatic crystals (IAWA: 136; 137; 138).

**Identification:** The taxonomic identification was limited due to badly damaged anatomical structure, especially in transverse section. It was not possible to correctly observe the diameter and the density of the vessels, the fibers and the rays. In turn, TLS and RLS are better preserved, especially RLS. *Olea capensis*, *Psydrax obovata* subsp. *obovata* and *Santalum album* are the species with more anatomical features matching the charcoal samples (APPENDIX 2 – TABLE 5). Therefore, the first two have no prismatic crystals and *Psydrax obovata* subsp. *obovata* has high rays. *Santalum album* are not present on the region. There are other species in Inhambane that have similar TLS and RLS to *Sclerocarya birrea, Cusonia spicata, Mammea Africana*, *Trema orientalis* and *Avicennia marina*. Therefore, despite limited observation of vessel diameter, the specimen vessels are clearly medium in size, whereas these reference species all have very large vessels. However, *Avicennia marina* seems to be the species with more anatomical features similar with the samples (FIGURE 11). The term cff. was used because in TS the features were limited and the level of certainty is low. However, TLS and RLS have many anatomical features close to the indicated species, namely the ray width (mostly uniseriate), the ray cellular composition and the prismatic crystals.

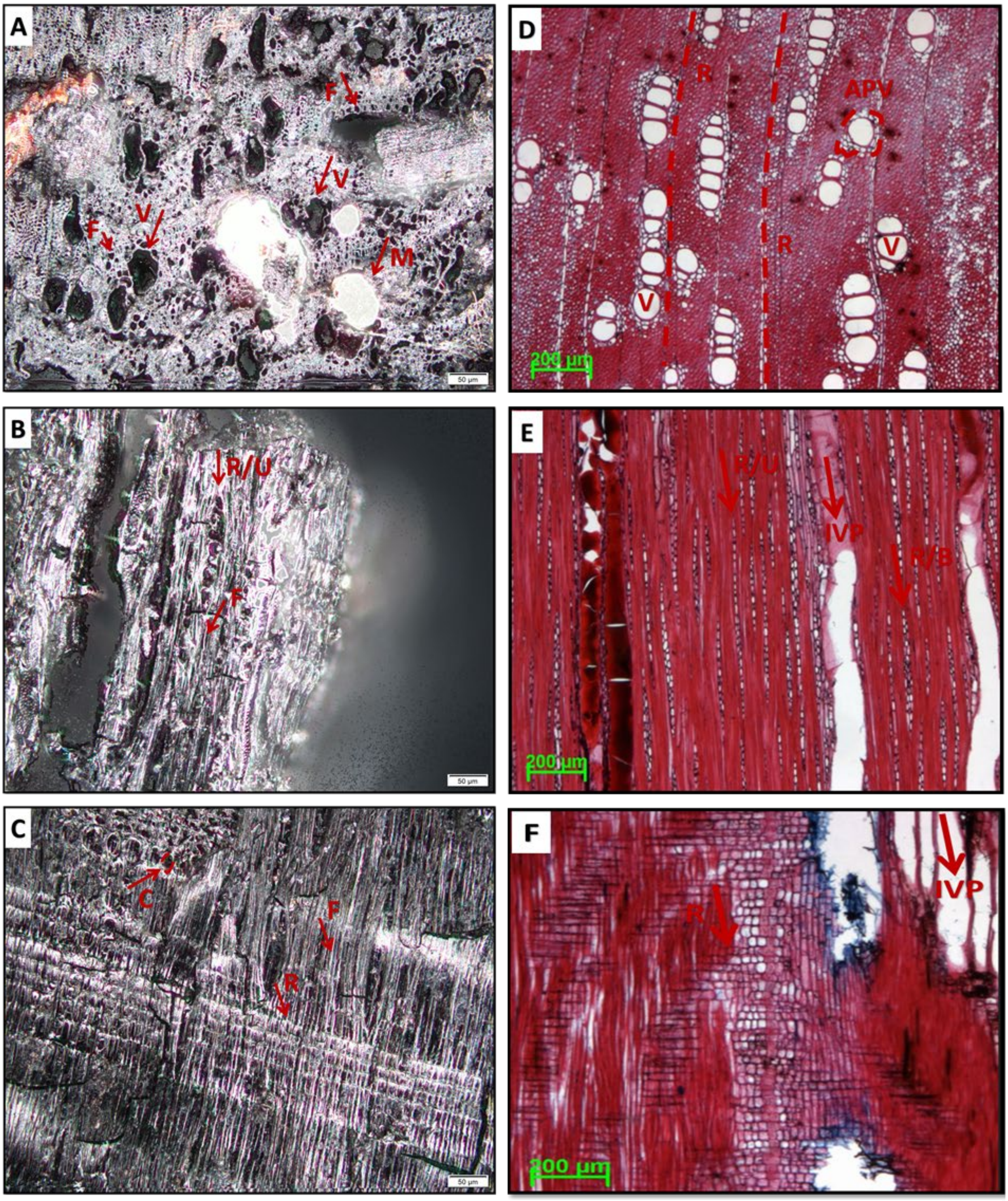



Figure 11 – A, B and C: PR15 26 (*Avicennia* cf. *marina*), D, E and F: InsideWood, 2004-onwards (*Avicennia marina*) **A)** TS x200; **B)** TLS x200 and **C)** RLS x200; **C** = Primatic crystal, **F** = Fiber, **IVP** = Intervessel pit, **M** = Mineral inclusion, **R** = Ray, **R/U** = Uniseriate ray, **V** = Vessel; **D)** TS; **E)** TLS and **F)** RLS; **APV** = Axial parenchyma vasicentric, **F** = Fiber, **IVP** = Intervessel pit, **M** = Mineral inclusion, **R** = Ray, **R/B** = Biseriate ray, **R/U** = Uniseriate ray, **V** = Vessel. Credits: Roxane Matias, ICArEHB.

**Indeterminable**

The fragments identified as Indeterminable demonstrate only some anatomical features, where absence is caused by taphonomic processes. In all fragments it was not possible to observe all the features of the three anatomical planes, as shown in FIGURE 12, which makes the identification difficult. All the features identified point to angiosperm species.

**Indeterminate**

The Indeterminate are those that have the entire cellular structure altered due to combustion as well as taphonomic processes. In these fragments is not possible to identify any anatomical feature (FIGURE 13).

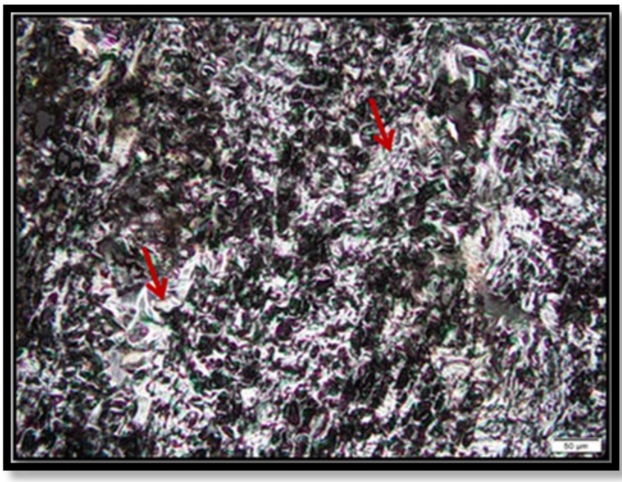


Figure 12 – PR1 9. Showing vitreous aspect on diagenesis. Credits: Roxane Matias, ICArEHB.

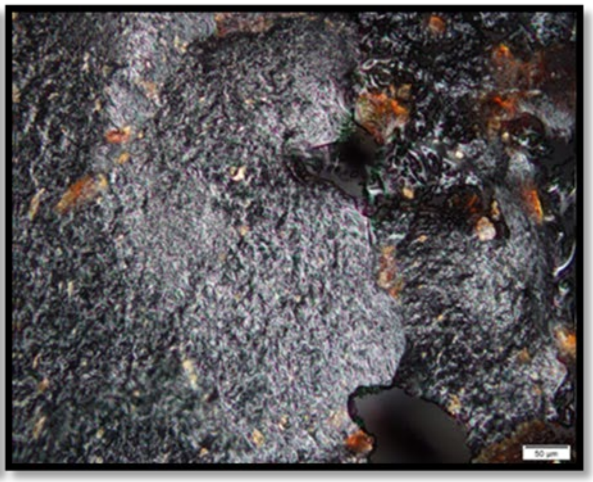


Figure 13 – PR1 75. Showing cellular structure altered due to combustion or taphonomic processes. Credits: Roxane Matias, ICArEHB.