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WOOD FOR CHARCOAL: IDENTIFYING TREE SPECIES FROM ARCHAEO-METALLURGICAL SITES AT CHIGARAMBONI, SOUTHEASTERN ZIMBABWE

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ABSTRACT

Charcoal was the fuel universally employed in smelting and forging metals. Special hardwoods with high caloric content were employed in most African prehistoric metallurgical industries. We focus on the charcoal recovered from Chigaramboni archaeo-metallurgical sites to identify the wood-fuel choices made by the precolonial industrialist workers at the site. The identification and analysis of archaeological charcoal assemblages from Chigaramboni was achieved by using a reflected light microscope and a reference collection of trees from Great Zimbabwe and Chigaramboni. A small range of taxa was selected by the ironworkers at Chigaramboni, including Dichrostachys cinerea, Faurea saligna, Brachystegia spiciformis, Burkea africana *and* Senegalia (Acacia) polyacantha. *We conclude that specific hardwood taxa were sustainably selected from a wide range of local trees so that the historic miombo forests have not changed significantly despite evidence of extensive ironworking.*

Key words: anthracology, Chigaramboni, archaeobotany, archaeo-metallurgy, charcoal studies.

INTRODUCTION

The spread of ironworking technology into and throughout Africa is still a topic of debate in archaeology (Childs 1991; Childs & Killick 1993; Childs & Herbert 2005). However, there is some consensus that between 500 BC and AD 500 the technology spread throughout central and southern Africa (Childs & Herbert 2005). In southern Africa, the technology and use of metals arrived together with Bantu-speaking agro-pastoralist societies (Childs & Killick 1993: 322; Killick 2009).

Metallurgical industry was firmly embedded in the social, political, and economic lifeways of these early farming societies. Metalworking provided agricultural implements and tools, currencies, weapons for war, and culturally significant objects. Arguably, the ability to extract metal from ore offered metallurgists an advantage in political, social, and economic negotiations (Iles *et al*. 2014). One of the most important aspects of the specialist's skill and knowledge base was being able to create and sustain sufficient heat for a successful smelt. This required knowledge of the burning qualities of different woods, and how to create charcoal from wood. A number of studies have highlighted the importance of charcoal in the extraction and smelting of metals (Horne 1982; Friede 1983; Schmidt 1997; Thompson & Young 1999; Iles 2014), but only a handful of researchers have studied the charcoal remains from archaeological smelting sites (Iles 2014). We focus on charcoal excavated by Webber Ndoro in the early 1990s from Chigaramboni, a cluster of iron smelting sites near Great Zimbabwe (Ndoro 1994). In so doing, we hope to initiate a dialogue in southern Africa about what woods were selected for the purposes of smelting iron, and the consequences that metallurgical activities may have had on the surrounding vegetation.

Charcoal from archaeo-metallurgical sites in Zimbabwe, and southern Africa in general, has received limited attention. Studies of prehistoric ironworking industries in these areas have tended to pay more attention to the rituals attached to smelting or smithing, and to understanding how the chemical reduction of the ore was achieved (Childs & Killick 1993; Grant & Huffman 2007; Chirikure 2015). The role that charcoal played as a reducing agent tends to be overlooked, and thus its importance in metal extraction is underplayed.

Horne (1982) drew attention to this point in her study of fuel used in Near Eastern metal production. Horne (1982: 9) argued that charcoal was an essential resource because it fulfilled two key functions: it was able to create a reducing atmosphere; and it could maintain the high temperatures needed to extract metal from ore. Charcoal requires oxygen to burn, but unlike wood and other fuel it has been carbonised, thus emitting carbon monoxide as it burns, which creates the necessary oxygen-starved atmosphere (Horne 1982: 8; see also Thompson & Young 1999: 224). It is for this reason Horne (1982: 8) noted, that charcoal was extensively used in the metallurgical industry until the coking of coal was introduced in the 17th century.

An increase in information about the production of charcoal for the purposes of smelting and smithing became available after the 1970s as a result of a growing interest in the study of the history of metallurgy and ironworking in general (see for example, Küsel 1974; Mackenzie 1975; McCosh 1979; Horne 1982; Friede 1983; David *et al*. 1989; Miller & Van der Merwe 1994; Schmidt 1997). Most of this information was garnered from experimental or ethnographic studies where, although recorded in different countries and regions, they highlight very similar practices. For example, in all cases, fresh wood was harvested for charring. In an account recorded by E.D. Giesekke on charcoal production in Venda, northern South Africa (translated and published in Friede 1983:1), forest trees that were "otherwise of little use" were harvested. Horne (1982: 10) noted in her Near Eastern study that hardwoods were preferred, because they burned with an "especially hot flame" and, that they had to be "cut live". Studies from central to southern Africa similarly underscore that charcoal was produced from hard timber (McCosh 1979), or from wood that produced hard charcoal which would burn slowly (Küsel 1974; Thompson & Young 1999: 224). Additionally, in their northern Cameroon study, David and colleagues (1989) noted that fluxing properties found in trees like *Combretum imberbe* may also have influenced the choice of wood.

In all the documented cases of charcoal production,

charcoal kilns or platforms were prepared and packed full with wood. These kilns were set up in close proximity to the desired trees, and the charcoal was transported in bags or baskets to the furnace (Mackenzie 1975; Horne 1982; Schmidt 1997). Once the wood was alight, the flame was smothered and the charcoal was left to smoulder – a process that could take up to a week (Horne 1982: 11; Friede 1983). In the southern African case, the kiln was observed for the duration of this period, so that in the event of flare-up, a warning could be sounded and the flame brought under control (Friede 1983). Despite being time-intensive, in most cases the process of charring wood was carried out voluntarily or on a part-time basis (Horne 1982: 11; Friede 1983) and could include women and children (Thompson & Young 1999: 227). However, in Tanzania, charcoal production was restricted to smelters (Schmidt 1997), and in northern Togo, to communities that specialised in charcoal making (De Barros 1986).

This research also offered some insight into the amount of fuel required for a smelt. Horne (1982) suggested that the fuel requirements for iron would be less than for copper, and that approximately 10 kg of charcoal would smelt 1 kg of iron. Friede (1983: 1), on the other hand, estimated that 80–90 kg of charcoal would be required to produce a 1.5 kg hoe. His assessment presumably included charcoal used in post-smelting refinement processes. Jensen's (1997: 40–41) description of a smelt in the Fouta Djallon region of Guinea detailed how 200 kg of charcoal was loaded into the furnace chimney and then after an hour, charcoal and crushed ore were loaded repeatedly at different time intervals. This study also indicated that different charcoal was used in the post-smelting operations during which the bloom was refined (Jensen 1997: 42). Schmidt (1997) observed during his study in northwestern Tanzania that stands of *Syzygium guineense* were cut down to make charcoal for the smelt. Trees varying from 8 cm to 50 cm in diameter were cut down, and the charcoal demand was between 130 kg and 180 kg per smelt (Schmidt 1997: 67–69). Schmidt (1997: 70) also noted that different wood was used to make charcoal for smithing. However, in a review of metalwork in sub-Saharan Africa, Miller and Van der Merwe (1994: 24) related how two different types of natural draught furnaces in Malawi used between 1000 kg and 1455 kg of charcoal to complete a smelt that took five days. Swan (2003: 44), in a review of the impact of mining on forests, estimated that roughly 7000 kg of wood would have produced 1000 kg of charcoal. Thus, while the quantity of charcoal burned would have varied according to the type of metal smelted and the kind of furnace used, it is clear that the metallurgical industry would have altered the forests. Furthermore, the regeneration of selected trees would have depended on the numbers removed and the speed at which they could regenerate.

While archaeological charcoals are routinely analysed from most sites, very few studies of charcoal from African metallurgical sites have been carried out (Iles 2014). Part of the reason for this is that charcoal from smelters tends to be poorly preserved, and samples are too small to be meaningful (Eichhorn *et al*. 2013). Researchers working on sites on the western margin of the Dogon Plateau in Mali studied a range of charcoal samples from dated slag heaps to reconstruct an anthracological sequence for the area. This study showed that while many species were incorporated in a smelt, high-quality woods dominated. Similarly, charcoal identified from Munsa sites in western Uganda revealed a broad mix of plant material, but researchers felt that a more extensive comparative base was needed before any generalisations could be made (Iles *et al*. 2014: 53).

Charcoal is obtained by pyrolysis of wood at temperatures between 350–800°C in the absence of oxygen. The temperature and duration of the burning affect the chemical and physical properties of charcoal, but do not affect the internal structure of wood which enables identification (Scholtz 1986; Tusenius 1986; Esterhuysen 1996; Allott 2005; Chikumbirike 2014). It should be stressed, however, that the charcoal examined from smelting sites has been burned twice, which can have an impact on its structural integrity. This is particularly true if the charcoal is produced from wet wood. The structural characteristics of each type of wood are affected by the moisture content, size, time, and temperature of charring (Prior & Alvin 1986: 247). For example, high moisture content in *Dichrostachys* resulted in "considerable ray distention and massive deformation of non-gelatinous fibres" (Prior & Alvin 1986: 243).

Further post-depositional processes affect the charred wood. These post-depositional processes can transform charcoal both quantitatively and qualitatively. These processes include: trampling, surface exposure, sediment moisture and/or acidity, bioturbation, and exposure to microbial organisms that exist in soil (Chikumbirike 2014).

THE STUDY AREA

A number of metallurgical sites were located to the southwest of Great Zimbabwe on the western side of the Chigaramboni Mountain ridge, in an area geologically endowed with iron-rich sedimentary rocks (Fig. 1) (Ndoro 1994). Ndoro (1991, 1994) recorded Early Iron Age sites at the foot of the Chigaramboni range, and more than nine terminal Zimbabwe tradition sites (Refuge period). He also identified several iron smelting furnaces, slag and tuyere mounds within and adjacent to the terminal Zimbabwe sites. Evidence for bellow-driven furnaces was found at three of the sites, while at the other seven sites tuyeres were fused together in groups suggesting that natural draught furnaces may have been used. Although the sites were never dated, Ndoro (1994: 32) noted that it was likely that these were the same sites recorded by Carl Mauch while he stayed with Adam Renders in 1871. Mauch was shown the sites by one of Chief Pika's sons and mentions "broken clay pipes of which often two were joined" (Burke 1969: 137). At this time, these sites were already in ruins and people living in the area claimed not to know who had used them (Burke 1969: 137).

The vegetation in the area is mainly broadleaf, deciduous woodland with open grassy patches. There is a combination of short and tall grasses in the area. Some of the tree species found around Chigaramboni include: *Brachystegia glaucescens*, *Brachystegia spiciformis*, *Diplorhynchus condolycarpon*, *Faurea saligna*, *Ficus* sp., *Grewia* sp., *Julbernardia globiflora*, *Kirkia acuminata*, *Monotes glaber*, *Strychnos madagascariensis*, and *Syzygium* sp. (Chikumbirike 2014). The soil profile ranges from mainly moderately shallow, greyish-brown, coarse-grained sands to similar sandy loams, over reddish-brown sandy clay loams formed on granite. However, the areas around Chigaramboni are characterised by heavy reddish clay soils, and the hills are mainly haematite ironstone with scattered *Senegalia/Vachellia* (*Acacia)* spp. vegetation (Ndoro 1991).

MATERIALS AND METHODS

The charcoal from Chigaramboni was excavated by Ndoro in 1993/4, and a surprisingly good sample of charcoal was recovered during these investigations. Unfortunately, while the samples were stored at the Great Zimbabwe Conservation Centre Museum, the excavation records seem to have been lost.

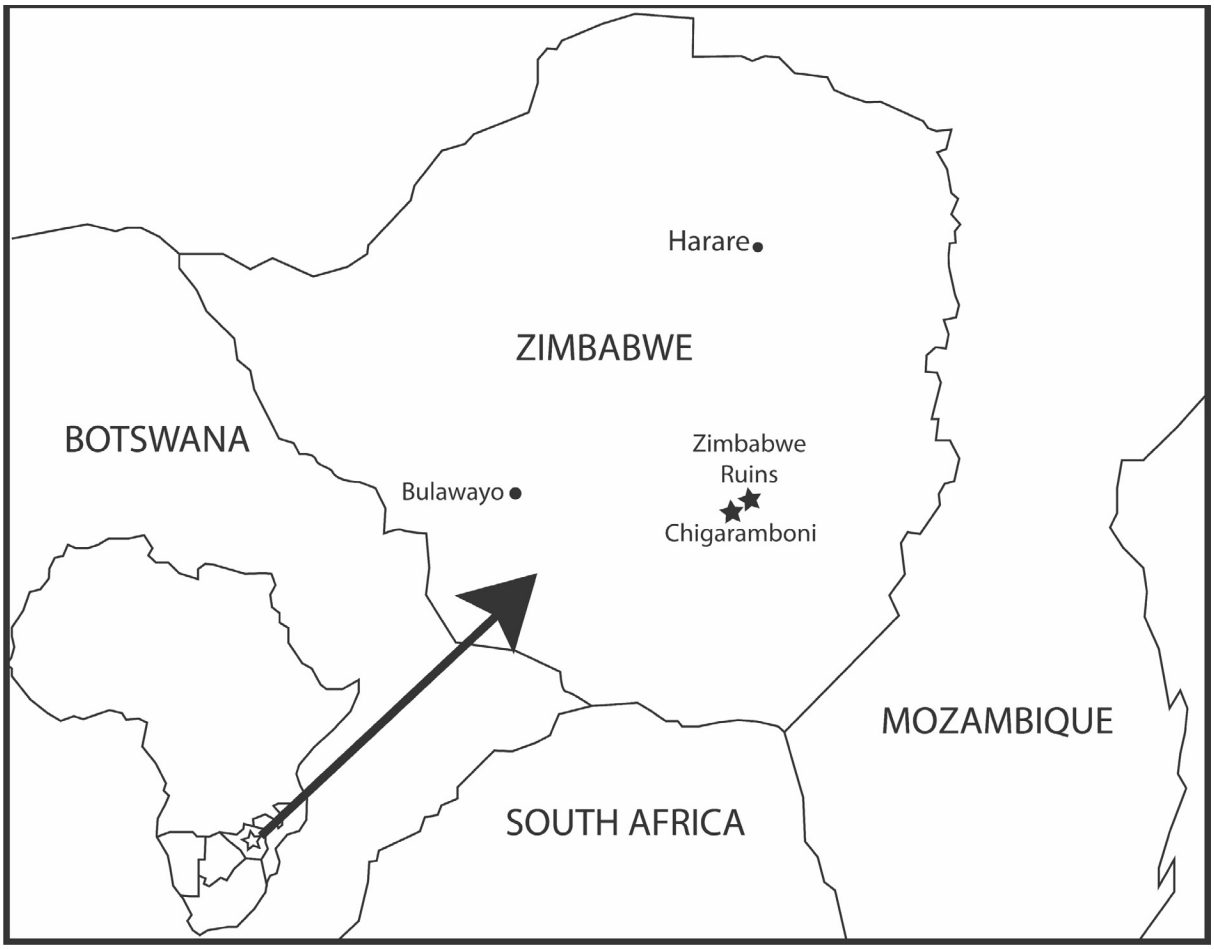

FIG. 1. *Location of the study area.*

We present what data are known, and publish the charcoal data under the names recorded on the bags.

Seven trenches and test pits were excavated systematically within the Chigaramboni area (Fig. 2). The excavated test pits were 1 m × 1 m, while the trenches were more than one square metre in area. Trench 1 and Trench 4 provided evidence of smelting while the other sites may have included past smelting activities. The charcoal under study came from different layers, and also in different quantities. The distribution of the charcoal fragments was not uniform in those arbitrary layers, or between different sites.

The sites have not been dated although they are in the same geographical area and are thought to be of the same period as they exhibited, more or less, the same cultural attributes. The time period for the sites under study is postulated to be the terminal phase of the Great Zimbabwe period. They are all archaeo-metallurgical sites that are believed to have supplied the city of Great Zimbabwe with some of the metal implements needed for various purposes. Regardless of how old or young these sites turn out to be, the charcoal samples provide the opportunity to record the types of woods selected for metallurgical purposes, and data to determine whether these activities had a lasting impact on the woodland.

All the charcoal pieces from the Chigaramboni sites were analysed. The charcoal was prepared in a laboratory using the fracturing technique for preparing macro charcoal. The technique was developed for rapid identification of archaeological charcoals (Esterhuysen 1992, 1996; Chikumbirike 2014; Chikumbirike 2016 *et al*.). Specimens were fractured by manually snapping or pulling apart the fragment of charcoal between the fingers and along the transverse (TS), tangential longitudinal (TLS), and radial longitudinal sections (RLS) for observation. The resultant planes are inevitably irregularly shaped. Specimens were observed with a reflected light microscope at ×50, 100 and 200 magnification. An adequate comparative collection of identified modern woods had to be established to aid with identification of archaeological charcoal, so the collection from Great Zimbabwe (Chikumbirike 2014; Chikumbirike 2016 *et al*.), and other reference material housed in the Evolutionary Studies Institute (ESI) and Archaeology Division (University of the Witwatersrand), was used. The description of the reference collection adhered strictly to the definition of anatomical features published by the International Association of Wood Anatomists (IAWA) committee (Wheeler *et al*. 1989), and to descriptions in Bamford (2005). The reference collection was prepared using the method outlined in Chikumbirike (2014).

RESULTS

It was immediately evident from some of the charcoal that wet wood had been selected for burning. For example, *Brachystegia spiciformis* specimens had bark attached and many of the vessels had ruptured. The impact of moisture on this species was also observed in the modern reference sample (Chikumbirike 2014). With the wood not completely dry, the increased burning temperature is accompanied by an increase of pressure which results in the rupturing of the tissue and the vessels.

A total of 1653 pieces of charcoal was analysed from the nine localities (Table 1). Two of the sites, Trench 1 and Trench 4, were considered smelting sites. These sites also produced the largest quantity of charcoal, 570 and 300 pieces, respectively.

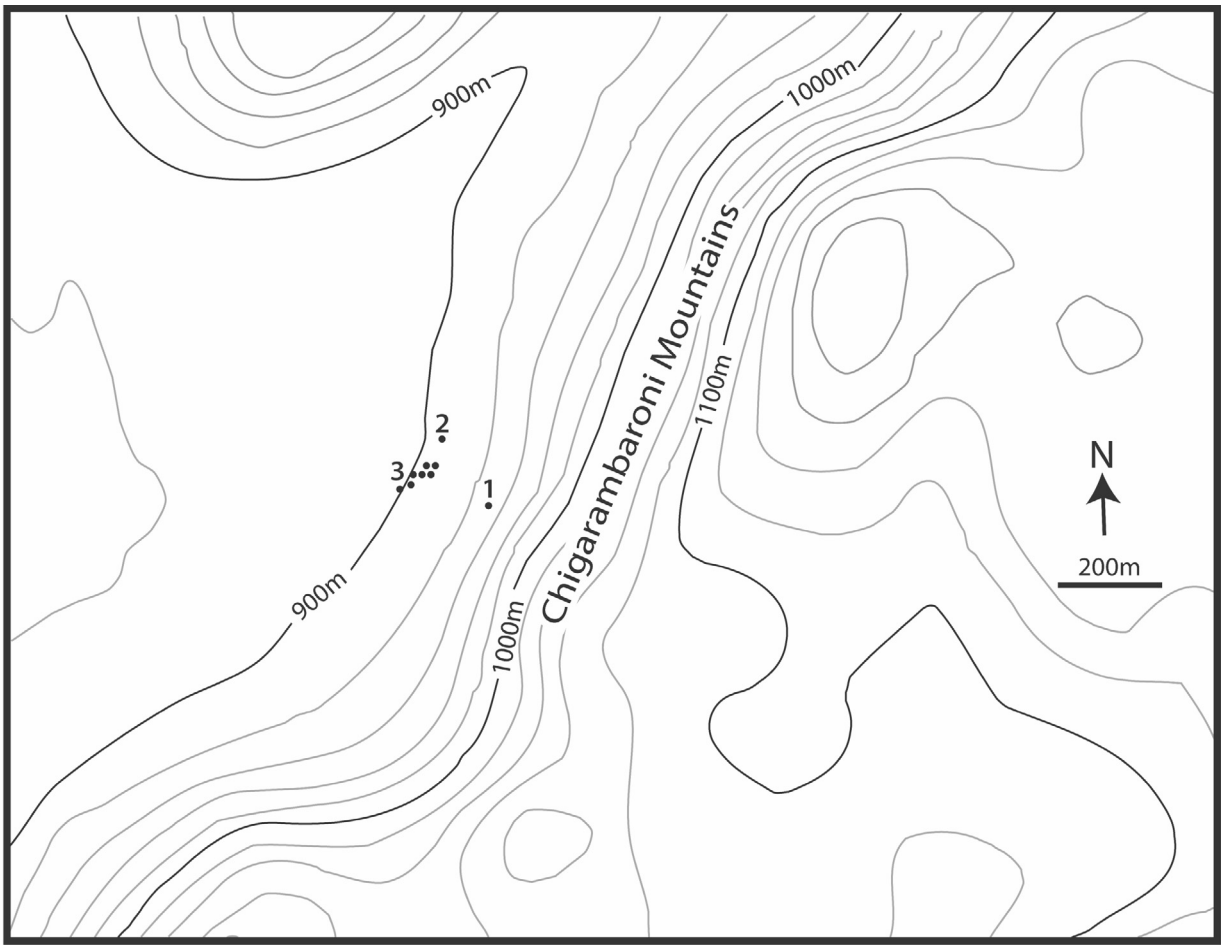

FIG. 2. *The approximate position of the sites based on available data: Chigaramboni* (1)*; Bondolfi* (2)*; a cluster including the road site, trenches and test pits* (3).

TABLE 1. *Species distribution from the Chigaramboni Mountain archaeo-metallurgical sites.*

Species	Chigaramboni	Bondolfi	Road site	Trench 1	Trench 2	Trench 4	Trench 5	Test Pit 5	Test Pit 7	Total
S. mellifera				10						10
Senegalia/ Vachellia (Acacia) sp.				10						10
S. polyacantha			253	416	11			5		685
V. tortilis			10					10		20
Araliaceae			2							2
B. boehmii		85		31		300			25	441
B. spiciformis	111			25			131		7	274
D. cinerea	5			48			31	43	3	130
F. saligna	2		18					18	2	40
F. macnaughtonii				20						20
K. africana									6	6
P. rotundifolia				6						6
S. brachypetala									2	2
Solanaceae				2						2
Non-identifiable				2					3	5
Total	118	85	283	570	11	300	162	76	48	1653

The other seven sites were more ambiguous and may also have included post-smelting activities. These included the Road Site (283 pieces), Trench 5 (162 pieces), Chigaramboni (118 pieces), Bondolfi (85 pieces), Test Pit 5 (76 pieces), Test Pit 7 (48 pieces), and Trench 2 (11 pieces).

The highest represented taxa were *Senegalia (Acacia) polyacantha* and *Brachystegia boehmii,* respectively (Table 1 & Table 2), which were recovered predominantly from the smelting sites. While smelting activities at Trench 1 included a wide range of taxa, only *B. boehmii* was recovered from Trench 4. *Brachystegia spiciformis* and *Dichrostachys cinerea* were the third and fourth most highly represented taxa; *B. spiciformis* was

TABLE 2. *Identification of charcoals from Chigaramboni: Key anatomical features, reference material and references.*

Species	Family	Key anatomical features used to distinguish species (for full description, see references). Note: dimensions are for charcoal and not living wood.	Reference material	References
Senegalia (*Acacia*) *mellifera*	Mimosoideae	Vessels solitary <100 μm diameter; Parenchyma aliform to mostly confluent to banded. Rays homocellular, procumbent, 1–3 but mostly 2 seriate.	fig. 91	Chikumbirike 2014: 165
Senegalia/Vachellia (*Acacia*) sp.	Mimosoideae	Vessels in short radial multiples. Parenchyma vasicentric to aliform to confluent. Rays homocellular, procumbent; width variable, height greater than 13 cells (Kigelia).	n/a	Allott 2006; Chikumbirike 2014; Chikumbirike *et al.* 2016
Senegalia (*Acacia*) *polyacantha*	Mimosoideae	Vessels mostly solitary; >100 μm diameter; <5 V/mm^2. Parenchyma vasicentric, not abundant. Rays 4 or more seriate, 300–500 μm high; homocellular, procumbent.	Not illustrated	Chikumbirike 2014
Vachellia (*Acacia*) *tortilis*	Mimosoideae	Vessels in short radial multiples 1–3, >100 μm diameter and 5V/mm^2. Parenchyma aliform (to confluent), abundant. Rays 2–3(–4) cells wide; homocellular, procumbent; *c.* 10–20 cells high. Prismatic crystals in parenchyma cells.	fig. 87	Chikumbirike 2014: 161
Araliaceae	Araliaceae	Vessels in 1–3 radial multiples; <50 μm diameter and >40 V/mm^2. Parenchyma rare. Rays 1–3–5 seriate with procumbent body cells and square to upright marginal cells.	Appendix A; figs in Appendix B	Allott 2006
Brachystegia boehmii	Caesalpinoideae	Vessels solitary and 2–4 radial multiples; diameter 85 μm; average 13 V/mm^2. Parenchyma confluent to banded and including vessels. Rays uniseriate, rarely biseriate; 2–16 cells high; weakly heterocellular mostly procumbent body cells and square marginal cells. Prismatic crystals in parenchyma and ray cells.	Z116, fig. 51	Chikumbirike 2014: 118
Brachystegia spiciformis	Caesalpinoideae	Vessels 1–3 in radial multiples; diameter 60 μm; average 22 V/mm^2. Parenchyma vasicentric to lozenge-shaped to confluent. Rays 1–(2) seriate, 4–20 cells high, heterocellular with mixed procumbent to upright cells. Prismatic crystals in parenchyma and ray cells.	Z42, fig. 34	Chikumbirike 2014: 101
Dichrostachys cinerea	Mimosoideae	Vessels mostly solitary, rarely 2–8 in radial multiples; diameter 75 μm; average 25 V/mm^2. Parenchyma aliform, confluent to banded. Rays 1–3 seriate, heterocellular with mixed procumbent, square and upright cells; idioblasts with crystals.	Z06, fig. 12	Chikumbirike 2014: 78
Faurea saligna	Proteaceae	Vessels solitary, tangentially arranged to diagonal; diameter 36 μm; average 133 V/mm^2. Parenchyma confluent and banded. Rays very wide 1–18 cells, aggregate rays, heterocellular with mixed procumbent, square and upright cells.	Z38, fig. 32 Appendix A no. 114; figs in Appendix B	Chikumbirike 2014: 99; Allott 2006
Faurea macnaughtonii	Proteaceae	Vessels solitary, in tangential bands; 50–100 μm diameter; 20–30 V/mm^2. Parenchyma vasicentric, banded (narrow but frequent). Rays very wide and high, 8–12+ seriate; body cells procumbent with 1–2 rows marginal square cells.	fig. 101	Kromhout 1975; InsideWood database
Kigelia africana	Bignoniaceae	Vessels solitary, <100 μm diameter. Parenchyma abundant; aliform to confluent. Apotracheal bands >4 cells wide; parenchyma strands 2–4 cells long. Rays 3–4 seriate, homocellular procumbent; rays 10–13 cells high.	Appendix A no. 30; figs in Appendix B	Allott 2006
Pterocarpus rotundifolius	Papilionoideae	Vessels 1– (2–3) radial multiples, diameter 58 μm, average 44 V/mm^2. Parenchyma aliform, and apotracheal banding. Rays 1–2 seriate, idioblasts; uniseriates homocellular to weakly heterocellular; biseriates heterocellular with body cells mixed square and procumbent; marginal cells square. Fibres rarely septate.	Z50, fig. 38 Appendix A no. 209; figs in Appendix B	Chikumbirike 2014: 105 Allott 2006
Schotia brachypetala	Caesalpinoideae	Vessels in radial multiples up to 8 cells; average diameter 50 μm. Parenchyma aliform to confluent to banded including vessels. Rays of two sizes: uniseriates weakly heterocellular; 3–4 seriates with mixed procumbent, square and upright cells.	Z141, fig. 53 Appendix A no. 187; figs in Appendix B	Chikumbirike 2014: 120 Allott 2006

present at four of the sites, while *D. cinerea* was recovered from five. *Faurea saligna*, *Faurea macnaughtonii* and *Vachellia (Acacia) tortilis* were also present in numbers, but only *F. saligna* was present at four of the sites. The least represented was the taxon *Schotia brachypetala*, and the families Solanaceae and Araliaceae, which were each represented by two pieces.

DISCUSSION OF THE ARCHAEOLOGICAL FLORA

In the Chigaramboni area, there are well over 100 species of hardwoods today, but only a limited number of species were selected for iron smelting and associated processes. Although we acknowledge that not all charcoal would have survived, we also note that woods like *M. glaber* (Mackenzie 1975) and *S. gerrardii* (Küsel 1974) that featured prominently in the ethnographic record, did not occur archaeologically.

Approximately 13 species were exploited in the Chigaramboni area, and some taxa are represented by more fragments than others. The number of fragments has been recorded, but is only used in a general sense in the interpretation because it may not directly reflect abundance or dominance of usage. This could have been due to a number of factors that include: the sampling method; physical properties of the taxa burned; the amount of oxygen that was exposed to the fire; the duration of the burn; and other taphonomical processes. Some charcoal woods are more brittle than others and so would produce more fragments. In addition, other wood species may produce only ash and no charcoal remains. A species presence, rather than its quantity, at more than one site is probably a better indicator of its popularity as a wood used in the production of charcoal for smelting and smithing.

Woods would have been selected for their burning properties and thus represent a subset of the local woody flora. The species can therefore be used to a limited extent to indicate past vegetation, but more importantly, the woods can give an idea about iron smelting wood preferences.

The *Senegalia/Vachellia* (*Acacias)* are prominent at the Trench 1 smelting site, and although *S. polyacantha* appears to have been used more broadly, all species are known to produce good fuel (Timberlake *et al*. 1999; Palgrave 2002). Most of the *Senegalia/Vachellia* (*Acacia)* species identified have a limited environmental range and provide good proxies for past environments. *Senegalia* (*Acacia) polyacantha* occurs in open woodland and the alluvium of small rivers. It is distributed on red or black clay soils under moderate rainfall conditions. *Senegalia* (*Acacia) mellifera* occurs in dry bushveld and semi-desert areas, often on Kalahari sands. It has a scattered distribution in Zimbabwe and is normally restricted to patches of a few individuals at low to medium altitudes (300–1200 m). It is associated with calcareous clays (Timberlake *et al*. 1999). *Vachellia (Acacia) tortilis* occurs in highveld and grassland; it is also found

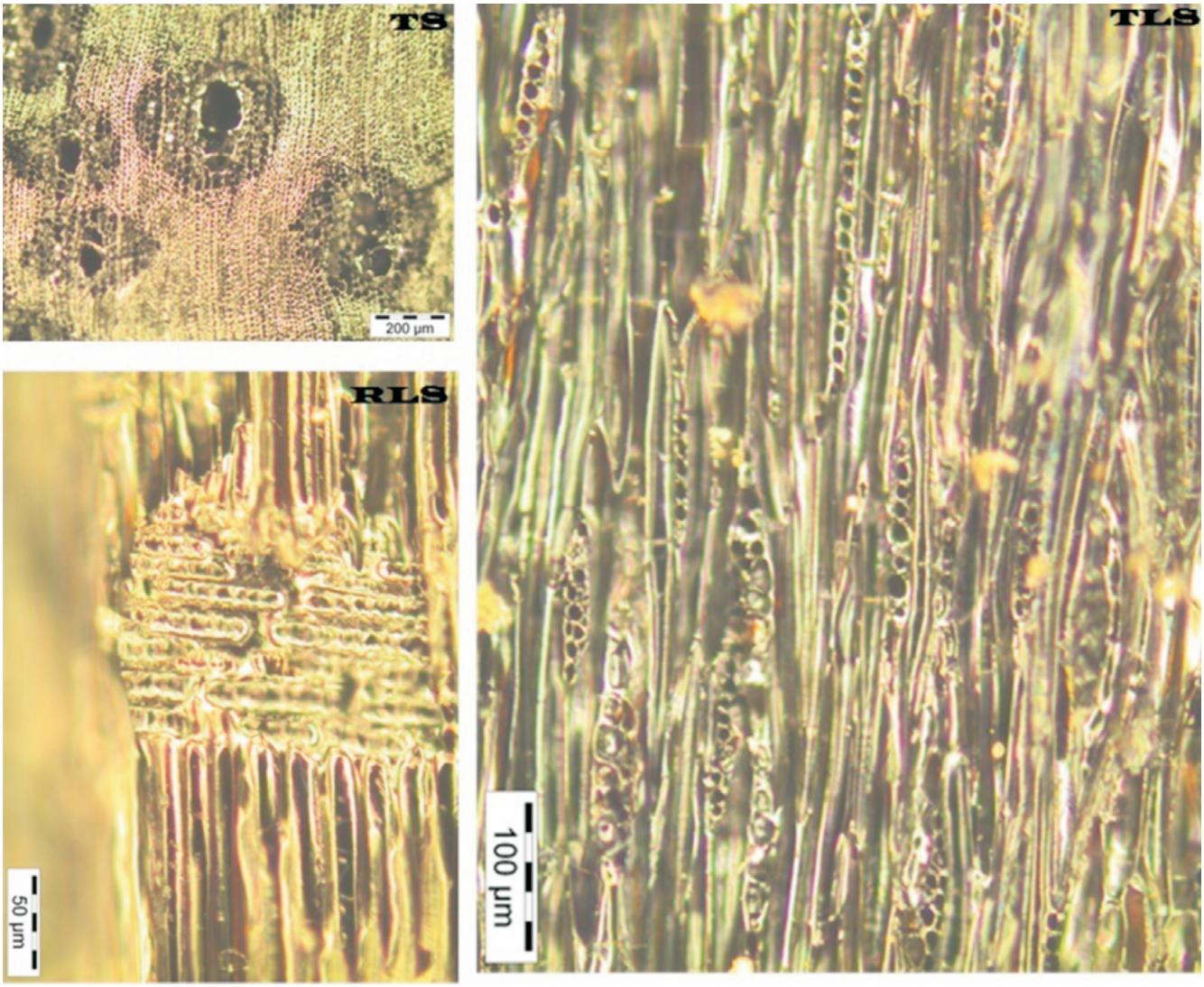

FIG. 3. Dichrostachys cinerea, *C-T1-L3-a, Chigaramboni, Trench 1. TS: transverse section; TLS: tangential longitudinal section; and RLS: radial longitudinal section.*

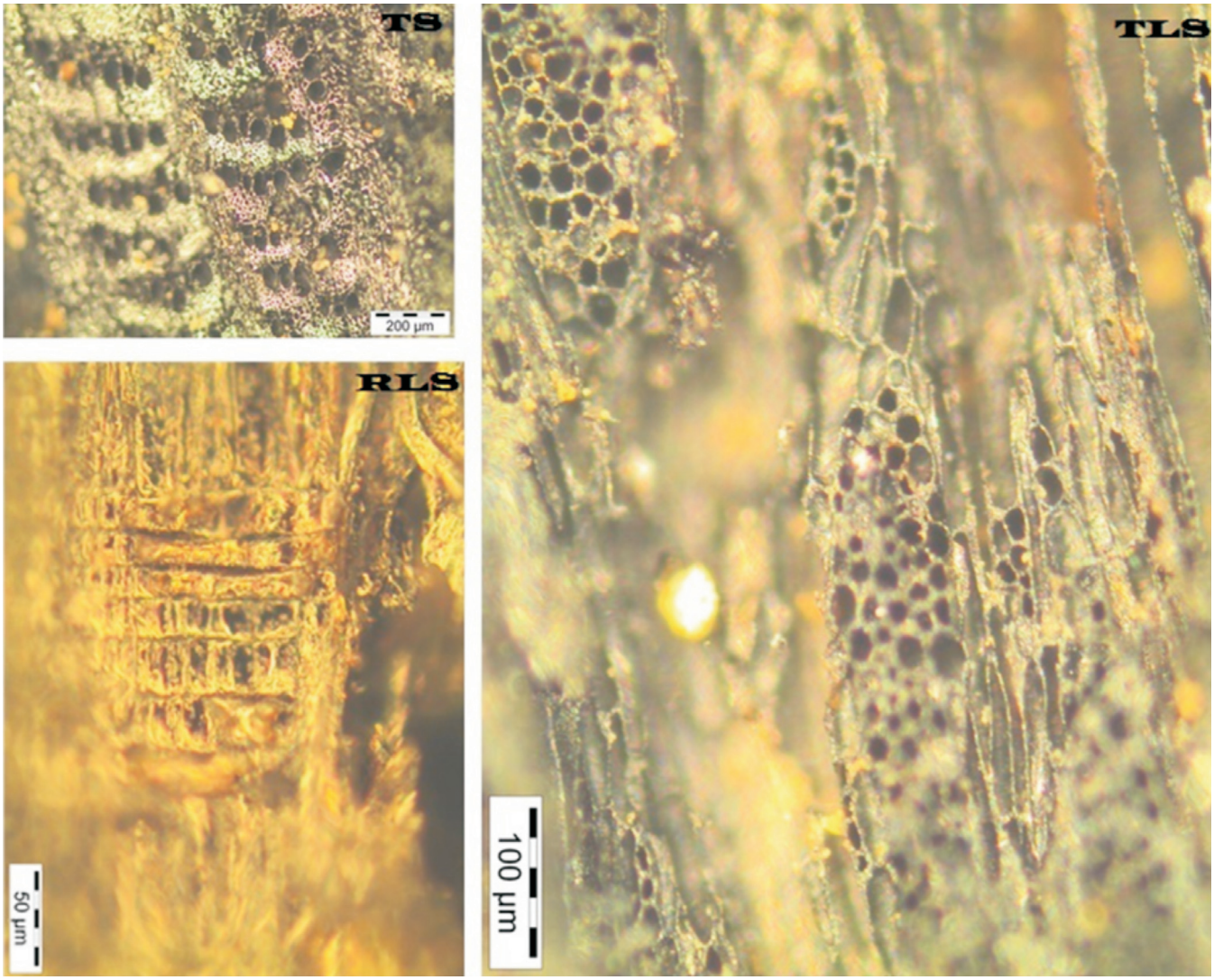

FIG. 4. Faurea saligna, *CP-TP7. TS: transverse section; TLS: tangential longitudinal section; and RLS: radial longitudinal section.*

in hot, drier conditions and is regarded as a bush rangeland encroacher (Timberlake *et al*. 1999). Today, the *Senegalia/Vachellia (Acacia)* species in the Chigaramboni area is less diverse than that which appears in the archaeological record. This may imply some measure of over-exploitation, or that the smelters of Trench 1 travelled further afield to obtain their charcoal.

Brachystegia spiciformis and *B. boehmii* both featured at the Chigaramboni sites (Table 2). Identification of the species focused on key anatomical features, reference material and references (Table 2). If the archaeological interpretation is that Trench 4 is only a smelting site, this would suggest that *B. boehmii* was preferred for this activity. *Brachystegia spiciformis* is a characteristic of miombo woodlands growing in association with *J. globiflora*, and is tolerant of a wide range of soil types (Drummond & Coates-Palgrave 1973; Palgrave 2002). *Brachystegia boehmii*, on the other hand, occurs in woodlands, particularly on poorly drained soils and rocky slopes (Palgrave 2002). *Brachystegia spiciformis* and *B. boehmii* are found in the area today. The smelters of Trench 4 thus appear to have harvested the local wood for the purposes of their smelt.

Dichrostachys cinerea was found at five of the Chigaramboni metallurgical sites. The charcoal fragments were found in the same context as iron slag and haematite, which may imply that it was part of the charcoal-ore mix fed into the furnaces. *Dichrostachys cinere*a (Fig. 3) is known to be a slow burner, and the plant is also known for its regenerative properties (Van Wyk & Van Wyk 1997). *Dichrostachys cinerea* is most commonly found at low altitudes and the trees grow 5–6 m tall; it also grows in all types of soils and in impoverished or overgrazed ground (Drummond & Coates-Palgrave 1973; Venter & Venter 1996; Van Wyk & Van Wyk 1997; Palgrave 2002).

Faurea saligna (Fig. 4) was identified at four of the metallurgical sites but at neither of the smelting sites. It is widely available but may have been sought after as a smithing coal. A few specimens of *S. brachypetala*, *K. africana* and *B. africana* were recovered from one Test Pit (7). These three species occur within the miombo woodlands.

Although the sample is limited, it seems to indicate that the woods used for iron smelting occur in the region today, and that the forest composition was similar to that of today. Additionally, we must consider that the smelters varied their choice of wood so as not to over-exploit the species that occurred in the immediate vicinity of the smelt.

CONCLUSION

We have shown that anthracology is a useful tool to use in understanding past human behaviour and activities on the landscape. We developed a comparative charcoal database, which formed the basis for identifying the archaeological charcoal assemblages recovered from the Chigaramboni area.

The Chigaramboni area is an archaeo-metallurgical landscape where the following taxa were exploited: *S. mellifera*,

S. polyacantha, *V. tortilis*, *B. boehmii*, *D. cinerea*, *F. saligna*, *F. macnaughtonii* and *K. africana*.

The charcoal assemblage shows continuity in the practice of burning fresh wood and the exploitation of mature vegetation for fuel. There is a propensity to choose good and slow burners, but the mix of woods at the smelting sites, and the variety of woods that were used before the 1900s, may suggest an awareness of the impact of over-selection and the need to allow for regeneration.

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