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Bio-archaeometallurgy, Technology, and Spatial Organization of Ironworking at Mjimwema, Njombe Tanzania

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Amongst the features of ironworking of sub-Saharan Africa can be counted: (1) the critical incorporation of rituals, symbolism, and medicines; (2) that some societies produced bloomery iron through two stages - namely, iron smelting and smithing - while others, employed a three-stage process where an iron refining process was situated between the former two stages; (3) that while iron smelting activities were generally secluded from the general population, iron refining and smithing were more often carried out in or near villages. The purpose of the current work is to examine the available archaeometallurgical remains of ironworking in order to investigate how the Mjimwema ironworking technology in Tanzania relates to these three features of the African ironworking process. To this end, methods including macroscopic examination of the remains, ethno-historical exploration of the process, and botanical classification of the bio-archaeometallurgical samples have been used. The results indicate that the ironworking at Mjimwema followed the two-stage process, and that the ironworking process symbolised the process of pregnancy and child-birth. With regard to the latter finding, it is argued that in order to fully understand the justification of the incorporation of rituals and medicines in the technology, we ought to give equal research attention to the socio-cultural contexts within which the technology operated. It is also argued that the same socio-cultural conditions explain the seclusion of both smelting and smithing activities from residential areas.

Introduction

Archaeology as a discipline in Africa was a colonial introduction towards the end of the 19th century, and it was around the beginning of the 20th century that ethnographic research on African iron metallurgy began (e.g. Wychaert 1914, Greig 1937, Cline 1937). The early writers focused on themes including (1) the history of the technology, (2) the technology, and (3) the culture of ironworking in Africa. The early researchers mostly relied on ethno-archaeological enquiry, oral tradition, and field experiments. Indeed, some African societies continued practising traditional iron production until the middle of the 20th century (e.g. David *et al.* 1989, Mapunda 1995b, 2010) before its demise mainly due to cheap importation of European tools (e.g. Stayt 1968, Kapinga 1990, Mapunda 2003).[1] Based on 20th century research we generally know the following about African ironworking.

Bio-archaeometallurgical Studies

The technologies of iron smelting consumed large quantities of charcoal (e.g. Killick 1991,

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Schmidt 1997b) and incorporated elaborate use of rituals, symbolism, and medicines (e.g. Cline 1937, van der Merwe and Avery 1987, Schmidt 1997a, Mapunda 1995a, 2010). Some writers have directly linked the use of large quantities of charcoal for ironworking with deforestation (e.g. Greig 1937, Muntz 1960, Haaland 1985, Van Noten and Raymaekers 1988:106, Barndon 1996:62, Childs 1996:285, Schmidt 1997b, Stromquist *et al.* 1999). However, because research elsewhere has indicated that ironworkers were species selective (e.g. Chaplin 1961, Davison and Mosley 1988, Mapunda 2003, Barndon 2004:90, Lyaya 2008, Mapunda and Lyaya 2009), linking the production of charcoal for iron smelting in Africa with general deforestation is perhaps an over-generalisation. However, it is imperative that both claims are validated or supported by empirical data for environmental change, and the possibility and role of other factors (whether natural or cultural) has not fully been considered and evaluated. What were the selection criteria for trees for ironworking charcoal? Unfortunately, the use of trees for charcoal has more often been studied in line with technical significance alone: (1) as fuel energy, to provide heat and temperature in the furnace(s) necessary for the smelting of iron ore oxides (e.g. Rehder 1999, Mapunda 2002), (2) as a reducing agent because charcoal in the form of carbon combines with oxygen to form CO2 and, with further carbon forms, carbon monoxide, which reduces oxides of iron to solid or liquid metal (e.g. Cottrell 1975, Avery *et al.* 1988, Rehder 1999, Henderson 2000), (3) as a contributor to the formation of slag (charcoal in the form of ash facilitates the separation of metallic iron) (e.g. David *et al.* 1989: 194, Henderson 2000), and (4) that some tree species were used for charcoal because they were very hard and burnt slowly or were ecologically efficient (e.g. David *et al.* 1989). However, apart from these technical functions, the trees used for iron smelting charcoal were critically selected because of their socio-cultural use, especially those closely related to pregnancy and child-birth (e.g. Mapunda 2010). So both technical and cultural factors mattered, and thus require equal research attention.

Linking the iron production process with the socio-cultural milieu did not end with the selection of charcoal species alone, and more importantly, the use of medicines, rituals, and symbolism was clearly linked with socio-cultural beliefs. Although these aspects have not received due weight, they were critical and significant because: (i) ritual symbolism and medicines, which included but were not limited to animals or animal parts (e.g. goats, cows, snakes, elephants, hippopotamus, antelope, buck, aardvark, lions, termite queens), birds of different colours (e.g. brown or white rooster), grasses of different species, food items (e.g. maize flour, beer), plants and trees of many and different species, and even human remains - so far particular to South Africa (e.g. Plug and Pistorius 1999, Beuster 1879 cited in Stayt 1968:61), were important for the smelters and served to ensure the production of high quality bloomery iron and steel (e.g. Phillipson 1968, Wembah-Rashid 1969, Killick 1987, Kapinga 1990, Mapunda 1995b, 2010), (ii) its incorporation in the technology mirrored and represented the way of life of people - including the ironworkers - within their respective societies (and this is, after all, the subject matter of archaeology), and (iii) it is an area of study by itself. As van der Merwe and Avery (1987:163) put it, "the knowledge required to assemble the full range of [Phoka] medicines for smelting [and sometimes refining and smithing] is extensive, particularly regarding plants [and animals]. The effort required to obtain everything is equally large [and risky]. This component is a technology in its own right". As archaeologists, therefore, we need to study why only certain plant and animal species were selected for the process of iron production. In order to reach this end, bio-archaeometallurgy is introduced as an alternative approach. It refers to the biological identification of the plant and animal

species that formed a major part of the ironworking, with a view to understanding the socio-cultural and anthropological reasons for their inclusion in the metal production technology. The bio-archaeometallurgical approach goes beyond the technical justification for the use of certain plants, especially those used for charcoal production.

The Process of Ironworking

The technology of iron smelting in sub-Saharan Africa was possibly due to independent invention and it was a bloomery process (e.g. Schmidt and Avery 1983, Killick 2004, Mapunda 2010). As in the rest of the world, it involved two stages, namely, iron smelting and smithing (primary and secondary) (e.g. Friede *et al.* 1982, Allen 1986, Rostoker and Bronson 1990, Miller and Killick 2004; Chirikure 2006). However, it is imperative to point out that not all sub-Saharan ironworking societies followed the two-stage process. Some societies - so far identified in eastern and central Africa - followed a three-stage process (e.g. Wembah-Rashid 1969, Barndon 2004, Lyaya 2009, Mapunda 1995b, 2010) which employed miniature furnaces generally called *vintengwe* to melt and refine the bloom from the primary smelting furnace before forging it into implements at the third stage (e.g. Wise 1958, Chaplin 1961, van der Merwe and Avery 1987). For example, and to elucidate this point, Wembah-Rashid (1969:66) wrote, "exactly there are three stages [in Ufipa Tanzania, that is three types of iron slags]: the kiln [smelting], the blast furnace [refining], and the smithing". For the sake of clarity, and because the three-stage process is not as renowned as the two-stage process, there is a need for archaeologists working in the region where the three-stage process is known to have been practised to devise a method of correctly identifying the refining process both in the field and in the laboratory. Because most of the iron smelters are gone, it is imperative that field methods should be given due research attention to identify and classify the archaeometallurgical remains of either of the two processes: the two-stage against the three-stage technology. Based on Mapunda's (2010:154-155) model of the macroscopic difference between smelting and refining slags and author's (2007) model on the macroscopic distinction of the smithing from smelting slags, this work examines archaeometallurgical evidence of ironworking at Mjimwema to determine whether Bena ironworking was a two-stage or three-stage process.

The Spatial Organization of Ironworking Processes

Finally, African iron smelting activities were generally, but not universally, secluded from settlements, women and strangers (e.g. Cline 1937, Barndon 2004, Mapunda 2010), whereas iron refining and smithing processes could be done within or close to residential areas (e.g. Greig 1937, Herbert 1993). The seclusion practise was mainly due to socio-cultural reasons; for example, Tswana people in southern Africa desired to conceal iron smelting activity because to them heat is the source of all problems such as drought, illness, mishaps, and death (Anderson 2009:223). They strongly believe that women are inherently hot but men are cool and stable, which means that in order for activities - especially those performed by men such as rainmaking, initiation, ritual offerings to ancestors, or iron smelting - to be successful, women, especially those menstruating or pregnant, should not be allowed to see or come close (Anderson 2009).

Besides socio-cultural factors, it is vital to note the seclusion process could have been due to technical aspects such as the need to be close to bulky raw materials such as ores, clay, and wood (e.g. Sutton 1985, Davison and Mosley 1988, Barndon 2004). However, there are a few exceptions where smelters can be shown to have opted to transport iron ores - especially pure magnetite - to residential areas, but they always concealed the smelting activity (e.g. Anderson 2009:214). So in light of the Tswana example, most smelters per-

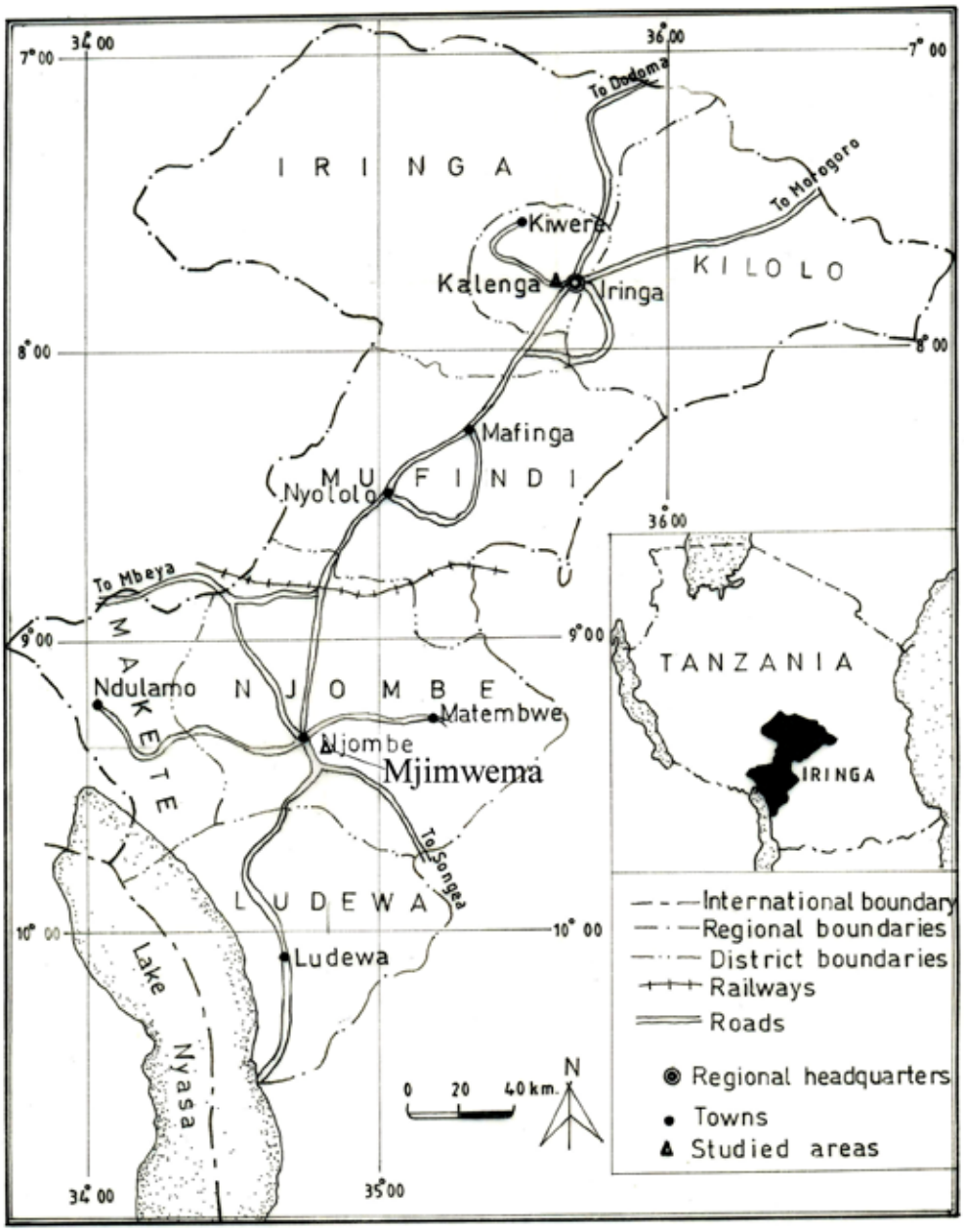


Fig 1: The location of Mjimwema in Njombe Tanzania.

haps veiled the rituals and smelting activities as a result of socio-cultural factors. Although socio-cultural aspects mattered, it is noteworthy that seclusion from the general public (including children) was perhaps also necessary for moral and disciplinary reasons. For instance, Rongo iron smelters of northern Tanzania performed pre-smelting ritual activities while absolutely naked (Schmidt 1996, 1997a). It could possibly have been considered socially immoral to let their wives, strangers, and children watch them while utterly

naked and in public! To strengthen this argument and because no such and other elaborate ritualistic practises were necessary and part of the post-primary smelting stages (iron refining and smithing), they were more often situated near or in habitation premises (e.g. Greig 1937, Herbert 1993).

Based on this background information, this paper examines: (1) the bio-archaeometallurgy of ironworking at Mjimwema, (2) the archaeometallurgical evidence of iron smelting and smithing processes at Mjimwema, in order to examine whether the Bena ironworking at Mjimwema used the two-stage or the three-stage process, and (3) the question of spatial organization of the Bena iron smelting and smithing activities. It is critical to answer these research questions, with the view of finding out how ironworking technology of Ubena fits and compares to other parts of the continent. This work is organised in such a way that before embarking on the research objectives, it starts with the review of some cultural aspects relevant and linked to the process of iron production of the Bena people, the main tribe at Mjimwema and Njombe (figure 1), which is followed by a review of the archaeological research in Ubena.

Some Cultural Aspects of the Bena People

The name Bena is identified with by a number of clans, including the Manga, Mtende and Kahemela of Ikilavugi, who believe it to originate with a founding father of that name. Others, especially those living in Ikilavugi, Usovi and Nyikolwe, believe that the name derives from either "hubena"- to reap finger millet (the people subsequently referred to as "Vabena vuledzi") - or from the practice of panning salt (Nyagava 1988). However the name Bena came into usage, today it refers to the people who speak a similar language, Kibena, share the same history and culture, and who principally live in Njombe, southern Tanzania. The Bena traditional ruler was called *mtwa* (or *watwa* in plural), and there is substantial oral evidence relating the history and political organization of the Bena (e.g. Culwick and Culwick 1934, Swartz 1964, Illiffe 1967, Kurtz 1978, Nyagava 1988, Monson 2000). For the purpose of this paper not all the evidence is presented, and here it suffices to discuss some socio-cultural aspects linked to the process of iron production; namely, those linked to marriage, pregnancy and child-birth, and religious aspects of the Bena.

The process of marriage in Ubena, as in other ethnic groups in Tanzania, meant passage from childhood to adulthood. One important step towards this end was the use of bride-price. In Bena society, the bride-price was three iron hoes (Mumford 1934, Culwick and Culwick 1934). The first hoe called *Kibani* was the sign of betrothal, the second hoe called *Ligeno* was paid in the early stages of marriage and it made marriage more binding, and the last hoe called *Lihetu* meant a husband's assumption of full rights and responsibilities of marriage with all they entailed (Culwick and Culwick 1934:154). Although it is not clear from the writers how bride-grooms got the iron hoes, especially during the period before colonialism, it can be argued that they had to work with smelters to raise the hoes (for similar practise in Ufipa, see Mapunda 2004:78-79), and the ability to obtain them symbolised that a husband was strong enough to marry. Should this have been the case in Ubena, then Culwick and Culwick's (1934:153) explanation that if the three payments [hoes] were made almost at once, this suggested the girl's parents felt confident that they were giving her into safe hands, is convincing. The introduction of money and importation of already manufactured hoes made the activity of raising bride-wealth less difficult. In Ufipa, for instance, the iron smelting process continued until the 1950s, because it was a traditional hoe that was required for dowry. In the context of the Ubena, ironworking was regarded as a vital part of the society, and this dictates a need to study the socio-cultural context if we want to interpret our metallurgical relics

or if we aim at producing a comprehensive explanation of the past (e.g. Mapunda 2004).

The process of child-birth is one of the most important family events, and the Bena are no exception in this regard. Towards the end of pregnancy, the wife leaves her husband's house to live either with her mother or mother-in-law (Mumford 1934). According to the oral evidence, if labour is difficult or prolonged, three old women should question the woman on suspicion of adultery. Adultery rarely happened, but if it transpired that a woman confessed the midwives would give her medicines to assist delivery; owing to the potency of the drug, delivery usually then proceeded without further difficulty (Mumford 1934). This accords well with the smelting process where any failures to produce good bloom were associated with adultery (e.g. Barndon 2004:91) or witchcraft, and the solution was, in many cases, use of more and stronger medicines (e.g. van der Merwe and Avery 1987). However, it is vital to note that there could have been possible failures due to technical reasons (e.g. Killick 1990, Ackerman *et al.* 1999).

In terms of religion, the Bena traditionally believed in one god (or God) called *nguluve,* the creator, who also deals with major episodes, and spirits of ancestors called *misoka,* who deal with affairs of individuals (Mumford 1934:221). The Bena people as the Hehe and Sangu tribes, classify offenses into (1) anti-social acts which, once committed, require redress through the payment of fines (for instance, the penalty for adultery is a payment of three cows), and (2) anti-religious acts e.g. doing things which are forbidden by religion called *mzilo* in Bena language, the punishments for which are variable consequences or disasters such as hunger and diseases. It is reasonable to seek to interpret the elaborate practise of rituals and medicines meant to appease ancestral spirits in the context of traditional African ironworking, because these practices reflect how society was structured and the technology that mirrored that society.

Archaeological Research in Ubena

Ubena is one of the Bantu-speaking societies in the southern highlands of Tanzania that has received relatively little archaeological attention. Mapunda (2010:67) explains this situation by relating the problematic access to these areas with the apparent scarcity of ethnographic information on ironworking technology. Strikingly, there is a relatively large amount of historical information in the archives about the Bena people from the beginning of the 20th century. We should not forget that during the colonial period, the interests of the explorers, traders, and missionaries, who were amongst the early writers of the history and archaeology of Africa, determined the type of information to collect and its subsequent interpretation (e.g. Monson 2000). For example, there is lack of early archaeological research in Ubena because the early writers in the region were possibly not interested in the archaeology of the area but rather in the history of the Bena (and Hehe) wars. This interest came from attempts to justify military intervention made under the pretext of trying to stop inter-tribal wars, but which resulted in colonization (e.g. Monson 2000). Post-independence, after 1961, the archaeology or archaeometallurgy of Ubena has been explored by Sutton (1985), Nyagava (1988), Msemwa (2001), and Lyaya (2008). It is important to note, however, that these researchers have had varying research questions and come from different educational backgrounds. Sutton (1985) focused on comparing Bena iron furnaces with those of their neighbouring Fipa, and aimed at determining responsible factors for the variation of iron furnace designs and the smelting techniques. Nyagava (1988) is an historian whose doctoral studies mainly examined the history of the Bena, but who in the course of said research became interested in and explored how ironworking revolutionalised agriculture in Ubena. The archaeological study by Msemwa (2001), which focussed on environmental impact assessment of the Upper Kihansi, has documented LSA lithics,

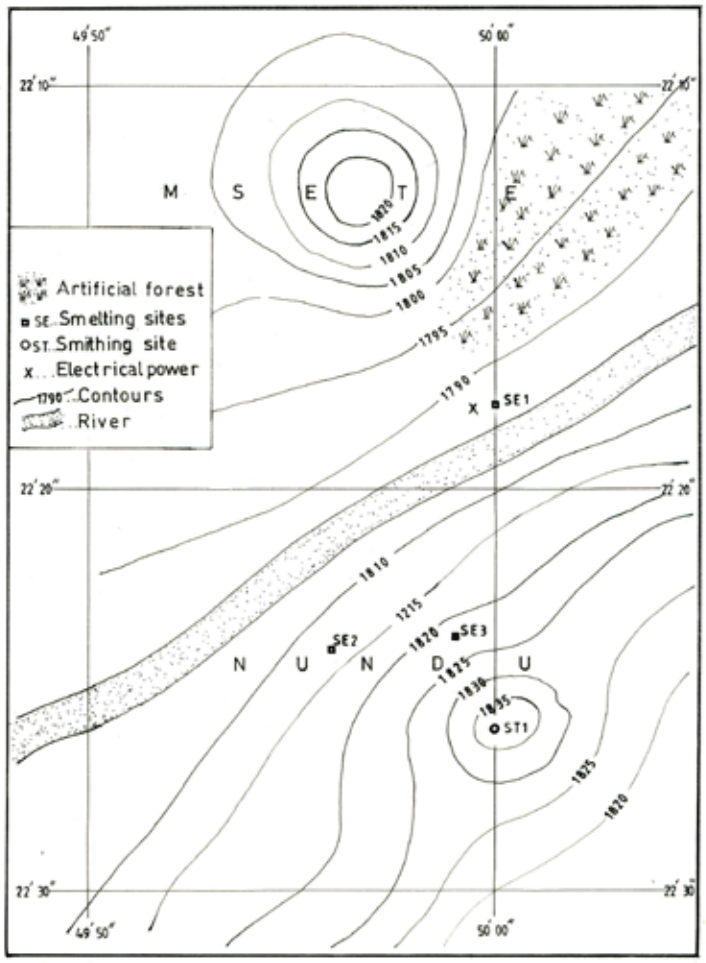


Fig 2: The Mjimwema sites plan.

EIA potsherds, iron furnaces, slags, charcoal, and daub. Lastly, Lyaya (2007) concentrated and reported on smithing and smelting slags on the one hand, and on the other explored the public archaeology in Njombe district. The previous archaeological studies in Ubena have been sporadic, but have initiated a move towards the reconstruction of the archaeology and archaeometallurgy of the Bena people. The traditional ironworking technology in Ubena was allegedly brought to its demise between 1925 and 1950 due to external factors.

As a step towards a more thorough knowledge of Ubena society and metallurgy, the current archaeometallurgical work examines both archaeological and oral evidence to address the key objectives outlined in the introduction section. The archaeological data were gathered from four ironworking sites (smelting and smithing) from Msete and Nundu sub-villages, separated by the Ngengedu River (figure 2). Only one site (SE1) was discovered in Msete, the rest are found in Nundu area (SE2, SE3, ST1), and of all the smelting sites only SE2 had a virtually intact iron smelting furnace (figure 3; for the section and plan of this furnace see figure 6).

Most of the smelting slags, tuyères, and potsherds were essentially surface collections, but the smithing site (ST1) was excavated down to 50 cm (figure 4), and Table 1



Fig 3: The intact iron smelting furnace at Mjimwema (SE2). Note that the section and plan of this furnace are represented in figure 6.



Fig 4: The floor of Nundu (ST1) Unit 1.

presents the summary of the excavated smithing materials. In additional to this archaeological data, oral evidence was critical and collected on the bio-archaeometallurgy of Bena ironworking. These data are here examined to address the three objectives presented earlier.

The Bio-archaeometallurgy of Ironworking at Mjimwema

Table 2 presents the local (Bena) and botanical names and families of the selected plant species, and the last column indicates the respective process for which the plant and tree species were exclusively used. From the

Level (cm)	Hammer scales	Droplets slag	Amorphous slags	Cake-like slags	Charcoal pieces	Tuyère pieces	Iron pieces
1 (0-5)	63,620	295	721	15	45	40	-
2 (5-10)	135,360	700	1140	12	800	65	18
3 (10-15)	169,200	?	1503	13	10	22	-
4 (15-20)	101,520	242	770	12	5	16	-
5 (20-25)	47,500	145	540	13	6	9	-
6 (25-30)	45,120	57	417	12	8	11	-
7 (30-35)	43,340	40	435	12	8	-	-
8 (35-40)	18,800	25	277	12	10	-	-
9 (40-45)	940	-	42	13	12	-	-
10 (45-50)	-	-	790	11	-	-	-
Total	625,400	1504	6635	125	904	163	18
% by number (out of 634,749)	98.5	2,369 ppm	10,453 ppm	197 ppm	1,424 ppm	257 ppm	28 ppm

Table 1: Summary of the Nundu Unit 1 material by number.

No.	Bena name	Botanical name	Botanical family	Process used for
1.	Ligema	*Ficalhoa laurifolia*	Theaceae	smelting
2.	Libadzamono	*Besama abyssimica*	Melianthaceae	smelting
3.	Likenza	*Olea europaea*	Oleaceae	smelting
4.	Lilingo	*Acacia tortilis*	Mimosaceae	smelting
5.	Likalati	*Agauria salilifolia*	Ericaceae	smithing, smelting
6.	Likufwa	*Myrica salicifolia*	Myricaceae	smithing, smelting
7.	Mono	*Ricinus communis*	Euphorbiaceae	medicinal plant
8.	Ng'anzo	*Passiflora sp.*	Passifloraceae	medicinal plant

Table 2: The Mjimwema bio-archaeometallurgical species for ironworking.

top, the first six species were jointly selected for smelting charcoal, but the *likalati* and *likufwa* species were exclusively used for smithing charcoal. The *ng'anzo* and *mono* species were vital ingredients of the medicinal package for iron smelting and smithing processes in Ubena. According to informants (Table 3), the charcoal species were selected because: (1) they were hardwood able to produce large fire, (2) they do not burn out quickly, and (3) they produce very strong fire in terms of heat. When the respondents were interviewed about how and when they discovered the distinctive qualities of the various species of tree used, they generally and simply said they had always used the same species for domestic wood and charcoal production since their forefathers. Besides those criteria, it should be noted that some of the species were directly associated with other socio-cultural functions, and therefore they were largely selected on account of social beliefs. Why is this important? The informants told me that the process of iron production in Ubena was often equated with the process of child-birth. This relationship is supported by the form of traditional iron furnaces, which bloat somewhat out on the side of the rake hole (also known as the birth canal) and have breasts (see figure 3).

On account of the social importance the Bena attach to child-birth and the complications or risks involved at child-delivery, the chief smelters had to be knowledgeable of traditional medicines related to pregnancy, child-birth and witchcraft. The use of the *likufwa* species seems to be associated with the healing of diseases such as abdominal pains, bleeding, and fresh wounds, most of which are especially threatening to pregnant women. The relationship between the plants and animals used in ironworking and their current use in society is interesting (it has been observed in Malawi by van der Merwe and Avery (1987:160)) because most of the plants [and animals] had medicinal purposes other than their use in smelting. It is equally possible to suggest that they were used for smelting because of their initial socio-cultural use in the society, but this is difficult to verify with the current data. In addition, the leaves of the *libadzamono* and roots of the *likenza* species, if burnt and powdered, could be prescribed to men with little or no sexual

Name	**John Akin Fute**	**Elia Mng'ongo**	**Samwel Mtikwa**	**Martina Sadala**	**Augostino Mtikwa**	**Tabita Mchungwa**	**Score**
Age	53	70	68	64	57	75	-
Sex	M	M	M	F	M	F	-
Interviewed	13/7/2008	4/7/2008	6/7/2008	13/7/2008	10/7/2008	13/7/2008	-
Ligema	×	×	√	√	√	√	4/6
Libadza-mono	√	√	×	×	√	√	4/6
Likenza	√	√	×	√	√	√	5/6
Lilingo	×	√	√	√	√	√	5/6
Likalati	√	√	√	√	×	√	5/6
Likufwa	√	×	×	√	√	√	4/6
Mono	√	√	√	√	√	√	6/6
Ng'anzo	√	√	√	√	√	√	6/6

Table 3: List of the informants (Phase I). Note that all informants were the sons or grandsons and daughters or granddaughters of some of the renowned smelters of Ubena.

power to increase sexual power or let them work properly. In Bena society, the death of an infant is symbolically linked to such a state of affairs or to adultery (see also Mumford 1934:213). The relationship between the plants and animals used in ironworking and their current use in society is interesting (it has been observed in Malawi by van der Merwe and Avery (1987:160)) because most of the plants [and animals] had medicinal purposes other than their use in smelting. It may be that the use of such species in the smelting process is directly related to sociocultural uses and it was believed to ensure successful production of strong or large bloomery iron, although this is difficult to verify with the current data.

In terms of general medicines, the *ng'anzo* and *mono* species were the necessary ingredients of iron smelting and smithing medicinal packages. Unfortunately, the interviewees were not able to mention all the other ingredients of the Bena ironworking medicines, but they were aware that the package included tens of items and promised to identify more species in the near future. The *ng'anzo* and *mono* species are currently used as medicines for stomache, bleeding and witchcraft, and, in addition, the *mono* species - a castor oil plant - was used in the smelting furnace as a symbolical grease (Lyaya 2008). It appears that the Bena symbolism fits well with the symbolism of the *nchinji* and *vizimba* medicinal packages among the Fipa (Mapunda 2010:107). The smelting medicines are the same medicines used today in that society to protect houses, crops, fishnets, and other valuable property against evil intentions. The Fipa *vizimba* medicines were recovered from the excavations of the furnaces, but with the exception of ritualistic pottery (figure 5) encountered at Nundu SE2 site (see figure 2), the excavation of the Nundu SE2 furnace yielded nothing that could be conclusively termed as ritualistic medicines. Although I am not entirely sure about the use of the pots, I strongly believe that the broken pots could have been used



Fig 5: The pottery of the Nundu SE2 site.

for similar medicinal purposes by the actual smelters. It is also possible that they might have been buried but were recently dug up and left there by the villagers who conventionally believe the medicines used by ironworkers were strong as well as eternal (for similar beliefs, see Mapunda 2010:160). For example, my informants believed and consistently emphasised that the Bena iron smelting medicines were very strong and no one, as a matter of belief, could dare to go into a smelter's farm or house with bad intentions such as theft or witchcraft.

The Technology of Iron Smelting at Mjimwema

a) The iron smelting furnaces

Of the three smelting sites, site SE3 had the remains of a partly fallen furnace, and site SE2 had a virtually complete furnace (see figure 3). The latter is 100.8 cm tall, and its external and internal diameters are 76 and 30 cm at the base, 67 and 30 cm at the body, and narrow to 50 and 30 cm at the top (figure 6). Although the top portion of the site SE3 furnace had collapsed, the still standing portion measured more or less the same base and body diameters including the wall thickness. The smelting furnaces at Mjimwema have a wall thickness of 23 cm at the base, 18 cm at the body, and 10 cm at the top. The peep hole is located opposite the birth canal

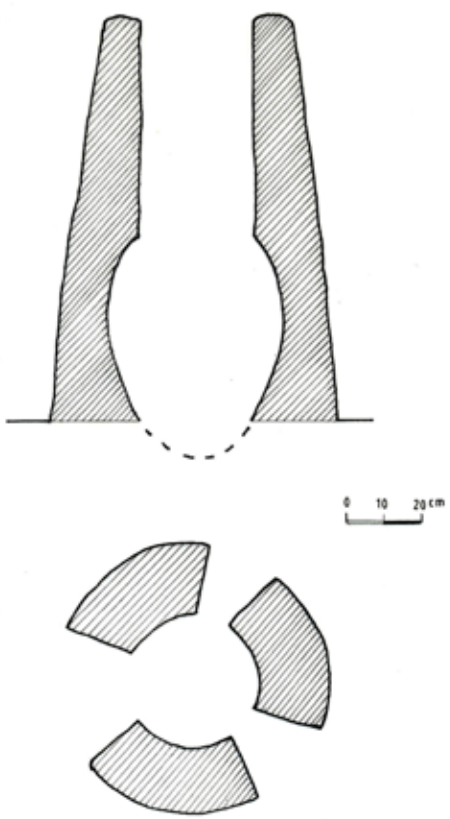


Fig 6: The section and plan of the Nundu SE2 intact furnace.

at 26 cm height from the base. Based on the height measurement and assuming that all the Mjimwema furnaces had similar heights of around 1 m, which is more likely to have been the case, the Bena furnaces closely resemble the Rongo (e.g. De Rosemond 1943) and the Pangwa smelting furnaces (e.g. Barndon 2004), but it is noteworthy that the Rongo furnaces were made up of slabs and the heights of the Pangwa furnaces could reach 1.5 m.

There are two subtle but observable external features on the furnaces at the front just above the birth canal: bloated stomach (the front furnace wall) and breasts perhaps symbolising a pregnant woman (see figures 3 and 5). As elsewhere on the continent (e.g. Mapunda 2010, van der Merwe and Avery 1987, Schmidt 1996, 1997a), this indicates that iron production at Mjimwema represented the process of pregnancy and childbirth.

b) The smelting tuyères and tuyère ports

The tuyères collected from both the surface and sub-surface had no proximal ends, but the few distal ends measured 6.7-8.5 cm and 3.5-4 cm respectively for external diameters and internal diameters, and had a thickness of *circa* 1.6 cm. In addition to the "birth canal", Mjimwema furnaces had three tuyère ports (see figure 6), but it is noteworthy that the former is larger than the latter ports perhaps because of its function - the child door measuring 30 cm both in width and height. The small tuyère ports measure 15 cm and 19 cm in width and height respectively.

Based on the field evidence, can we comprehend on how these furnaces were operated? The general study of tuyères ends, especially those with flaring proximal ends, is critically useful for suggesting the type of furnace operation. The flared tuyères are associated with forced draft mechanism, because these acted as receptacles for the bellows(e.g. Mapunda 2010). Although no tuyères with proximal ends were found at the sites, based on the height of the furnaces and the number of the tuyère ports, it is possible to suggest that these furnaces operated by forced draft (e.g. van der Merwe and Avery 1987). For a natural draft operation to be technically efficacious, a height of at least 1.5 metres is needed (van der Merwe and Avery 1987:149). The forced draft interpretation is supported by oral evidence that suggests bellows were used in Ubena, but hitherto we do not know whether or not the tuyères, some of which are massive pieces, were used for slag-tapping as well, and this remains to be researched in the near future.

c) The smelting slags

82 samples of the smelting slags of Mjimwema were examined (figure 7). They have mass range of about 1 g (especially droplets slags) to about 14 kg, but most of the small-



Fig 7: The smelting slags of the Mjimwema area.



Fig 8: The smelting slags with flow marks.

sized slags (*circa* 66%) weigh around 2 kg, and the rest are large and weigh between 2 and 14 kg. The former group includes droplet slags and the majority small amorphous slags, but the latter includes blocky, cake-like slags and the minority amorphous slags. Of all the analysed slags, about a third showed flow texture and the rest were melted. Only a very few samples were unreacted pieces.

The colour of smelting slags at Mjimwema is basically grey or greyish, but depending on the ferro-magnetic property, which was tested via bar and pencil magnets, the few slags that attracted to the magnets were reddish grey and some were brownish grey. It seems the reddish and brownish were oxidised owing to some magnetism in them. The cake-like slags were highly oxidised, the most dense and with more magnetism than any other slags. The high ferro-magnetic content of the cake-like slags is possible to explain, for the bloom was close and sat on top of the cake slag (for same results, see Lyaya 2007:55, Mapunda 2010:79).

The slag evidence, especially the droplet slags, suggest that the Msete furnaces were possibly pit-furnaces (e.g. Schmidt and Childs 1985:56), but this interpretation can be challenged by the presence of slags with conspicuous flow marks (figure 8). It is possible, however, that these are the result of slag dripping into the slag-pit during the early phase of smelting (for a similar view, see Haaland and Msuya 2000:81, Haaland 2005). We will need additional field data, and metallographic data on the size of the crystals, to prove or disprove the pit-furnaces interpretation or hypothesis.

The Iron Smithing Process at Mjimwema

a) The stratigraphy of site 1 (ST1)

Figures 9 and 10 respectively present the plan of Nundu ST1 and the wall profile of the excavated Unit 1. The four layers of the profile could indicate that the site was occupied at four periods, but unless the site is dated the layers could equally suggest four smithing seasons. Regardless of which was the case, Stratigraphy 1 was the shortest and Stratigraphy 2 was longer than 1 and 3, and Stratigraphy 4 was the longest of all periods, which lasted longer before the technology was brought to its demise towards the mid 20th century due to external factors such as massive importation of European tools (for comparison elsewhere, see also Chaplin 1961:53, Brock and Brock 1965:97, Davison and Mosley 1988:73, Humphris *et al.* 2009:360). Because smithing materials were retrieved from all the excavated levels down to 50 cm (see Table 1), we can confidently assert that all four layers represent the same type of activity - iron smithing. As noted above, unless the layers are dated it is difficult to assign lengths of time or to associate scales of production to them, because different appearance of the layers look is perhaps due to different sedimentation rates.

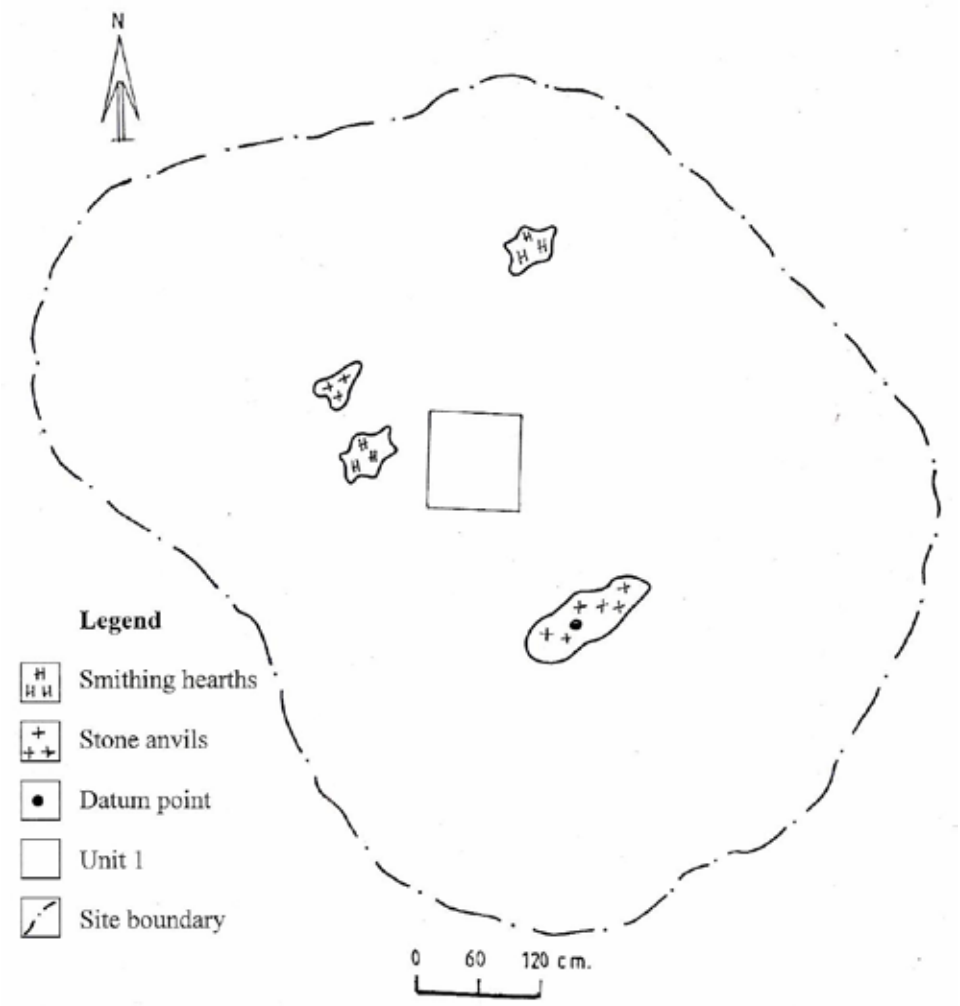


Fig 9: The plan of Nundu ST1 site.

b) The smithing slags

Most of the smithing slags are highly magnetic and oxidised, because these aspects are an essential part of the blooms before they become squeezed out during the forging process. Physically, the slags are greyish, brownish, reddish, or in between these colours, and exhibit very rough surfaces incorporating sand or quartz particles, all of which can be associated with the magnetism and oxidation properties.

By number, the majority of the smithing slags (see Table 1) are scale-like (also called hammer scales) and account for *circa* 98.5% of the total number of slags. These are followed by conglomerated or amorphous slags (*circa* 10453 ppm (parts per million), and *circa* 2369 ppm) which are droplet slags (also referred to as slag spheres (Starley 1995)). Both groups (figure 11) were formed from sparks of iron oxides produced during the beating of the bloomery iron. The next group comprises cake-like slags (also known as plano-convex bottoms (Bachmann 1982), smithing hearth bottoms, or smithing hearth cakes (Crew 1996)) amounting to *circa* 197 ppm. The cake-like slags, which are the most recognisable residue of smithing, often form

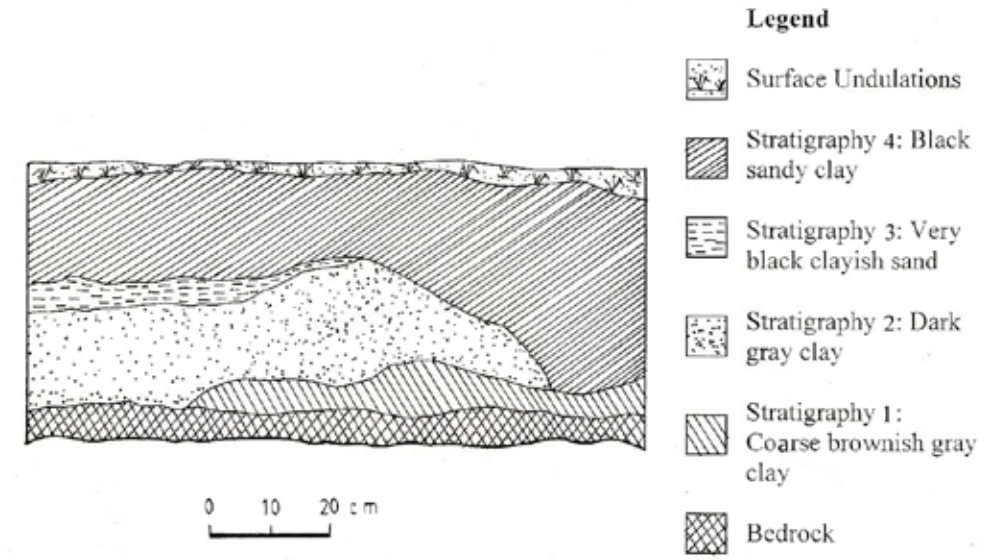


Fig 10: The profile of the southern wall of Nundu (ST1) Unit 1.

below the blowing hole. Finally, agglomerated slags are always amorphous, and were formed as the result of the hearth being cleaned when hot, which possibly explains their distorted shape. While the percent by number and weight for each of the smithing slag groups (see Table 1) can vary at different sites, it is critical to note that for a site to be classified as an incontrovertible smithing site, the hammer scales, droplets, cake-like and amorphous slags should perhaps be largely considered as chief indicators of the process.

What type of process was followed at Mjimwema sites: two stage or three-stage? Although the quantity of smithing slags would vary at different sites depending on the scale of production and length of occupation, the size or weight of slags - especially the cake-like and amorphous types in eastern and central Africa - is critically important to understanding the nature of the ironworking process. An informed field experience on the nature of the slags can be used to examine and segregate the two-stage from the three-stage process. To get to this end, all the amorphous and cake-like slags of the Nundu smithing site were



Fig 11: The scale (left) and droplet (right) slags of Nundu ST1.

weighed, and results indicated that virtually all cake-like and amorphous slags weighed from 0.25 to 2 kg. If this weight is compared to amorphous and cake-like slags from the Fipa smithing sites,, which weighed less than a half a kg (Lyaya 2009), there is a clearly observable difference. I cannot be entirely sure that this observation would remain consistent if the research matrix were to be extended, but the smithing slags that came directly from the primary smelting furnaces would be expected to be relatively denser and larger than the smithing slags that came directly from the secondary



Fig 12: The big basaltic anvil and the stone hammers of Nundu ST1.



Fig 13: The Small Basaltic Anvils of Nundu ST1.

refining furnace, because most of the impurities (e.g. charcoal and slags) would still be included or attached to the bloom at the former stage, whilst such impurities would be fewer in the latter stage as they would have been removed during the refining process. Unlike in Ufipa, there is no ethno-historical evidence of smiths practising the three-stage process, and intensive and extensive field walkover surveys at Mjimwema searching for refining sites and slags (based on Mapunda 2010 model) yielded nothing of the refining process. Also, we know that the three-stage process smelted less pure lateritic ores (e.g. van der Merwe and Avery 1987), but according to Sutton (1985), the Bena smelted black highly magnetic sands in the short furnaces. According to John Akani Fute (53) – a grandson of a smelter- the black magnetite sands called *mdapu* in Bena language, were collected and prepared from rivers by women who exchanged or sold it to the smelters in return for goods like iron hoes. Therefore, and based on the smithing slag evidence and the knowledge we have of the three-stage process, it seems more likely that Bena ironworking was a two-stage process.

c) The smithing tuyeres

Because of their fragmentary nature, it was difficult to measure their internal and external diameters, but the analysed body segments of the tuyeres have a thickness ranging from 1.2 to 2.8 centimetres. On the inside parts, they show mainly a white or whitish colour, and on the outside parts they are coloured grey and brown. The whitish colour is an interesting phenomenon because it may mean that the smiths selected refractory clays to make tuyères, but this, together with the question of the ceramic inclusions, will need to wait for chemical data in the near future.

d) The smithing anvils and hammers

The Nundu smithing (ST1) site consists of two sets of basaltic anvils, a big one on the left side of the site with a datum point (figure 12), and a small one on the right (figure 13). I suspect that the former was used for some sort of primary smithing work, and the latter was used for the secondary finishing, because the small anvil is worn out with four conspicuous depressions or dolly holes on it. The big anvil lacks the depressions, but clearly displays evidence of being used. In addition, the latter is relatively far from the smithing hearths, but the former is close and in between the two smithing hearths (see figure 9). In addition to the anvils, there were broken basaltic stones at the site (see figure 12), which appear to have probably been used as hammers for they show use-wear marks at their ends, and they are unusual or exotic type of stones in this area. While it is

yet to be resolved whether they were used for primary or secondary smithing, we have evidence from Unyiha, southwest Tanzania, that heavy beating was done using big stone hammers, and light or finishing beating was done by the light hammers (Brock and Brock 1965:98). It is therefore more likely that Nundu hammers were used for primary smithing because they are relatively heavy.

The Spatial Organization of the Ironworking Process at Mjimwema

Most of the African iron smelting activities were generally secluded from habitation areas and Bena ironworking is no exception. The nearest household to the smelting area is *circa* 2 km. In addition to smelting, the iron smithing process was also secluded and situated adjacent to smelting furnaces (see figure 2). While Sutton (1985) linked seclusion with the desire to get close to the bulkiest raw materials such as ores and wood for charcoal, that was probably a secondary concern. There are two primary reasons why iron smelting in Ubena was secluded from residential premises: (1) The Bena symbolically associated the process of iron production with the processes of pregnancy and child-delivery, and during the last days of pregnancy and child-birth, the woman left home to live elsewhere with her mother or mother-in-law and the whole process of child-delivery was supervised by well-experienced and older women who also qualified as herbalists (Mumford 1934:213). In the context of iron production, the furnace was the mother-to-be, the smelters took the position of the older women, and the smelting area could possibly be regarded as the home of the pregnant woman. (2) The process of child-birth was often difficult, and this was considered to be due either to mishaps or adultery. In either case, experienced older women, as noted above, were involved due to their knowledge of the medicines required for successful delivery of a child. For the same reasons, the smelters had medicinal packages, which were used for the same purposes - including the protection of the smelting site from witchcraft - all of which were aimed at the successful production of a child. The chief iron smelters kept the secret of their techno-medicines not only from the public, but also from other assistants and smelters, because that functioned like a right of patent to the technology (see also Mapunda 2010). While secluded, the smelters took advantage of the close raw materials, and the pre-smelting rituals could similarly be performed.

Although both smelting and smithing processes were secluded, the smelting sites are located in the valley along the river and the smithing site is on top of a hill (1840 m a.m.s.l) with large trees and suitable stones for smithing. The availability of these trees for the construction of sheds and the stones for anvils and hammers may have influenced the smelters or smiths to chose the site. That being the case, they perhaps took advantage of the apparent charcoal sources, the smelting tuyères, and if the smelting tuyères were not re-used for smithing activities, they likely used the same of source of clay to make blow pipes for the latter process. However, we currently have no chemical data to support the hypothesis. If the sites were dated, it would be possible to explore the possibility that both processes were hidden for fear of punishment after they were banned by colonial administrators. If this were the case, it is possible that the smithing process could otherwise have taken place close to or within villages.

Conclusion

The Bena of Mjimwema linked metal production processes with the process of womanhood, pregnancy, and child-birth, and because of this association, their iron smelting furnaces were decorated with features expressive of a pregnant woman. The selection of the bio-archaeometallurgical species for ironworking was based on the same medicinal practices used to ensure the successful birth of a child, represented in met-

alworking by the bloomery iron. Therefore, in order for archaeologists to comprehend the culture of metal production in terms of rituals, symbolism, and medicines, they need to give due research attention to the socio-cultural context within which the technology operated.

The Bena iron technology was a two-stage process, whereby smelted bloomery iron was directly forged into implements at the smithing stage. Both the iron smelting and smithing stages at Mjimwema were secluded from settlements chiefly for socio-cultural reasons. In the near future, the questions of technological efficiency, the nature of the raw materials (especially iron ores), and whether iron workers selected clay for different technical functions, all require prompt investigation - possibly using science-based approaches in archaeometallurgy.

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