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Archaeology of Hehe Iron Smelting Technology at Kalenga, Southern Tanzania

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Abstract

The culture and technology of African traditional ironworking are greatly varied and have been examined within various traditional ironworking societies in sub-Saharan Africa. Unfortunately, archaeometallurgical remains in some societies that once practised ironworking such as the Hehe, a Bantu-speaking people of southern Tanzania, have not been adequately studied. This paper examines the archaeological materials of ironworking in Kalenga Division, with a view to illustrate the iron production techniques of the Hehe and compare these techniques to metal production technologies in other parts of the continent. The macroscopic analysis of the remains indicates that the Hehe iron smelting was a forced-draft operation. The furnaces were made of clay rolls, and the slag was collected at the bottom of the furnaces in the slag-pits. This iron production technique, as is herein argued, relates to furnace designs of the last millennium BC and the first millennium AD in eastern Africa. However, it is noteworthy that the Hehe ironworkers did not decorate their furnace clay rolls as it was with some of the Early Iron Age (EIA) furnace materials.

Key Words

ironworking, Ngongwa furnaces, overlapping furnaces, flared tuyeres, working place (WP), Kalenga, Uhehe, iron smelting, clay rolls.

Introduction

Ethnographic research interest on African iron metallurgy matured at the beginning of the 20th century (e.g. Wychaert 1914; Cline 1937). The early research focussed on investigating, among other aspects, (1) the origins and spread of ironworking, (2) the techniques and processes of iron metal production, and (3) the symbolism, medicines and rituals of ironworking. Based on most of the 20th century research evidence, students of African iron metallurgy can now cast away claims that iron technology was introduced in sub-Saharan Africa from north Africa, Europe or Asia (Schmidt and Avery 1983; Mapunda 2010). There is no proof that ironworking technology was introduced from anywhere else (Killick 2004: 101). In addition, because the Early Iron Age (EIA) research evidences from Taruga in northern Nigeria as well

as Kagera in Tanzania are so different from known European and Asian evidence, Schmidt and Avery (1983: 432) have reasoned that African ironworking was due to independent inventions (see also, Craddock *et al.* 2007: 1). However, it is noteworthy that generally we lack conclusive data for the independent invention position, because virtually all the oldest dates of ironworking in eastern Africa, for example, came from dubious contexts (Killick 2004). According to Killick (2004, 2009), we should not concentrate on 14thC dates alone while addressing this theme, but we should draw our inferences from comparative studies of ironworking technology itself across the globe. Alternatively, it is time to start developing and using other dating methods such as thermoluminescence in order to avoid the problem of 'old wood' charcoal (Killick 2009). Research on the second theme, how iron was produced in Africa, has received relatively detailed attention, and in terms of the processes involved, we know now that generally African ironworking was a direct bloomery process in contrast to the Chinese indirect blast furnace process. The end product of iron smelting in the former was the bloom of iron, while the end product of the latter was cast iron, which required elaborate decarburization process in order to work it into implements. Nonetheless, David *et al.* (1989) have published a different process in Mafa, northern Cameron, thought to be in between the bloomery and blast furnace processes, which perhaps indicates that African ironworking was more than a simple bloomery process (e.g. Childs 1996; Killick 2004). In addition, there are numerous ethnographic studies suggesting that some traditional ironworkers produced liquid iron especially in central and southern Africa (e.g. Cline 1937; Phillipson 1968; Prendergast 1974). However, these claims have been evaluated or rejected, but such re-assessments have not been backed up with archaeological as well as archaeometallurgical data (see van der Merwe 1970; Prendergast 1974). The iron smelting furnaces employed in sub-Saharan African ironworking are greatly varied and ranged from a mere hole in the ground to elaborately decorated and substantial structures kept in semi-permanent use (e.g. Davison and Mosley 1988; Childs 1991; Rehren *et al.* 2007), and operated by either forced-draught or natural draught mechanisms. The iron smelting furnaces were generally constructed from fired bricks, wet clay rolls, and coils (e.g. Schmidt 1988; Childs 1996; Craddock *et al.* 2007), direct wet mud clay (e.g. Greig 1937; Chaplin 1961; van der Merwe and Avery 1987), and stone slabs (e.g. De Rosemond 1943; Anderson 2009). The size of the furnaces could be related to their draught mechanism and number of tuyère ports per furnaces (e.g. van der Merwe and Avery 1987).

The investigation on the third theme: symbolism, medicines, and rituals of ironworking, has also been given relatively due consideration, Through the available information, we know that smelting could not be conducted without these socio-cultural recipes (e.g. van der Merwe and Avery 1987; Mapunda 2010, 2011). This involved decorating iron smelting furnaces in some traditional societies to symbolise a woman ready to wed (e.g. Childs 1991; Collett 1993; Barndon 2004), or generally to represent the female process of reproduction: adulthood, wedding, labour, and

the delivery of the baby (e.g. Wise 1958: 109; Barndon 1996; Schmidt 1997, 2006). The practise of medicines and rituals of ironworking in Africa all served to expel evil spirits, catalyse the smelting process, and more significantly were used as a patent right to those who knew the practises (e.g. Greig 1937; Wembah-Rashid 1969; Barndon 1996: 65; Mapunda 2002a; Craddock *et al.* 2007; Mapunda 2011). While we know more on the three research topics that have dominated metal production research in Africa (e.g. Killick 2004), it is noteworthy that there are some themes that were left out or have received relatively less research attention including: (1) microscopic examination of the extraordinary macro-variation of ironworking technology, (2) mass balance calculation of how much iron was produced at the African ironworking sites, (3) the history and technology of non-ferrous metallurgy in southern Africa, (4) the role of water in African metallurgy (Mapunda 2010), and (5) the bio-archaeometallurgy of African ironworking (Lyaya 2008; Mapunda and Lyaya 2009). In addition, it is possible that all ironworking societies have not been studied. I believe it is our responsibility as archaeologists to continue studying these sites, and whenever possible, and based on new information, we ought to challenge, rethink, revise or cast away misrepresentations of the sub-Saharan African technological past (Schmidt 2006: 7). Finally and in terms of chief research methods, the early researchers fundamentally employed experimental, ethnographic and oral historical approaches in the reconstruction of African iron metallurgy. Because most of the ironworkers have now passed away (Barndon 2004; Killick 2004), and because iron smelting enactments have often failed (Haaland 2004; Mapunda 2010), today we are obliged to rely on archaeological (field) and archaeometallurgical (laboratory) methods.

This study presented here uses mainstream archaeological methods to examine the available evidence of ironworking in Kalenga. This area was chosen because the Hehe practised traditional ironworking and are also famous in terms of historical military tactics in eastern Africa (for details, see Mumford 1943; Redmayne 1968a 1968b; Sutton 1969 1971; Kurtz 1978; Ofcansky and Yeager 1997). Iron was a central focus and a necessary ingredient for their military success, socio-cultural aspects such as marriage, and agricultural and hunting activities. Here, smelting furnaces, tuyères, and slags have been examined in order to understand the technology of metal production and spatial organization of ironworking of the Kalenga Administrative Division, in Iringa region (Fig. 1), southern highlands of Tanzania. Literally and in Hehe language, Kalenga means "the little water" (Redmayne 1968b: 425).

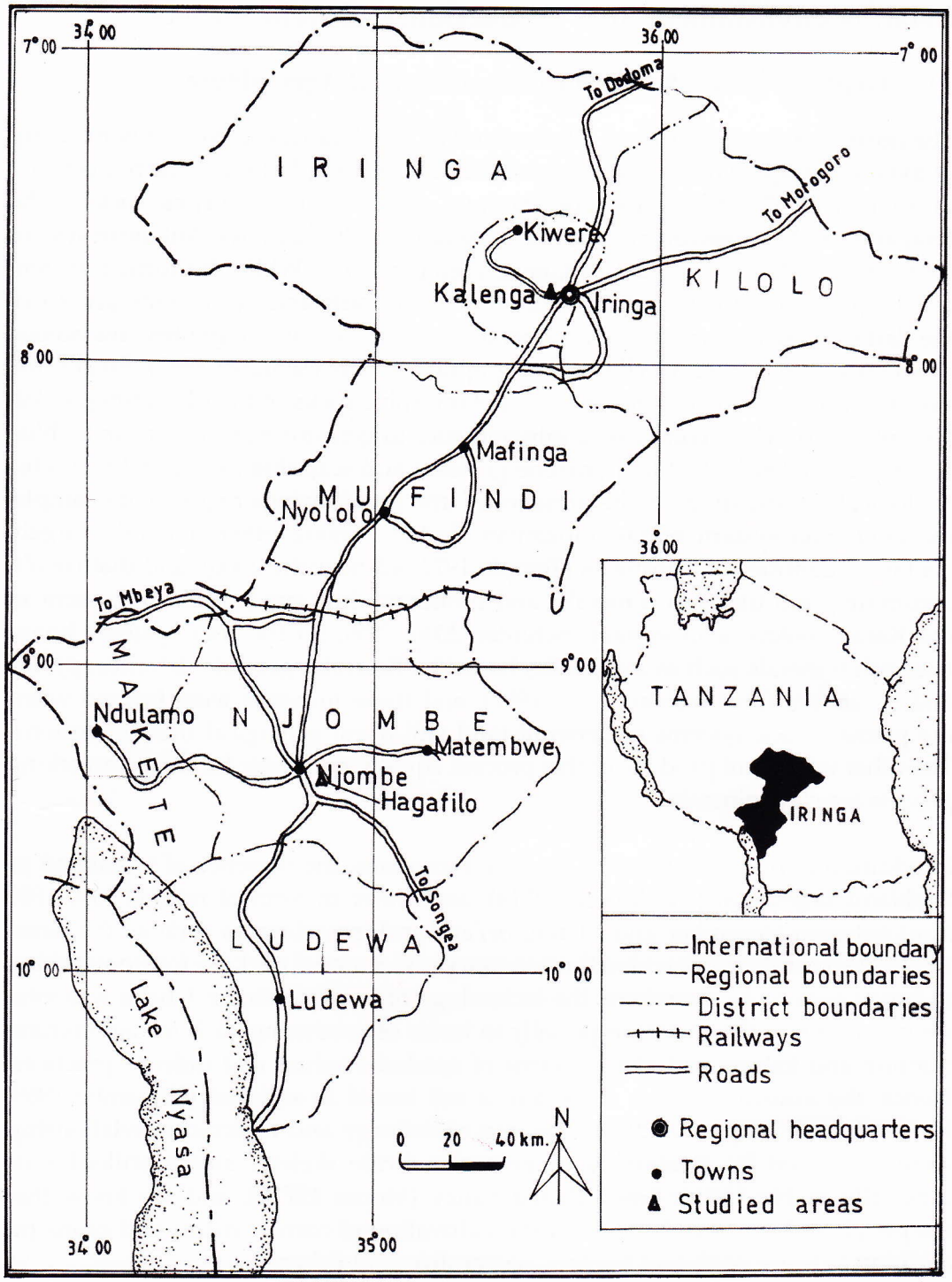


Fig. 1: Research Area: Kalenga in Iringa, Tanzania

Relating Environment, Iron Production, and Hehe Society

a) Geology of Uhehe, Iron Production, and Agriculture

The north and western parts of Uhehe (land of the Hehe) are geologically made up of the metamorphic rocks of the Tanzanian Craton (Temple 1971), which according to Schlüter (1997, 2006) consists of granitoid rocks. The metamorphic rocks of the Usagaran and metasediments and metavolcanics of the Karagwe-Ankolean system lie to the south-western part of Uhehe (Temple 1971). While the former system consists of psammitic to pelitic metasediments (biotite and hornblende gneisses), the latter system composes of minerals such as sandy quartzites, micaceous quartzites, iron, nickel, phyllites, and graphite schists (Schlüter 1997). Finally the eastern part of Uhehe is composed of metamorphic rocks of the Mozambique Belt (Temple 1971), which comprise of minerals such as gemstones, ruby, tanzanite (blue zoisite), hornblende, biotite, pyroxene gneisses and scapolite (Schlüter 1997). This geological context suggests the presence of iron ores in Iringa region. For example, the Dodoman system of the Tanzanian Craton, among other minerals, largely contains quantities of ironstones (Temple 1971: 42; Schlüter 2006), and that cobalt, chromium, and titanium minerals, and numerous iron ore bodies are present in the Karagwe-Ankolean system (Schlüter 2006: 229). So the rock-systems house iron-rich minerals such as magnetite, hematite, ilmenite, goethite, laterites, pyrite, and pyrrhotite (see Anthony *et al.* 1997), and these minerals were formed when the primary rock-systems underwent (and still does) geological transformations. The other important produce of this process equally necessary for the ironworking process are clay minerals.

In addition to the availability of abundant iron ores, the presence of woodland or bushland vegetation (e.g. Moore 1971a), and water in form of rainfall (600-1000 mm) between December and March, or/and in form of rivers such as the Great Ruaha (Jackson 1971) provided the necessary raw material package for ironworking in Iringa region. As elsewhere, the technology of ironworking in Uhehe was vital for prosperity of the society, especially in terms of producing tools for agriculture, hunting and fishing and also in terms of symbolic values and defence practices. Hence, the ironsmiths were respected, if not feared in societies (Kimambo 1969; Haaland 2005; Mapunda 2010). The iron metallurgy and agriculture relationship were reinforced by availability of generally fertile skeletal montmorilloid soils especially in the Upper Great Ruaha valley (Moore 1971b), and we know that the people of Iringa are famous for the cultivation of corn or maize and beans (in addition to being proficient hunters, pastoralists and fishers).

b) Iron hoe: a Compulsory Socio-cultural Recipe in Hehe Marriage

Based on marriage customs of the Hehe, the groom-to-be was is required to acquire and take two traditional iron hoes to the bride's family to symbolise the request

for, and acceptance of the marriage (Mumford 1943: 220). The first iron hoe was decorated with beads around the handle, and should this be accepted and indeed praised, then the second iron hoe was subsequently sent prior to bride-price arrangements. This custom is common is and similar to the Fipa of south-western Tanzania (e.g. Mapunda 2004) and the Bena of the southern highlands of Tanzania (e.g. Culwick and Culwick 1934). However, it is vital to note that while the Fipa and the Bena considered the hoes as part of the bride-price, for the Hehe it was a symbolic consent to proceed with the bride-price and marriage arrangements (Mumford 1943). Although Mumford (1943) does not explain who was responsible for the acquisition of the hoes, perhaps it was exclusively the responsibility of the groom-to-be as observed among the the Fipa of southwestern Tanzania (Mapunda 2004), and the Matengo of southern Tanzania (Kapinga 1990).

The groom-to-be had to demonstrate to his parents and senior in-laws that he was strong enough to marry the daughter, and this being the requirement, grooms-to-be were obliged to provide their labour to the chief iron smelters over a period of time, in return for a certain quantity of the smelted bloom at the end of every smelting episodes or smelting seasons. The smelted bloom was collected and eventually forged into hoes for this purpose through the assistance of iron smiths. So, the process of obtaining these hoes was not a one-off exercise, but a slow process of accumulating the iron that took up to three smelting seasons, equivalent to three years or more.

Elsewhere and among the Matengo, Kapinga (1990: 59) observes that it was perhaps this socio-cultural requirement that compelled young people to render their labour for iron smelting throughout the ages. It is not clear why most of societies in southern Tanzania (e.g. Mumford 1943; Mapunda 2010) and in South Africa (e.g. Plug and Pistorius 1999: 181) chose a hoe for this socio-cultural requirement and not another item. Perhaps this was due to the fact that many societies in Tanzania, for example, depended (and still do) on agriculture for socio-economic development, and therefore the hoe was a symbol of (re)production. Whatever the case, it suffices to understand that Hehe grooms-to-be had to demonstrate their strength through labour provision in order to meet this socio-cultural requirement. The introduction of a monetary economy and the importation of ready-made hoes from the outside world challenged and made the process of bride-price acquisition less difficult. It is important to note, however, that the Fipa continued practising the traditional hoe-giving tradition, although they were forbidden to smelt by colonial administrators (Mapunda 2004: 78), and the persistent resistance explains why it took so long to abandon ironworking in Ufipa until 1950s. In addition to the need of traditional hoes for marriage, the Fipa hoe was of better quality than the imported one, as Wise (1958: 111) observes, "this hoe [Fipa traditional hoe] will last its owner for three or four cultivating seasons, at least twice as long as the factory made article [hoe]". Therefore, the Fipa people became accustomed to the new way of life pretty slowly.

The demise of traditional ironworking in Tanzania as well as in other parts of the continent was due to competition from the relatively cheap European metalware and scrap iron (e.g. Chaplin 1961: 58; Mapunda 2003: 71; Ige and Rehren 2003: 16), and along the coast of East Africa the fall in traditional iron production was especially due to Portuguese invasion, among other factors, who deliberately suppressed local production (e.g. Mapunda 2002b: 85).

c) *Iron and the Hehe Wars*

Most of the history of the Hehe people is in association with the historical inter-tribal and international wars that they fought. After the unification of the Hehe in the 1850s, the first chief of the Hehe led them in a series of inter-tribal wars. He fought chiefs Mtengela of Utemikwila, Merere of Usangu and Chipeta of Ungoni, and won a decisive victory (Redmayne 1968b). Chief Munyigumba died in 1879 and was buried at Lungemba, and his son, called Mkwawa succeeded him. Chief Mkwawa selected Kalenga as the new capital in 1880. While inter-tribal wars continued, the Ngoni and the Hehe made an agreement in 1881 to make peace because there had been heavy losses on both sides. But the Hehe continued fighting and conquering other tribes. They fought the Sangu, Masai, and made brief raids in Unyanyembe, Ugogo, Usagara, and Uvidunda (Mumford 1943; Redmayne 1968a, 1968b). Through raids, the Hehe acquired many colonies where they obtained cattle, prisoners, and trade goods, and indeed in the 1880s, they had become a recognized threat to traffic on the caravan route (from the interior to the Tanzanian coast) , especially between Kilosa and Mpwapwa (Redmayne 1968a).

They resisted German colonial penetration in Uhehe, fighting and defeating the Germans in 1891. In this memorable war, the Hehe killed many Germans including their commander Zelewski (also known as *Nyundo*, meaning, hammer), who was struck with a spear by Muvangulumemila Mwampunza. According to Mumford (1943: 419), the German loss included "10 Europeans, about 200 men, as many guns, 3 cannons, 23 donkeys, 96 porters, and most of the baggage". Similarly, the Hehe losses were heavy, but this confirmed their reputation as the most powerful military tribe in East Africa (Mumford 1943). Mkwawa was therefore named the Black Napoleon.

The Germans fought back the Hehe in 1894 under new governor, Von Schele. When the Germans reached Kalenga the fighting was hand to hand, from the roofs of the huts and in the doorways. Mkwawa escaped unrecognized. The Germans destroyed the fort and later in 1896, they built a fort, which they called New Kalenga (Redmayne 1968a: 53). The Germans ruled Uhehe in 1897 via Mpangile and later via *akidas* and *jumbes*, and searched for Mkwawa for the followed 18 months. The Hehe resistance weakened gradually because of the absence of chief Mkwawa for his coordination abilities, also hunger and diseases threatened the Hehe. Finally, on the 19th July, 1898 Mkwawa committed suicide at Pagawa, and the Germans cut off his head

and took it to Germany perhaps for examination and display in museums. This war cost the Germans more effort and blood than they had expected (Redmayne 1968a). After this international war the Hehe did not want to participate in any other war including the Majimaji rebellion of 1905-1907 (Iliffe 1967) perhaps because of the aftermath of the previous wars. Mkwawa's head was brought back to Tanganyika in 1954, and it is securely kept in the Mkwawa Museum at Kalenga.

There is a lesson to learn from the Hehe wars; that the dominance and military strength of the Hehe for virtually a century were mainly linked to their fighting tactics and weapons such as spears, bows and arrows, all of which were made of local bloomery iron. Although guns were introduced by Arab traders in the first decade of the 19th century, the traditional iron weapons continued to play a significant role, due to socio-cultural beliefs the local weapons were believed to be powerful and stronger than the imported guns. It is unfortunate to see that although ironworking contributed greatly to the socio-economic history of the courageous Hehe people, the study of iron production technology in Uhehe has not been granted due weight and recognition. This work is an endeavour towards this end.

The Archaeological Evidence of Ironworking in Kalenga

The early research on the archaeology of Iringa districts focused on the study of Isimila Stone Age site. Thematically, the research at Isimila can generally be grouped into several themes: (1) the technology of the ESA (Early Stone Age) stone artefacts of Isimila site (e.g. Howell 1961; Cole and Kleindienst 1974; Clark 1988), (2) the culture and environment of the hominids that lived at Isimila sites and its outskirts (e.g. Hansen and Keller 1971), (3) dating of the deposits of Isimila (Howell 1972), and (4) the cultural sequences of the later prehistory of Isimila (Willoughby 2007). Outside Isimila, there have been cultural heritage impact assessment (CHIA) studies (e.g. Masao 1995; Msemwa 2001), a study of symbolism of iron smelting (Halifan 2005), and more recently Biittner *et al.* (2007) have published some fieldwork results of their ongoing research on rock art of Iringa, specifically in Kalenga Division.

The work presented here is based on three fieldwork seasons in Kalenga to document the archaeological evidence of ironworking technology in Uhehe in 2006, 2008, and 2010. In August 2006, 11 iron furnaces, slags, furnace bricks and tuyères were encountered at Ngongwa site in Mkoga village through surface surveys. The excavation of this site retrieved 2457 slag fragments (39 kg), 53 fragments of tuyeres (2 kg), 70 complete furnace clay rolls 19 kg), 9 potsherds (250 g) and 67 charcoal samples (500 g), and these materials have been reported elsewhere by this author (Lyaya 2007). While surveying for rock art sites, the October 2008 fieldwork team at Mangalali site (also known as HxJg 110) encountered about 10 small iron smelting furnaces, as well as heaps of slags in association with tuyères and other debris. Finally, during the summer of 2010, the site of Magubike was briefly surveyed (also

known as HxJf 7 and 11) and here about 8 iron smelting furnaces, slags and tuyères were recorded. These materials have been examined and the results are helping to understand the iron smelting technology of the Hehe people.

The Ngongwa Iron Smelting Furnaces

The iron smelting furnaces of Uhehe with reference to Kalenga are herein referred to as the Ngongwa furnaces, because they were first discovered at Ngongwa site in 2006 and so this is the type-site. The Ngongwa furnaces walls (clay rolls) are relatively small in size, measuring approximately 9.5 to 11.5 cm long, 4 to 5 wide, and 4 to 7 cm thick. The walls can be described as small clay rolls. Such furnace building materials make Ngongwa furnaces unique and different from their neighbours: Bena (e.g. Sutton 1985; Lyaya 2008) and Fipa furnaces (e.g. Barndon 2004), were all built from lumps of wet clay. They are also different from the Rongo iron smelting furnaces which were built of slabs (De Rosemond 1943). However, based on the use of clay rolls to construct iron smelting furnaces in Uhehe and the practise of slag-pit furnace technology, it is possible to state that the Ngongwa furnaces can be related to EIA furnaces from Rwanda and Burundi (e.g. Craddock *et al.* 2007), Usambara Mountains (Schmidt 1988), and Uhaya (land of the Haya) (e.g. Childs 1996). Craddock and others (2007: 2) have recently reported EIA iron smelting furnaces from Rwanda and Burundi that were made of clay rolls with simple impressions perhaps as some form of decorations.

Also, the EIA iron smelting furnaces from Rwanda and Burundi, Usambara and Uhaya in Tanzania were described as slag-pit furnaces (see Schmidt 1988: 36; Childs 1996: 285). As for the clay rolls, however, there is no intentional forms of decoration whatsoever on the Ngongwa furnaces, which consequently sets them apart from those found and described by Schmidt (1988: 36) and Craddock *et al.* (2007: 2) respectively. I am not entirely sure on the source of the evident differences in the decorating designs and the use of clay rolls instead of bricks, but it could perhaps be a function of time and space. Apparently, Magubike site dates to between *cal.* 1320 and 1620 AD (dated by Pamela Willoughby), while the Usambara sites located approximately 450 km north of Uhehe, for example; date to the mid second millennium AD (Schmidt 1988).

Besides the isolated clay rolls, there are frequent and observable remnants of the actual smelting furnaces. These are associated with other smelting debris in secondary context surrounding the working place (WP). These furnaces regularly contain an intact lump of slag at the bottom and occasionally appear overlapping each other (Fig. 2). The inside part of the furnace wall appears somewhat reddish brown, but the outside part is light or dark brown. The difference is possibly attributed to the difference in the thermal conditions where the inside of the furnace becomes hotter than the outside. While the external diameter of these furnaces ranges between 46 cm and 70 cm, the internal diameter ranges between 36 cm and 63 cm. Based on these measurements, the Ngongwa furnaces are relatively small in size and diameter, for

example when compared to Njanja furnaces of Zimbabwe, which measure 70 cm-120 cm in diameter (Chirikure 2006: 144). Although it is difficult to reconstruct the actual height of a collapsed furnace (e.g. Craddock *et al.* 2007: 5), it is more likely that on top of the 10.30 cm height of the remnant furnaces (Fig. 3), there was an additional height because there are lots of the furnace clay rolls at all the studied sites (Fig. 4) that were removed from the original furnaces in order to collect the bloom or initiate other smelts. Oral tradition suggests that these furnace were knee-high, which further strengthens the proposition that the Ngongwa furnaces were short shaft-furnaces.

As noted earlier, Ngongwa furnaces systematically contain an intact lump of slag at the bottom, and this indicates that slag drained down to the slag-pit. Unfortunately, it is difficult to measure the depth of the slag-pit of the Ngongwa furnaces because based on their overlapping nature, it appears that the slag blocks were intentionally moved away from the WP and deposited elsewhere with other debris to allow and give space for subsequent smelts. Although the depth of the pit cannot exactly be known, the evidence of intact lump of slag at the bottom of all the furnaces, in addition to the presence of droplet slags at the Kalenga sites, strengthens the slag-pit practise of slag removal within these furnaces (Schmidt and Childs 1985: 56).

Lastly, the small clay rolls were either naturally or intentionally mixed with sand or quartz minerals more likely to enhance the thermal properties of the materials (e.g. Childs 1996; Chirikure and Rehren 2004). But in order to distinguish between natural and intentional tempering, further petrological examination of the clay rolls is needed (Childs 1989), and this will be carried out in the future.



Fig. 2: The Overlapping Ngongwa Furnaces

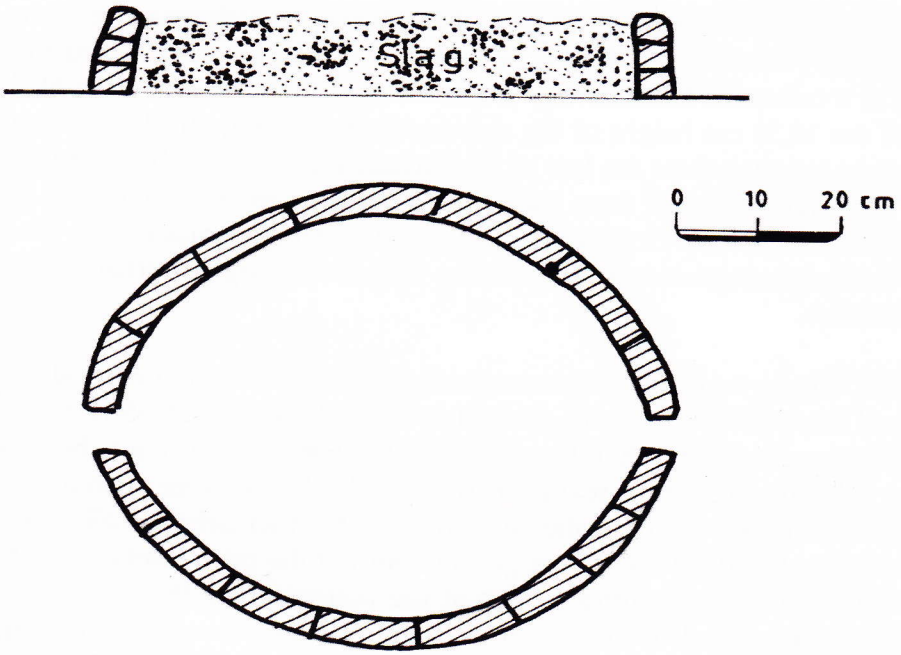


Fig. 3: The Plan of the Ngongwa Furnaces



Fig. 4: The Ngongwa Furnace Clay rolls

The Working Place (WP)

As noted earlier, one possible explanation for the overlapping furnaces is that they were dismantled to allow subsequent smelts. If this was the case, it is correct to suggest that the furnaces were meant to serve for single smelts (e.g. Sutton 1985; Childs 1996). It is noteworthy that all of the studied sites from the Kalenga region have depressions at the centre, measuring about 5 m to 7 m diameter, 70 cm - 100 cm deep, and between 90 m and 140 m^2 area (Figs. 5 and 6).

Excavation of one of the depressions at Ngongwa site retrieved furnace-clay rolls, tuyeres, slags and potsherds. The context of the excavated materials tend to indicate that the depression was a working place (WP), where the actual iron smelting took place, or where the smelting furnaces had been situated. It appears that the iron smelters, after each smelt, dismantled the smelting furnaces for bloomery iron or steel collection, and moved the furnace and other debris away from the WP to where they are actually found today. In addition and as an alternative explanation, the depressions could as well have been used to provide a source of clay for the making of the furnace bricks, coils and tuyères, but this has yet to be verified through chemical analysis of both clay samples from the depression and furnaces bricks from respective sites.

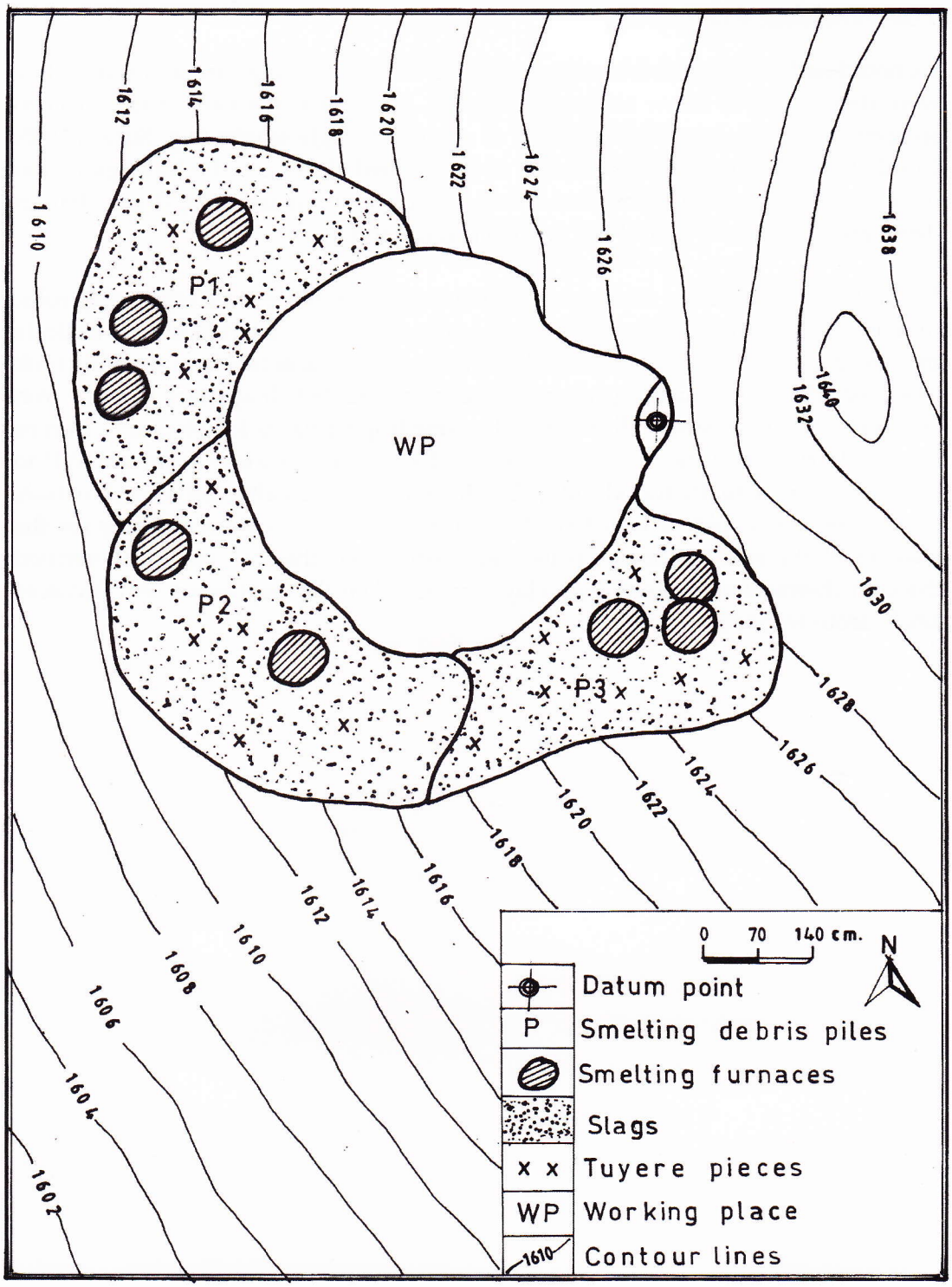


Fig. 5: The Working Place (WP) at Ngongwa site

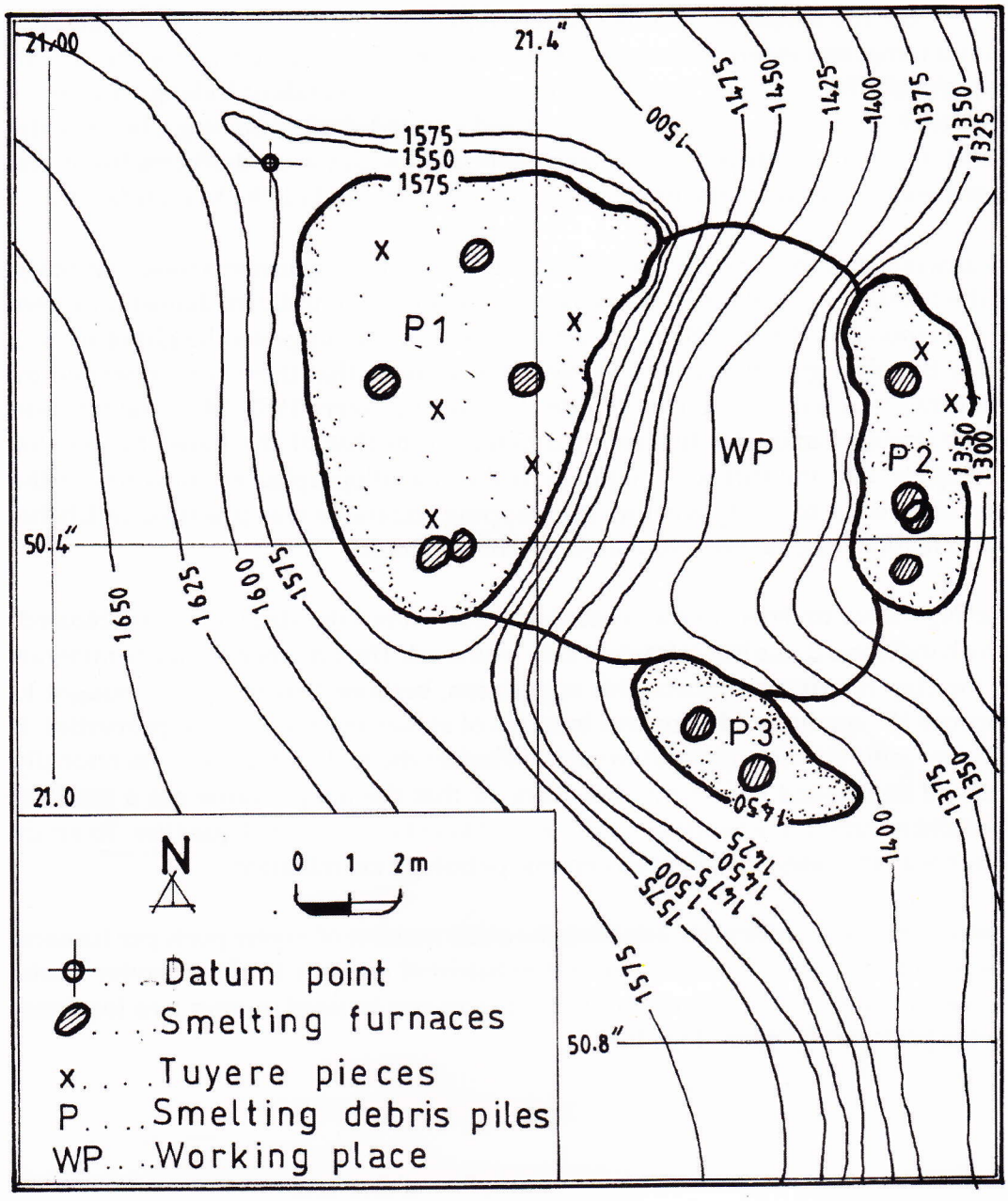


Fig. 6: The Working Place (WP) at Magubike site

The Ngongwa Tuyeres

The tuyères of the Kalenga Division appear in two shapes, namely; those complete ones with flared proximal ends, and those incomplete with uniform diameter from tip to tip (Fig. 7). The complete flared tuyeres measure 9.5 cm to 15.5 cm long, 2.5 cm to 3.0 cm internal diameter, and 5.5 cm to 6.5 cm external diameter. It has been difficult

to measure the length of the other tuyère type because they were incomplete, but their internal and external diameters range between 2 cm - 2.5 cm and 4 cm - 4.5 cm respectively. Based on the flared or trumpeted proximal ends of Kalenga tuyères, it is more likely that the Hehe people practised a forced-draft technology, because the flared or trumpeted tuyeres have been associated with forced draft practise in the flared ends allowed for the insertion of the bellows (Childs 1996; Mapunda 2010).

Meanwhile, it is well known that the natural draft smelting furnaces took advantage of the buoyancy of hot air and have been associated with uniform diameter tuyeres (e.g. Mapunda 2010: 153; Barndon 2004). Based on the suggested height of up to 1 m for the Ngongwa furnaces, however; it is unlikely that these were operated by a natural draft mechanism (see van der Merwe and Avery 1987: 149). The function of the uniform diameter tuyères, if different from that of the flared tuyères for air supply into the furnaces, requires further metallographic examination of the respective slags to verify whether slag tapping technique was practised in Uhehe, and whether these tuyères were used for this function.

The Ngongwa tuyères are slag-coated and sometimes the distal ends are bloated, which indicates that a less refractory clay was used. The presence of quartz minerals in the clay matrix strengthens this suggestion, because tempering was sought to improve the quality of the tuyères in terms of enhancing the thermal properties. It is noteworthy that it is difficult to verify whether the metal producers intentionally crushed and added quartz into the clays, or that the temper ature are a result of different natural clays recipe carefully mixed to enhance thermal qualities. To verify which was the case, we will need ceramic petrology examination.

Lastly, it has been difficult to establish the exact number of tuyère ports per furnace. The remnants of the furnaces are not substantial enough to show tuyère ports. However, the size and diameter of the furnaces can be used to infer two (or three) tuyère ports per furnace (Fig. 3).

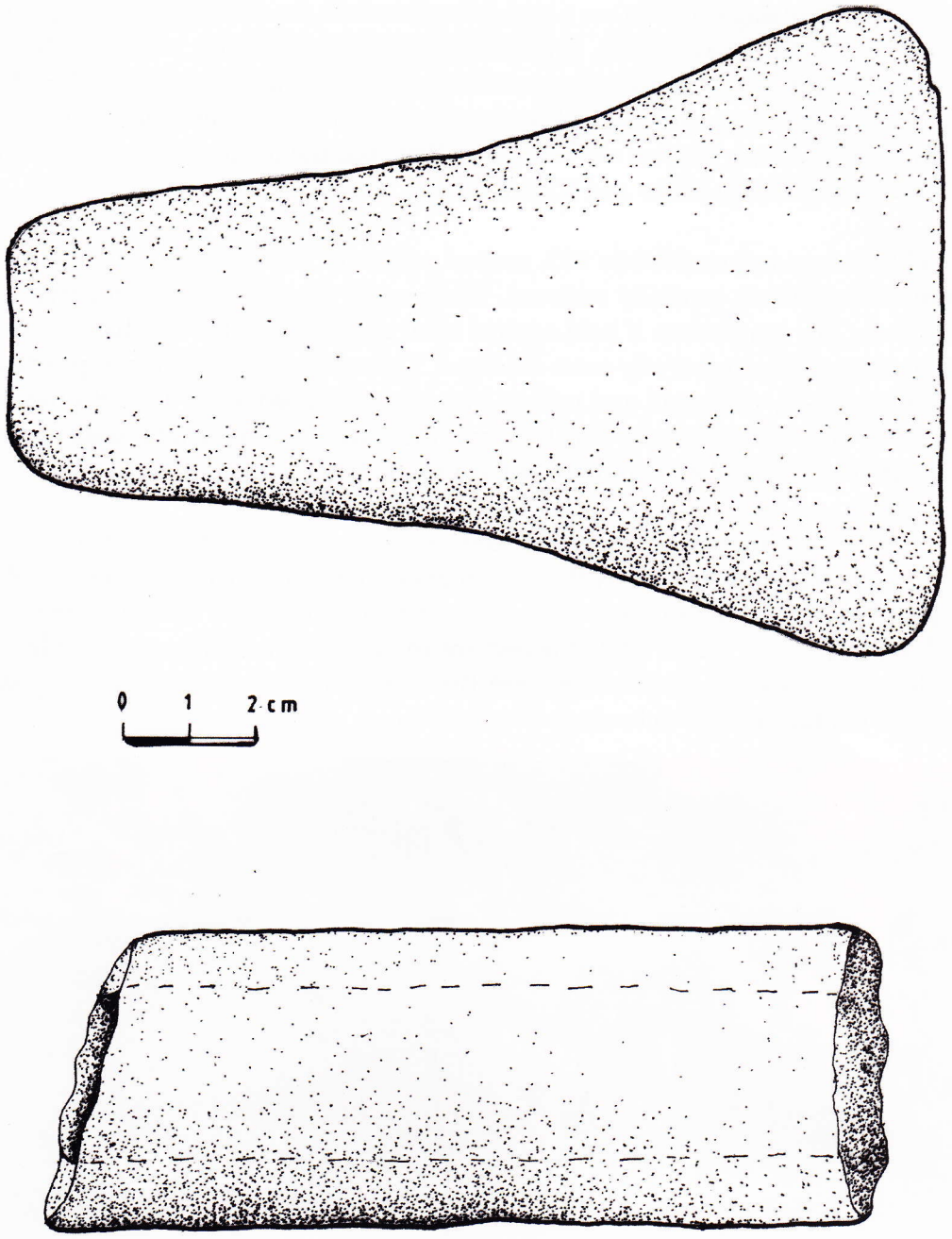


Fig. 7: The Ngongwa Tuyeres

The Slag Physical Attributes

The slag fragments of this area weigh between 1 kg to 25 kg (Fig. 8). The majority are amorphous, although a small proportion are either cake-like or droplet slags. The cake-like slags had melted and solidified at the bottom of the furnaces in the

slag-pits. While slag droplets are a major characteristic for smithing sites (e.g. Miller and Killick 2004; Lyaya 2008), Schmidt and Childs (1985: 56) maintain that the small beads [or droplets, own interpretation] are excellent diagnostic markers for a furnace-pit smelting technology. However, it is worth noting that droplets produced during the smithing process are usually hollow, but the droplets produced during smelting are not (e.g. Miller and Killick 2004).

Of all the slags, approximately 90% melted and show flow texture, and about 10% were unfortunately partially reduced. In terms of ferro-magnetic property, over 75% show low magnetism if held against a bar magnet, and the rest have medium magnetism and are relatively more oxidized. There is a strong relationship between slag magnetism, oxidation and colour. The more oxidised slags are both medium magnetic and reddish brown in colour, and the lower ferro-magnetic slags are both less oxidised or weathered and are greyish in colour.

In terms of inclusions, impressions and surface condition, the slags consist of noticeable sand and very rarely they impregnate charcoal or wood pieces. Of all the slags, over 50% have impressions perhaps of wood and other inorganic materials and about 40% are rough while the rest are smooth. So, in addition to droplet slag evidence, the texture, impressions and the rough surface conditions of the slags support the furnace-pit technology proposition.



Fig. 8: The Kalenga Slags

Discussion

This paper has provided a macroscopic description of the remains of the iron production technology in Kalenga Division. From these descriptions, the design of the smelting furnaces, mode of air supply into the furnace, slag collection techniques, and spatial organization of the technology have been considered. This section discusses these objectives in relation to the presented archaeological data above in terms of furnaces, tuyeres and slags. For the sake of clarity, each of these objectives is dealt with separately.

First, the Hehe ironworkers built their iron smelting furnaces using small clay rolls. It has been difficult to identify nearby sources of clays that were used to make the small bricks, but it is possible to suggest that such sources were not too far from the smelting sites, or the depressions at the sites may have served for this function. However, this needs chemical data for verification. The Ngongwa furnaces were not bowl furnaces, but short shaft furnaces. What remains unknown is the actual height of the furnaces, but based on diameter of these furnaces, it has been possible to hypothesize a height of up to a meter. The design of Ngongwa furnaces with slag-pits provisions, the apparent evidence of flared tuyères suggest the use of bellows and clay rolls to build the furnaces and can be used to compare them with the EIA furnaces of eastern Africa (see Schmidt 1988; Craddock *et al.* 2007). The fact that some of the EIA furnaces were constructed using clay rolls (e.g. Craddock *et al.* 2007: 2) instead of fired bricks is interesting and requires examination. It is possible that the change in the design of the construction materials could be attributed to time and experience facets. It might be that some of the brick-made furnaces were technically less efficient (for example, see Craddock *et al.* 2007) possibly due to heat loss in the spaces between one and another brick courses, but through repeated experience, ironworkers became aware of this problem and tackled it by the use of wet clay rolls instead of the fired bricks.

However, the question of how efficient the Ngongwa furnaces were in terms of retaining necessary temperature and atmospheric conditions for the reduction process is important, but has not been addressed with the present data, because this needs microscopic and chemical data of the slags to verify the technical efficiency of the furnaces (see Rehren *et al.* 2007). Therefore, this remains to be addressed in future research. In order to verify this proposition, it will be necessary to microscopically examine slags from the Usambara mountains.

Second and with regard to the way air was supplied into the furnace, it is possible to suggest a forced draft operation using bellows. The flared or trumpeted proximal ends of tuyeres are associated with forced-draft smelting furnaces (Childs 1996; Mapunda 2010). The proposed height of say, less than a meter, is perfectly congruent to this kind of operation. Van der Merwe and Avery (1987) have suggested a height of at least 1.5 meters for a natural draft operation.

Third, the Ngongwa furnaces were possibly slag-pit furnaces. This means the slag drained down to a pit at the bottom of the furnace, and once this pit got filled with slag the end of a smelt was reached. The proposition of a slag-pit technology is based on: (1) The presence of intact lump of slags at the bottom of all of the furnaces in Kalenga. (2) The rough physical attributes of the slags strengthen this suggestion, because if the slag had been horizontally tapped out of the furnaces, the remains would have been macroscopically different (Lyaya 2009). (3) Droplet slags, which are characteristic of slag-pit technology (Schmidt and Childs 1985), have been recovered in large quantities from all the Kalenga sites (see Miller and Killick 2004). However, it is noteworthy that flow slag can be so confusing to classify either to slag-pit or slag tapping processes (e.g. Haaland 1994/1995; Haaland and Msuya 2000; Haaland 2005). It is imperative, therefore, that the present suggestion of slag-pit furnace be tested microscopically to find out the presence of magnetite skins or thin and elongated fayalite crystals in the slags (e.g. Miller and Killick 2004; Chirikure 2006; Chirikure and Rehren 2006; Humphris *et al.* 2009; Iles and Martinon-Torres 2009). If the Ngongwa furnaces were a slag-pit technology, then it is correct to pose that the furnaces were meant for single smelts after which they were dismantled for bloomery iron collection, and this helps to discern their secondary contexts with other debris around the WP.

Finally, all the studied Kalenga smelting sites are located in the mountains away from the settlements, which suggest that there was perhaps an intentional desire to seclude the activities from the general public for socio-cultural reasons, or iron smelters desired to be close to the bulkiest raw materials such as iron ores and wood for charcoal. To elucidate this aspect of seclusion, the Hehe customs and traditions maintain that when a pregnant woman is close to deliver a child, she moves away from her husband's house and lives with her mother-in-law or with her own mother (Mumford 1943). More important to note is that during delivering process the mother-to-be will be fully taken care of by renown village midwives. These old women were responsible for all necessary rituals and ensured a safe delivery of the child, and in case of any difficulty, they resorted to the use of traditional medicines (Mumford 1943).

Meanwhile, the husband was denied access to see his wife until she delivered and until when all the preliminary rituals to the child were successfully accomplished, which could take up to two weeks. What can we learn from this socio-cultural aspect of the Hehe people in relation to traditional ironworking? There is no simple answer to this question, but an attempt can be made. Unless we symbolically relate iron production process to pregnancy and child delivery (Collett 1993; Schmidt 1997, 2006; Mapunda 2010), the seclusion of iron smelting activities would largely be insensible. However, it is noteworthy that the current symbolic interpretation of the seclusion of iron smelting activities, that the actual iron smelters were symbolically the husbands married to the furnace (wife) is not universally applicable, and

inherently; it tends to silence the role of midwives or women in pregnancy and child delivery process. As noted above, the Hehe customs and traditions maintain that the father-to-be stayed home and the responsibility of child delivery process was administered by prominent midwives. Therefore, it is the husbands who stayed home, those who should symbolically be likened to women whose access was denied to smelting activities, and similarly, the midwives who were responsible for the delivery process of a child should symbolically be likened to the actual iron smelters whose responsibility was to ensure production of iron. The pregnant woman will symbolically fit to be the iron smelting furnace, and bloom in place of the child. This new interpretation of seclusion symbolism gives due weight to the role of midwives and fits well in the Hehe ironworking context.

Therefore, the explanation of iron production and (re)production symbolism such as that of the Haya in northeastern Tanzania (e.g. Schmidt 1997, 2006), where men are symbolically equated to iron smelters, and that the smelters are symbolically married to their furnace wife, needs to be evaluated in the light of new research findings and in view to recognize the role of traditional midwives during pregnancy and child delivery. Based on the ubiquitous occurrences of the iron smelting furnaces including other archaeometallurgical remains in Uhehe, it is likely that iron smelting technology was practised at a large scale and might have been so important for socio-economic aspects of the Hehe people. Socio-culturally, ironworking process provided the Hehe with hoes for agriculture, which was (and still is) the backbone of the lifeline of majority Tanzanians. Other special tools for hunting and fishing, and in particular, traditional hoes were the primary prerequisite for bride-price arrangements and symbol of being accepted to marry someone's daughter.

Politically, it is more plausible that the famous chiefs Munyigumba and Mkwawa of the Hehe took advantage of the bloomery iron produced, to smith many weapons such as spears, bows and arrows for wars against their inter-tribal enemies and thereafter against German intrusion in the last quarter of 19th century. Although the Magubike sites have been dated, there is need to date the other sites in Uhehe in order to confirm the suggested links between ironworking technology in Uhehe and the reigns of the Hehe chiefs.

Conclusion

The iron production technology of the Hehe involved short shaft furnaces, which measured about 1 meter. These furnaces were constructed using small clay rolls, and the air supply into the furnaces was performed using bellows. Flowing slag was allowed to collect at the bottom of the furnace through the so-called slag-pit technique. All the smelting activities in Uhehe were secluded from the public domain, because of both socio-cultural and technical reasons.

In terms of future research avenues, there is a need to look at the nature of the plants and animals that were part of the iron production process (bio-archaeometallurgy) in order to find out whether the Hehe ironworkers were a select species which practised an omnivorous consumption of animals and plants, if at all; and look at the reasons of each of their choices. Also and finally, there is a need to conduct chemical analysis of the remains in order to examine the technical parameters of the Ngongwa furnaces (e.g. Whiteman and Okafor 2003; Miller and Killick 2004). This will be important to bridge the gap between traditional ethno-historic and anthropological approaches and old fashioned techno-historical engineering approaches (Rehren *et al.* 2007), by combining a broad culturally –embedded approach of typology with comprehensive scientific research aimed at understanding Hehe smelting operations.

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