Iron mining and metallurgy in pre-colonial Zimbabwe: A review

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ABSTRACT: Zimbabwe, a land with abundant iron ores, has been populated since the 6th century AD mostly by iron-using, Shona-speaking agriculturalists. The extractive iron metallurgy they employed in the late 1800s was the bellows-powered, forced-draught furnace – in contrast to general practice north of the Zambezi. The Njanja clan of east-central Zimbabwe – the best known local exponents of this technology – constructed batteries of small furnaces each with two, rear, tuyère holes. Prior to the 15th century, however, large natural-draught furnaces with multiple tuyère holes were the dominant smelting apparatus. During the Zimbabwe Culture period in the 14th-15th centuries, non-agricultural production (mainly gold and ivory, plus iron and copper) came under the control of political élites overseeing a redistributive economic system with exports to the east African coast and beyond. The advent of the smaller forced-draught furnace may be related to the eventual decline of the Zimbabwe Culture and its economy.

A 1500-year-old technological tradition

The Shona-speaking peoples of Zimbabwe and their Iron Age ancestors have inhabited the plateau between the Limpopo and Zambezi rivers since the mid-1st millennium AD when the first farmers arrived with a fully developed iron technology. Primarily mixed farmers, they sought to avoid the sometimes disastrous effects of periodic and unpredictable drought by engaging as part-time or seasonal specialists, and to the extent that their local environment and resources allowed, in additional economic activities such as cattle-herding, ivory-hunting, salt-extraction and the mining of gold, copper and iron. Unlike gold and copper, iron was an essential commodity in the economic, social and political life of these societies. It not only provided tools for clearing the land, tilling the fields, and mining ores, as well as weapons for hunting and war, it was also used as a form of currency. It was exchanged for other goods, used in payment of bride wealth, land or mining rights, as tribute, and as symbol of chiefly authority. Iron ore mining, smelting, and forging were therefore widely practised craft skills throughout the Iron Age, and they continued as vibrant economic activities into the very early colonial period.

Research in recent years has shown that far from remaining static through many centuries, the social and economic role of iron and the technology of its extraction in Iron Age Zimbabwe witnessed dynamic change in both time and space. Information on Iron Age iron technology on the Zimbabwean plateau is largely dependent upon archaeology and the recording and excavation of furnace remains, tuyères (air pipes) and smelting slag, together with the recognition of ore-preparation sites such as grinding hollows ('dolly holes') and rock anvils and hammers. In favourable conditions, the age of a smelting site can be determined by radiocarbon dating of charcoal embedded in slag. The importance of archaeological research is especially true for the early periods. While Arab and (especially) Portuguese documentary sources are of some value in the middle periods from about the 11th century, the greater part of what is known about Shona iron technology in the late

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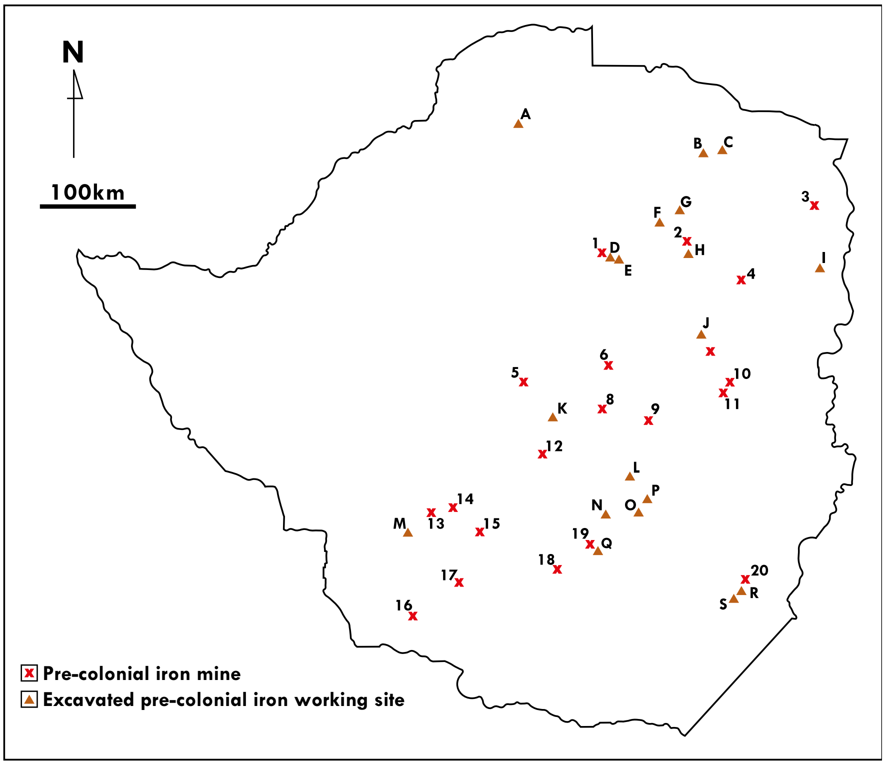

Figure 1: Distribution of pre-colonial iron-ore mines and excavated pre-colonial iron-working sites in Zimbabwe.
Iron ore mines:
1, Darwendale; 2, Arcturus; 3, Makaha; 4, Anwa; 5, Redcliff; 6, Mwanesi; 7, Hwedza; 8, Mvuma; 9, Felixburg; 10, Dorowa; 11, Shawa; 12, Shurugwi; 13, Thabas Inyoka; 14, Mulungwane; 15, Filabusi; 16, Antelope; 17, Gwanda; 18, Mberengwa; 19, Buchwa; 20, Mhangula/Manyoka.
Iron-working sites:
A, Mukwichi; B, Swart Village; C, Baranda; D, Tarnagulla; E, Gwebi Junction; F, Surtic; G, Chisvingo I and II; H, Gilnockie; I, Ziwa; J, Shaka; K, Senale; L, Gokomere; M, Matopo Hills; N, Chivi; O, Chigaramboni; P, Goose Bay; Q, Nenga; R, Mhangula; S, Kwali Camp.

pre-colonial period comes from the observations and enquiries of late 19th-century travellers, soldiers, missionaries, colonial administrators, miners and Geological Survey officers (*e.g.* Baden-Powell 1897; Bent 1893; Hall 1909; Hall & Neal 1902; Knight-Bruce 1896; Burke 1969; Sawyer 1894; Shimmin 1893; Theal 1964) and, in more recent years, from the work of oral historians and other academics (*e.g.* Beach 1977; 1980; 1984; 1994; Mackenzie 1975).

Iron Age iron-mining

Zimbabwe is well provided with a diverse range of iron deposits in many parts of the country, a fact noted by the Portuguese missionary Fr. M. Barreto in 1667 (Abraham 1961). The explorer and geographer Carl Mauch observed numerous iron-ore mines around the country in the early 1870s (Burke 1969) and many have now been identified (*e.g.* Summers 1969) (Fig. 1). Other mines are indicated in oral testimony and Portuguese sources at Shawa, Mahugwi, Maungwe, Manyika, Sanga and Teve (Beach 1977). The mines were generally open quarries. Many were quite large: for example, those at Mwanesi (Fig. 2) were 45 m long, 15 m wide and 9 m deep (Worst 1962). Near Mberengwa there were ‘ancient workings extending in an unbroken line for at least twenty miles’ (Hall & Neal 1902).

Most of the known mines were associated with the iron-formations (or ‘banded ironstones’) that are a common component of most of the country’s Archaean greenstone belts and are also found in parts of the Limpopo belt in the south (Amm 1940; Ferguson 1934; Macgregor 1935; 1937; Maufe 1920; Maufe et al. 1919; Phaup 1932; 1933; Stowe 1968; Worst 1962). Others occur in less common geological formations. For example, Dorowa is a magnetite-bearing carbonatite complex (Summers 1969), whereas the Anwa deposit (Bent 1893) consists of loose magnetite sand derived by weathering of dolerite. Magnetite sand, possibly with a similar origin, was also used as an iron ore in Nyanga. In some cases, an iron-ore source has been inferred from the concentration of smelting debris in the close vicinity; for example, magnetitiferous ironstone in the Mhangula/Manyoka hills (Swan 2007) near Chiredzi, an unusual asbestiform magnetite found in the Great Dyke near Darwendale (Prendergast 1979a), and several sites near Buchwa mountain (Van der Merwe 1978). Many smaller sources may never be identified, such as low-grade laterite which could be picked up on the surface; this ore type was used in Nyanga and by the Manyubi in Matobo (Cooke 1966).

Since potential ore was so widespread, all villages were either less than a few days’ march from an iron deposit or were in contact with a village within easy reach of one. The choice of a particular source of ore must have been decided by considerations of distance, ownership and metallurgical quality. Although local deposits were mined in many cases, some groups travelled long

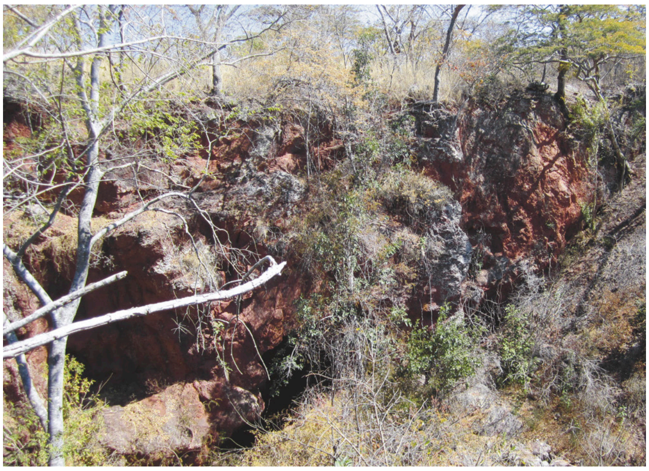

Figure 2: Part of the large, heavily overgrown, Shona iron-ore quarry at No.4 Body, Berlena farm, Mwanesi. (Photo: M Prendergast).

distances to obtain a particular ore. Thus, the famous deposits on Hwedza mountain were occasionally exploited by people from as far away as Gutu, Seke and Shurugwi (almost 200 km to the SW) (Beach 1977). No doubt any necessary beneficiation of the ores, such as separating the magnetite-rich and silica-rich bands (in the case of iron-formations at Hwedza), would be carried out at the mine site to save weight.

Although in the 19th century the Hwedza mines lay within the territory of the local Mbire people, rivalry over their use led to armed conflict with the Njanja people to the south of Hwedza (Beach 1977; Mackenzie 1975; Prendergast 1974). From time to time, the Njanja would form an armed band, go to Hwedza mountain, mine ore, and then beat off attacks by rivals until they had smelted enough ore on the spot to take home and keep them in hoes until the next expedition (Prendergast 1974); evidence of such mine-site smelting at the Gandamasunga quarry on Hwedza mountain can be seen today. On other occasions, the Njanja paid for access to the mines and took the ore back to their villages to smelt.

Despite the favoured status of certain iron deposits, such as Hwedza, little is known about the metallurgical suitability of the different ores for the smelting techniques used in the Iron Age (see below), or even the nature of the ore mined in many cases. Most of the iron-formation quarries seem to have been in either the primary magnetite-rich rock or the massive haematite-rich enclaves formed by secondary processes. Unlike the magnetite-rich bands (see above), which are both high grade and naturally permeable, the haematitic ore bodies mined in modern times at Buchwa are generally hard, impermeable, and the iron-rich portions difficult to separate and concentrate (Worst 1962). The haematitic ores formerly mined by Iron Age people near the surface of modern ore bodies (*e.g.* Mwanesi, see above) may have been relatively decomposed and more friable than the ore mined today. The nature of the ore is also uncertain where both primary magnetite and secondary haematitic ores seem to have been mined from the same general ore source – for example, on Hwedza mountain – suggesting that different ores could be mined in close proximity. High-grade ores were more suitable for pre-industrial smelting operations as they gave higher yields and less slag, although hard, impermeable haematite did not behave satisfactorily during smelting. Magnetite ore from Dorowa was not favoured on account of its high phosphorus content (Beach 1977). Low-grade lateritic ores required ‘very hard work’ to produce iron (Cooke 1966). The iron ore mined at Arcturus was soft and rich in manganese and the powdery limonite ore from Thabas Inyoka may have been altered haematite (Prendergast 1974).

In general, in a region well endowed with a wide range of iron ore sources, Iron Age people seem to have preferred higher-grade ores. This most likely accounts, at least in part, for the relatively small amounts of slag noted at pre-colonial smelting sites in Zimbabwe compared to those in some other parts of Africa, where slag accumulations at some smelting sites reach 10,000 tonnes or more (*e.g.* Cline 1937; Swan 2003).

Pre-industrial iron metallurgy in sub-Saharan Africa: The bloomery process

Before the advent of modern blast-furnace technology in the 16th century (at least in Europe), iron was generally produced in the solid state by means of the ‘bloomery’ process (*e.g.* Avery & Schmidt 1979; Gordon & Killick 1993; Miller 1997; Tylecote 1965; Tylecote et al. 1971). In this batch-type process, a mixture of iron ore and charcoal is blown with air via tuyères in some form of shaft furnace. The ores generally used in the bloomery process are sufficiently high grade to be self-fluxing; enough ferrous iron combines with the silica in the ore to form a fayalitic slag, and in most cases no added flux is required.

At the normal operating temperature of about 1,200°C (too low to produce cast iron), the liquid slag separates from the solid iron bloom which forms in the hearth as a porous mass of ‘sponge’ iron, unused charcoal and viscous slag directly beneath the hot, reducing zone around the tuyère nozzles (Fig. 3). The largely inert charcoal bed (between tuyère level and the hearth floor)

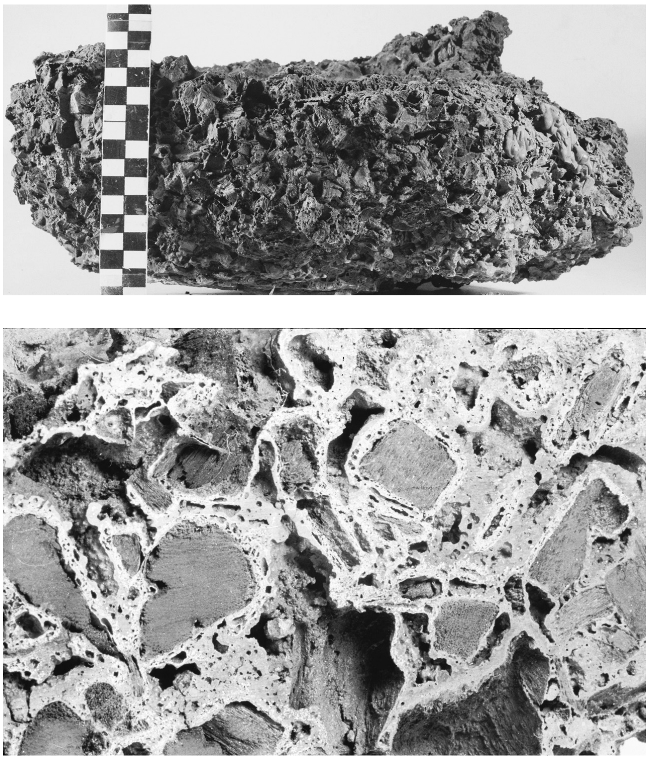

Figure 3: Crude iron bloom and section from a pre-colonial iron-smelting site in Zimbabwe. Top: A mass of iron, charcoal and slag from below tuyère level. Scale in 10 millimetre units. Bottom: Detail. Note fine grains of metallic iron (white) and minor enclaves of slag (dark grey) forming thin films around large pieces of remnant charcoal (pale grey). Image width c.70 mm. (Photos: Ilo the Pirate).

must be deep enough to hold the growing bloom, allow air circulation, and assist efficient slag-metal separation by collecting the most viscous slag and ore fines, thus also keeping the tuyère nozzles open (Fig. 4).

Smelting is paused periodically to withdraw the bloom from the hearth through the front rake hole. When cool, the bloom is broken up to separate the sponge iron, which is then reheated and consolidated by hammering to expel the remaining slag and charcoal impurities. Finally, the crude 'wrought' iron is worked into the final product by further hammering and welding in a smithing forge with or without carburization and tempering with water.

The products of bloomery technology tend to be heterogenous with variable amounts of carbon and slag impurities. Yields are relatively low and the compositions and quantities of the ore and the slag produced are not very different. Consequently, in Europe, bloomery technology died out rapidly once more productive and efficient blast-furnace technology was introduced.

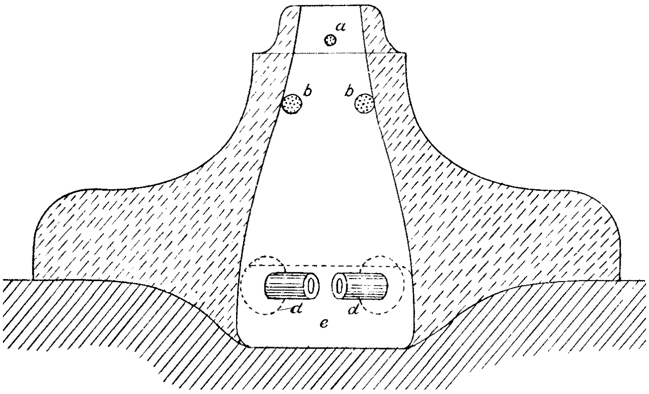

Figure 4: Section through Njanja iron-smelting furnace. Note general anthropomorphic shape with lateral projections and a pronounced shoulder and 'eye-hole'(a) directly beneath the charge hole at the top, breasts (b), two tuyères and tuyère holes (d) at approximately 90° at rear, and charcoal bed (e). Internal height, 0.86 m; hearth diameter, 0.43 m. (Scaled drawing in Sawyer 1894).

There are two main types of bloomery furnace and both have been used in pre-industrial smelting in Africa: natural-draught and forced-draught furnaces, both with walls normally made of fired clay (Childs & Killick 1993; Cline 1937; Tylecote 1965). The main difference between the two types is the method of blowing. In natural-draught furnaces, the air is drawn in by convection induced by the 'chimney' effect via up to ten tuyère holes arranged regularly around the lower circumference; in forced-draught furnaces the air is pumped by bellows, normally made of animal skins or a combination of skin and ceramic pot, via a relatively small number of tuyère holes normally positioned at the rear. In natural-draught furnaces, the tuyère holes may accommodate several tuyères arranged in bundles; one tuyère per hole is the norm in forced-draught furnaces. To achieve the 'chimney' effect, natural-draught furnaces are therefore relatively tall and wide with a shaft-like shape (>1.5–2.0 m high and about 1 m in diameter); forced-draught furnaces are usually short and squat in shape (height and diameter both under 1 m). In both furnace types, a narrow opening at the top allows the charging of ore and charcoal. The charcoal bed and tuyères are arranged, slag is tapped, and the bloom withdrawn, through a front rake hole located at the base.

Important attributes of natural-draught furnaces are their large capacity and low labour requirements; on the other hand, smelting times are long (although this promotes more even carburization of the bloom), fuel usage is high, and the process is difficult to control. By contrast, forced-draught furnaces, while relatively fuel-efficient, easy to control and able to deal with a wider range of ore types, have low capacity and produce less homogenous carburization; importantly, forced-draught smelting requires continuous bellows-pumping by one or more men depending on the number of tuyère holes (*i.e.* one man per pair of bellows per tuyère hole).

The great variety of environments, iron-ore sources and cultures in sub-Saharan Africa has given rise to many different variants of both types of furnace. The natural-draught furnace was the predominant type of bloomery furnace used in Africa; indeed, whether or not invented on the continent, it was widely adopted in, and almost exclusive to, Africa. Their distribution coincides with the thinly populated, dry, infertile, savannah (miombo) woodland zone that covers vast tracts of sub-Saharan Africa outside the grassland, tropical and arid zones (Killick 2015). The preference for fuel-intensive, but labour-efficient, natural-draught technology may be an adaptation to the abundance of wood to make charcoal and the labour-intensive 'slash and burn' agriculture required to grow crops in this zone (Swan 2003). The other advantage of the low labour requirement may be the potentially lower likelihood of leaking technical and ritual secrets to rivals (see below). By contrast, the use of forced-draught furnaces is more scattered.

19th-century Shona iron technology: Njanja iron-masters and the forced-draught furnace

Against the trend in Africa north of the Zambezi, and throughout the miombo woodland zone in general, forced-draught technology appears to have been the sole iron-smelting method in use on the Zimbabwean plateau in the 19th century. The Njanja people, who have lived in the region south of Hwedza mountain for around 300 years, were its foremost, and most famous, exponents by mid-century and remained so until the arrival of colonial forces in 1890 (Chirikure 2006; Dewey 1991; Franklin 1945; Goodall 1946; McCosh 1979; Posselt 1926; 1927; Stanley 1931; Prendergast 1974; but see especially Beach 1977; 1980; 1984; 1994; Mackenzie 1975). In the immediate pre-colonial period, the Njanja homeland was called the 'Wolverhampton of Mashonaland' (Shimmin 1893) and labelled on the map as an 'Iron Smelting District' which was 'entirely given up to the smelting business, and outside the kraals usually are erected two or more furnaces' (Bent 1893, 272). In another report, Njanja iron-smelting operations were a centre of 'modern industry' with up to 20 furnaces operating on a shift system (Knight-Bruce 1896).

Published descriptions, drawings and photographs of Njanja furnaces (Shona: *vira*) show they were sub-circular with internal hearth diameters of about 0.45 m and internal heights of about 0.90 m. The earliest depictions (*e.g.* Sawyer 1894; Fig. 4) show the super-structure of the typical Njanja furnace had a sub-vertical shaft with a pronounced shoulder and 'eye hole' just below a narrow charge hole at the top. Each had two holes low down at the rear for fired-clay tuyères (*nyengo*), with 25–35 mm bores, and a broad, low rake hole below ground level in front. The bellows (*mvuto*) were made from the skins of goats that had been flayed alive to ensure successful smelting (see especially McCosh 1979). The slightly backward-slanting front facade was characteristically embellished with moulded female breasts, sexual organs and cicatrization marks (Fig. 5). There might be a small hole in the hearth floor to hold charms.

Side accessories moulded in clay appear to have included lateral projections, which (in addition to emphasising the anthropomorphism of the furnace) may have acted as a heat shield and a step to observe, and to charge ore and charcoal through the charge hole, slight depressions to hold hand measures of charge, and a small ore-preparation floor with low clay walls. The smelting crew comprised at least four operators: the supervisor or iron-master (*mhizha*), two bellows operators, and an assistant to prepare the charge; smelting and bellows-pumping might be accompanied by drumming and singing.

Little is known of the metallurgical details of Njanja furnace operations – for example, the composition and physical condition of the ore, beneficiation and pre-roasting procedures (if any), the sizes of ore and charcoal when charged, ore-fuel ratios, charging and blast control, pre-heating of air flow, etc – all of which would have affected the yield and carbon content of the bloom. Consistent with the high grade of the ore smelted (see above), little tap slag seems to have been produced, most of the slag remaining in the charcoal bed. Blooms (*hona*) were first worked up using rock anvils and hammers, followed by forging in small open hearths with one tuyère. Iron hammers and iron spikes set into baulks of wood were used in the final smithing stages (Fig. 6). As in most of sub-Saharan Africa, quench tempering in water was not used. There were no rituals associated with forging.

The overt sexual symbolism and stylized female form of Njanja smelting furnaces (*e.g.* Baden-Powell 1897, 397), together with the use of charms and ritually prepared bellows, place Njanja iron-smelting within the ideological context of pre-industrial iron technology that prevailed across sub-Saharan Africa. Lacking knowledge of the physicochemical and thermodynamic

Figure 5: Two Njanja iron-smelting furnaces constructed at Charter Range for the visit of His Royal Highness, the Prince of Wales, in the early 1920s. Note the general similarity in both size and shape to the furnace shown as a scaled drawing in Figure 4, the side accessories, plus cicatricization marks below the breasts, and the front rake hole beneath a low arch, with a charcoal (?) stockpile at the rear. The air blast, provided by two men operating four goatskin bellows, would have been directed through two horizontal tuyeres inserted into moulded holes at the rear of each furnace. (Photo: National Museums and Monuments of Zimbabwe).

Figure 6: Njanja smithing operations, here using modern hammers (?), at the same event as shown in Figure 5. Note the bellows-blown forge to the left. (Photo: National Museums and Monuments of Zimbabwe).

processes involved in smelting ore to metal, a complex and dangerous activity requiring high levels of skill and experience, pre-industrial iron-masters in Africa explained, and sought to control, their technology in terms of natural and social processes (*e.g.* Childs & Killick 1993); in other words, 'Iron smelting was an anthropocentric ritual analogizing production as reproduction' (McCosh 1979, 160).

For many African iron-masters, successful iron-smelting was contingent upon not only technical skill but also the approval of the ancestral spirits which depended upon the celibacy of the crew (temporary 'husbands' of the furnace) and the absence of menstruating women (sources of pollution). The ancestors could be appeased with prayers and offerings at each stage of the mining and smelting process. Sexual incontinence and ritual pollution could be avoided by physical separation and the siting of smelting operations well away from the village, although women could be employed in mining, charcoal-burning and porterage. Charms could be used to counter the malign effect of menstruating women and the harmful ploys of jealous sorcerers. Removing the furnaces from public view also helped to preserve the secrecy of ritual and technical procedures. Although Njanja iron-masters retained the sexual symbolism of the smelting process and made use of charms and certain other rituals, they appear to have relaxed several of the ideological aspects of African iron technology; in particular, furnaces were built close to villages and there were fewer restrictions on women.

Mining, charcoal-burning and smelting required much labour and so were conducted in the dry, agricultural off-season. Large gangs of men and women were despatched to Gandamasunga, Hwedza mountain, to mine ore, which was brought home in sacks on the backs of oxen. Large quantities of charcoal were required; it has been estimated that Njanja smelting operations used 1,400 to 2,000 medium-sized trees each year (Swan 2003), so the land near smelting villages may have resembled the empty bush evident in photographs of early 20th-century gold mines in Zimbabwe. Furnaces were constructed in central factories of 10–20 *vira* which were operated throughout the season on a shift system. Each furnace could produce three or four *hona* a day, enough iron for four or five hoes (*badza*). Forging of hoes continued throughout the year. Excess production could be held over to later years if and when access to the Hwedza mines was not possible.

Besides hoes, the main product item essential for farming, Njanja production included axes, knives, adzes, spears, razors, ornaments and the keys of the *mbira*, a musical instrument with special significance in Shona society. Large trading parties of 15–20 men hawked these items over wide areas of the south and south-east of the country, particularly Bocha, Gutu, Chirumhanzu, Ndanga, Chivi, Nyashanu and the Ndau lands beyond the Save river several hundred kilometres away (Mackenzie 1975).

Demand for hoes was particularly high in those areas where recent settlers were opening up new farmland. Their wares were exchanged for wives (20 hoes), cattle (10–20 hoes), goats, and salt in markets set up by local chiefs. Prices increased further away from home. Orders were taken for future sales. The Njanja also traded with Portuguese and others from the east coast, allowing them to acquire cloth, guns, beads and shells.

Njanja enterprise was centralized around several independent iron-masters who exercised technical and ritual supervision of a large pool of labour, all of whom were linked in some way by family ties. The iron-masters were respected for their knowledge and expertise and the ability their skills gave them to increase their wealth and to acquire wives and enlarge their kin group. They gained local power and influence in this way and many became headmen. Young men were attracted as apprentices to provide labour in exchange for acquiring skills of their own and marriage to an iron-master's/headman's daughter.

The Njanja remained primarily farmers. As part-time iron-masters, they owed their economic and political success to a variety of factors: command of forced-draught smelting technology and adaptation to a particular source of metallurgically suitable iron ore (which they could access but, paradoxically, never owned), a large, kin-based labour pool, rational organization of all aspects of production (especially the concentration of smelters at supra-village level and the moderation of certain aspects of traditional ideology), manufacture of quality products, and an understanding of the market.

Although the most important, and certainly the most celebrated, iron workers in pre-colonial Zimbabwe, the Njanja were not the only such group encountered by late 19th-century observers. For example, in Chivi there was 'a great industry' where 'whole villages devote their time and energies to [iron-smelting]' (Bent 1893, 45), while Mberengwa was called 'the Birmingham, Walsall and Wednesbury of the ancients in Rhodesia [now Zimbabwe]' and 'chief iron-producing centre in Rhodesia ... of the natives today' (Hall 1909; Hall & Neal 1902). Large-scale iron-working was noted in Chirumhanzu as well (Knight-Bruce 1896). The Mbire north of Hwedza mountain were also considered an iron-working group (Mackenzie 1975), as were several others such as the Kalanga in Matopo (Hatton 1967).

These groups all appear to have used variants of forced-draught furnace that were broadly similar to those of the Njanja (*e.g.* Bernhard 1962; Cooke 1959; 1966; Hatton 1967; Hubbard 2006; Huffman 1978; Robinson 1963; Van der Merwe 1978). Several furnace sites assigned archaeologically to the nineteenth to early twentieth centuries have been excavated in various parts of the country (Tab. 1, Fig. 1); a few have been radiocarbon dated (*e.g.* Prendergast 1978; 1979b). Many of them comprised up to six (or more) furnaces, usually arranged in a line, as well as ore-preparation and bloom-working areas and slag and tuyère dumps, suggesting use over long periods (Bernhard 1962; Chirikure & Rehren 2004; Cooke 1959; Prendergast 1978; 1979b). Most furnaces had two tuyère holes while a few (at Chivi and near Bulawayo) had only one.

The most unusual furnace was Type B at Ziwa, Nyanga. This furnace type was distinctly oval in plan and the two tuyère holes (on either side) were aligned parallel to the hearth's long axis which was perpendicular to the front view (Bernhard 1962). Many of the excavated furnaces displayed sexual symbols and one had a central hearth hole for placement of charms. Many sites contained remnants of ore (either iron-formation or massive haematite, or both). A few other sites have rare indications of the possible use of a lime-rich fluxing agent, for example, burned bone (in Nyanga) and shells.

Much is now known about the type of furnace used by the Shona in 19th-century Zimbabwe. The prehistory of the forced-draught tradition remains more obscure, as does its links with other smelting technologies that now appear to have prevailed during the long Shona occupation of the country in earlier centuries.

Iron metallurgy in the mid-1st to mid-2nd millennium AD: The natural-draught furnace

The archaeological evidence for iron-working in Zimbabwe before the 19th century remains fragmentary, although the broad narrative is becoming clear from excavations and radiocarbon dating, especially for the early to mid-2nd millennium (Tab. 1, Fig. 1). The earliest evidence is from sites dated to the mid-to late 1st millennium at Gokomere, near Masvingo (Robinson 1963), and Kwali Camp, Malilangwe, in the south-east Lowveld (Swan 2007). The latter site disclosed furnace rubble, slag, tuyères, iron blooms, charcoal, and locally sourced magnetite ore, indicating that iron-smelting took place there throughout the 6th to 8th centuries.

The oldest furnace hearth so far excavated in Zimbabwe was at Gilnockie, near Arcturus, Harare, with a radiocarbon date of 1030 (Swan 1997; 2008). That furnace had a hearth diameter of 1.2 m and at least seven tuyère holes, making it most likely a natural-draught furnace. Another interpreted natural-draught furnace, on pottery evidence probably from the same general period (750–1050), was excavated at Goose Bay, Lake Mutirikwi, about ten km NE of Great Zimbabwe (Masvingo) (Huffman 2007; 2016). Large, with multiple tuyère holes, the hearth of this furnace had a very unusual, narrow, elongate shape. Interestingly, natural-draught furnaces (with fused,

Table 1: Excavated Iron Age iron-smelting sites and furnaces, Zimbabwe.

Site or location	Hearth diameter (m)	Internal height (m)	Charcoal bed depth (m)	No of tuyere holes	Bore of tuyeres (mm)[1]	Radiocarbon date (AD)[2]	Sources
19th to early 20th (?) century							
Senale	up to 0.8	0.90	0.20–0.26	2 at rear	25–37.5	1905 ± 50*	Prendergast 1978
Chisvingo II	0.45–0.50	0.80	0.24	2 at rear	27–32	1915 ± 45*	Prendergast 1979b
Shaka	0.40	0.65	0.20	2 at rear	30–37.5	1840 ± 50*	Prendergast 1978
Chivi	0.35	0.76	0.15	1 at rear			Robinson 1961
Matopo Hills	0.75	0.84	0.30	1 at rear			Cooke 1959
Ziwa A-type	1.00	1.00	0.35	2 at rear	30–40?		Bernhard 1962; Chirikure & Rehren 2004
Ziwa B-type	0.3 x 0.7	0.58	?	2 at sides	30–40?		Bernhard 1962; Chirikure & Rehren 2004
Late 16th to early 18th (?) centuries							
Baranda					20–30		Chirikure & Rehren 2006
Chisvingo I	0.55	0.87	0.16	4 at rear and sides	30	1700 ± 50*	Prendergast 1977
Mukwichi	0.56 x 0.43				22–35?	1565 ± 80*?	Garlake 1971
7th to 15th centuries							
Mhangula	> 0.50					1420 ± 60**[a]	Swan 2007
Gwebi Jctn	1.23			Multiple		1385 ± 45*	Prendergast 1975; 1979a
Tarnagulla	1.14		0.25	10?	25–28	1340 ± 40*	Prendergast 1975; 1979a
Nenga	> 1.00			Multiple	50	1270 ± 50**[b]	Van der Merwe 1978; Swan 2008
Surtic	> 0.70			Multiple	38	1159 ± 35**[b]	Swan 2008; Prendergast 1983
Gilnockie	1.20		> 0.12	5 or 7	35–40	1030 ± 40**[b]	Swan 2008; Swan 1997
Swart Village					40		Chirikure & Rehren 2006
Kwali Camp					60	580 ± 60**[a] 690 ± 40**[a] 780 ± 70**[a]	Swan 2007
Chigaramboni	1.39?						Ndoro 1994
Goose Bay				Multiple			Huffman 2007; T N Huffman, pers. comm. 2006

Notes:

[1] Small and large tuyere bores are not necessarily confined to forced-draught and natural-draught furnaces respectively. Fused tuyere bundles at Tarnagulla and Chigaramboni suggest multiple tuyeres in each tuyere hole may have compensated for lower air flow through small-bore tuyeres.

[2] Not all radiocarbon dates have been calibrated: * = Uncalibrated; ** = Calibrated, calibration method. [a] = Beta lab INTCal04/Intercept Method, [b] = Pretoria Radiocarbon Calibration software, version 1.02.

small-bore tuyères) were also in use across the border in eastern Botswana around the same period (Huffman 2016). Furnace remains excavated at several metallurgical sites elsewhere in Zimbabwe, with dates from the mid-12th to the late 14th centuries, are considered to have been of natural-draught furnaces on account of their large size and multiple tuyère holes (Tab. 1, Fig. 7, 8) (Prendergast 1975; 1979a; 1983; Swan 2007; 2008; Van der Merwe 1978).

Although no furnace remains were seen at Swart Village, about 120 km NNE of Harare, the large amount of tap slag and the relatively large tuyère bore (40 mm) suggested to the excavators that natural-draught technology was employed at this site which, on pottery evidence, belonged to the period 800–1200 (Chirikure & Rehren 2006). A large hearth with a diameter of 1.39 m and fused bundles of tuyères investigated at Chigaramboni, 10 km W of Great Zimbabwe, may have been of a natural-draught furnace but has not been dated (Ndoro 1994). Furnace remains with an interpreted hearth diameter greater than 0.50 m were recovered from an early 15th-century site at Mhangula, Chiredzi, in the SE lowveld (Swan 2007); the minimum diameter of this furnace may be consistent with the use of natural-draught technology.

All investigated furnaces used prior to the 15th century in Zimbabwe have been either of demonstrable natural-draught type, or had features not inconsistent with that type, and many, if not most, of these sites had evidence of smelting on a large scale. Some had features of ritual significance. No furnace of unequivocal forced-draught type has yet been recognized from that early period in Zimbabwe.

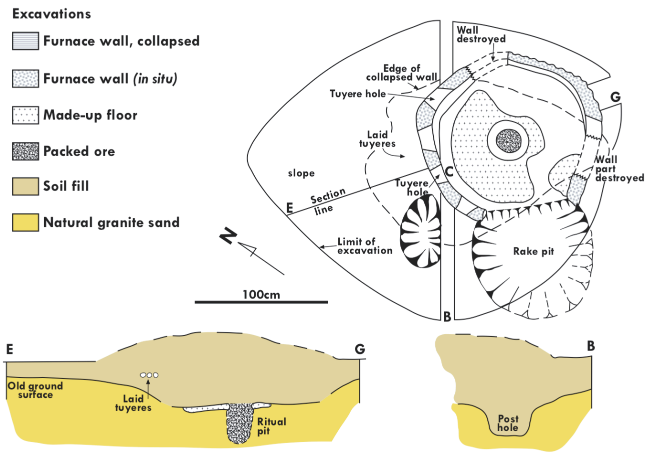

Figure 7: Simplified plan and section of excavated natural-draught furnace, 1340, Tarnagulla farm, near Darwendale. Bar-scale is 1.0 m (Adapted from Prendergast 1975).

The Zimbabwe Culture: The roles of iron and the iron-master

The use of natural-draught furnaces in Zimbabwe during the late 1st to mid-2nd millennium, and the large scale of iron-smelting in this period, coincided with a general rise in food production and population densities as new lands were opened up to agriculture, and also with concomitant and far-reaching changes in economic and social structures. Where the local resources and environment allowed, cattle-herding, hunting, and gold- and copper-mining became important economic activities, in turn leading to increased craft specialization, long-distance trade and social differentiation, and to more complex settlement patterns and political organization (*e.g.* Pikirayi 2001).

Beginning at Mapungubwe in the northern part of South Africa in the 13th century, and extending to the Shona state of Great Zimbabwe in the 14th to 15th centuries and to its 15th to mid-19th century successor states of Kame (Khami) and Danangombe in the west of Zimbabwe and Mutapa in the north, local populations came under the suzerainty of political elites residing in hilltop stone palaces. Exercising authority in part through sacred kingship and ritual seclusion, these bodies assumed control of the production of gold, ivory and other commodities, and of their external trade with the east coast of Africa (Huffman 1996; 2009; 2010; 2014; Swan 2008). The wealth and social stratification of this so-called Zimbabwe Culture contrasted sharply with the relatively impoverished and more egalitarian society so typical of the Shona peoples of the 19th century.

Iron-masters in the late 1st to mid-2nd millennium, initially most likely independent operators similar to those of the 19th-century Njanja, would have responded keenly to the growing market for agricultural, mining and masonry tools and exchange goods at this time (*e.g.* Pikirayi 2001). As production grew, some may have gained sufficient wealth and power to join the emerging elites, although there is no special evidence of this. The increased production did not take place either within or near the stone-built state and provincial capitals despite the often-large populations gathered around them: smelting debris contemporary with elite occupation is limited or wholly absent at these sites (*e.g.* Great Zimbabwe), which were located more to oversee local populations than local manufacturing. Instead, iron production seems to have been centralized close to favoured ore sources such as Mhangula/Manyoka (Chiredzi) (Swan 2007) and the Darwendale area (Prendergast 1979a), which were contemporary with Great Zimbabwe and later Zimbabwe Culture capitals and whose wide distribution helps account for the general dispersal of smelting activities.

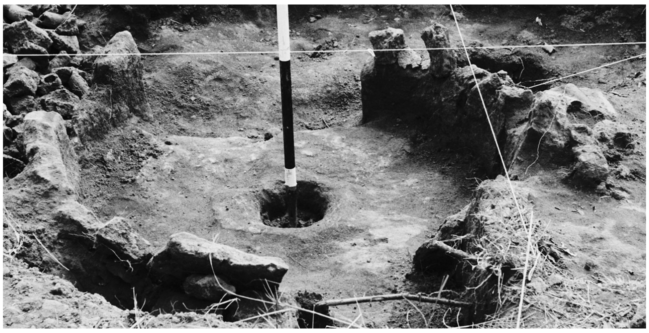

Figure 8: Remains of excavated furnace in Figure 7, viewed from the rear. Ranging pole scale in 0.20 m units (Photo: M Prendergast).

The surplus wares of such important production centres are likely to have been directed towards elite sites. Ironware was valued by Zimbabwe Culture elites above other metals (including gold) as a potent symbol of power and authority (Chirikure 2007; Herbert 1996), and certain special items (such as welded double-gongs from the Congo) may have had a ceremonial use. Large ironware hoards – including wire, hoes, axes, chisels, spears, knives discovered at Great Zimbabwe (Garlake 1973; Herbert 1996) – were probably sent as tribute from such peripheral smelting locations and may have been stored for redistribution through clientship and kin networks. The role of Zimbabwe Culture elites in this redistributive system reinforced their power and prestige and ensured that the wealth generated by iron production accrued largely to them rather than to the iron-producing communities themselves.

Intriguingly, the 12th-century Arab geographer al-Idrisi referred to Sofala, an important east-coast trading port in that period (Ducène 2011; Theal 1964), as a source of quality iron products as well as gold, possibly implying the export of iron from the Zimbabwean plateau (*e.g.* Beach 1994). While the relatively low volumes of slag at individual Zimbabwean smelting sites (see above) may cast doubt on iron exports in this early period, both the predominant use of high-grade ores (which produce little slag) and the widely dispersed nature of iron-smelting make the possibility of such exports more credible.

The political organization of the Zimbabwe Culture depended on craft specialists of different kinds and the elites sought to dominate these craftsmen by various means. In the case of the iron-masters, ideological control of their technological and ritual power appears to have been exercised, in part, through the elites' use of iron insignia to legitimize their authority (Herbert 1996), and, it has been suggested, the demonstration of elite involvement in iron production through symbolic smelting within the palace enclaves (Chirikure 2007; Collett et al. 1992), although solid archaeological evidence for this practice is lacking. It is in the context of such ideological symbolism that the enigmatic cache of iron ore in a cave in the Eastern Enclosure at Great Zimbabwe may have meaning (Huffman 1996). Tied iron production within the Zimbabwe Culture is somewhat analogous to the Kalanga smelters in Matopo, who manufactured iron weaponry for the armies of the intrusive Ndebele in the 19th century (Hatton 1967).

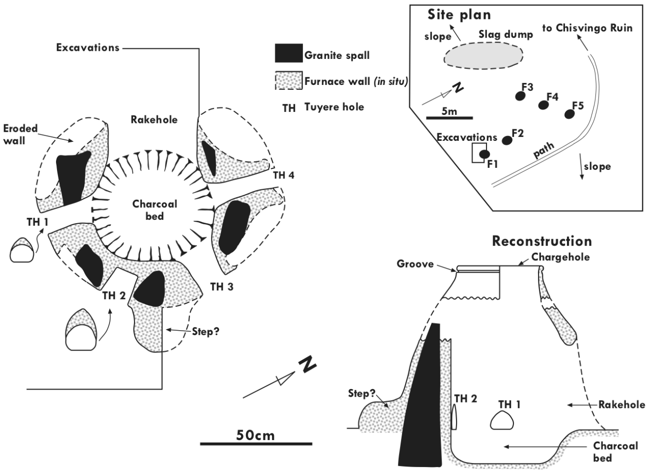

Figure 9: Simplified plan and section of excavated forced-draught furnace, 1700, Chisvingo I, Masembura. Bar-scale of main drawing and reconstruction section is 0.5m. Note battery of five furnaces (F1–F5) and stone reinforcement (Adapted from Prendergast 1977).

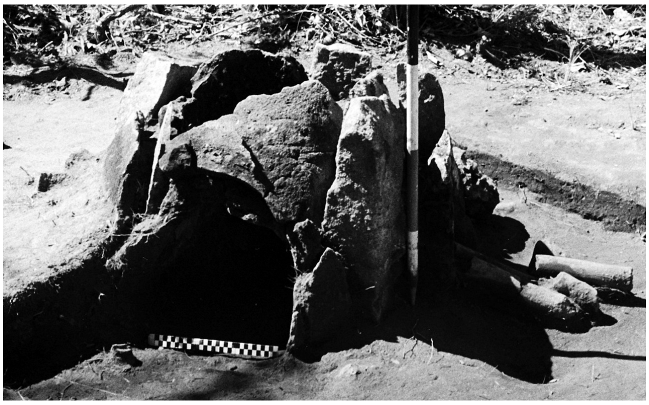

Figure 10: Remains of excavated furnace in Figure 9, viewed from front. Ranging pole scale in 0.20m units. (Photo: M Prendergast).

Technological change in the mid-2nd millennium: The advent of the forced-draught furnace

The nature of Shona metallurgical technology in the mid-2nd millennium is less clear. Only two furnaces have been investigated from this period (late 16th to early 18th century) in Zimbabwe (Tab. 1, Fig. 1). The best preserved was Chisvingo I. That furnace (*c.* 1700), with very unusual stone reinforcement (Prendergast 1977), had a hearth of relatively small diameter (0.55 m) and four tuyère holes (one blocked) arranged around the rear and sides (Fig. 9, 10); because of its small size, and despite the relatively large number of tuyère holes for this size of furnace, it has been interpreted as a forced-draught furnace. The second, at Mukwichi in Hurungwe, was much more fragmentary (Garlake 1971). This furnace had an egg-shaped hearth plan but no preserved tuyère holes; its small size (about 0.46 m wide and 0.56 m long) make it probably of forced-draught type. Associated pottery suggests a link to a nearby settlement with a radiocarbon date of 1565. Another site in northern Zimbabwe, with minor iron-smelting debris and pottery from approximately the same period (1500–1700), is Baranda, 135 km NE of Harare (Chirikure & Rehren 2006). On the basis of the relatively narrow bore of the tuyères (20–30 mm), the furnaces used here were also considered to be small and blown by forced draught. Although Baranda has no stone walling, other finds at this site support its interpretation as a Mutapa provincial capital.

Despite the limited evidence, the forced-draught tradition so prevalent in 19th-century Zimbabwe appears to extend as far back as the late 16th century, at least in the northern part of the country. On the other hand, the use of as many as four tuyère holes may be an echo of the preceding period when natural-draught technology was paramount. If so, in a simplistic interpretation, the mid-2nd millennium may have seen a shift of some sort between one bloomery tradition and another.

The causes of such a remarkable change are probably related more to social and economic trends than to environmental factors and the need to conserve fuel (see above). The Zimbabwe Culture and its state system, so dependent on external trade in gold and ivory, was in steady decline from the end of the 17th century (Pikirayi 2001) as the gold mines became depleted above the water table and elephant numbers decreased due to over-hunting. Economic decay of the Changamire and Mutapa states into the 19th century was accompanied by Portuguese interference (in the north) and internal strife, disease, migration and general disturbance. The demand for agricultural ironware in these unstable conditions must have been significantly reduced and so the productive advantage of large-capacity natural-draught furnaces fell away.

If this helps explain the declining use of large natural-draught furnaces and a new preference for forced-draught technology on the Zimbabwean plateau around the mid-2nd millennium, the provenance of the latter remains a mystery: independent development is unlikely and so its source may be external and its arrival associated with the migrations that were a feature of this period. Forced-draught technology was not unknown in southern Africa even before the mid-2nd millennium, and has been reported, for example, from Early Iron Age contexts in eastern Botswana (Huffman 2016), so the appearance of this smelting tradition in Zimbabwe by the mid-2nd millennium would not be surprising. Only further archaeological research can reveal its origin and timing of arrival.

The passing of a technological tradition

The Njanja iron-masters fascinated the early Rhodesians (or colonisers) who, on the one hand, found their craft a charming example of an exotic and 'primitive' industry that had long disappeared from their own countries, and, on the other, sensed a subversive intimation of African technological ingenuity that ran counter to colonial pre-conceptions. In this spirit, the Rhodesian Native Affairs Department arranged several public demonstrations of Njanja smelting between the early 1920s and 1950s in various locations, including Johannesburg, Harare and Bulawayo, and at Charter Range near the Njanja homeland (*e.g.* Franklin 1945; Goodall 1946; Maufe 1920; McCosh 1979; Posselt 1926; Stanley 1931). The great interest in these displays was largely touristic and ethnographic. In 1972 another demonstration in Charter district, organized by a group of South African metallurgists and archaeologists, had a specifically technical purpose and was closely observed and recorded; unfortunately, the results were disappointing and, as far as is known, the research was never published. The Njanja were also engaged to create the iron-smelting exhibit in the Zimbabwe Museum of Human Sciences in Harare and, in the early 1990s, they starred in an American film documentary, *Weapons for the Ancestors* (Dewey 1991).

Even before 1890, the increasing encroachment of the modern world and the intrusion of industrial capitalism from across the Limpopo had led to the easy availability of cheap, mass-produced ironware and thus changed the internal market forever. The local iron industry struggled on for a while but was effectively strangled by restrictions imposed by colonial 'diktat' after the first revolt against colonial rule in 1896–97 (Mackenzie 1975; McCosh 1979). The old smelting skills survived in the minds of old men and the forges continued in use to make repairs and to fashion new implements from scrap, as they still do today in rural Zimbabwe. Nevertheless, the ability to make iron blooms from Hwedza ore seems to have drained away within a generation or two: photographs of successive Njanja demonstrations hint at a degeneration in the design and construction of furnaces which, from the 1930s, lose the typical shaft shoulder of Njanja furnaces (Fig. 4, 5) and become more cone-like. The furnace used in the 1972 experiment was distinctly dome-shaped without a deep rake hole and no satisfactory bloom was produced, probably because the charcoal bed was too shallow. By then, the iron-ore quarries were overgrown and the *vira* cracked; the corpus of knowledge and expertise built up by countless *mhizha* over many centuries was gone. A 1500-year-old technological tradition had foundered under the weight of 20th-century colonialism and industrial technology.

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centuries, it was edited by Martin Prendergast and John Hollaway and published in 2019 by the Chamber of Mines of Zimbabwe (ISBN 978-1-77906-610).

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