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Style, Technology, and Iron Smelting Furnaces in Bantu-Speaking Africa

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INTRODUCTION

The purpose of this study is to investigate how and why iron smelting furnaces exhibit style. This goal stems from a broader question concerning why a great diversity of iron smelting furnaces exists in sub-Saharan Africa, particularly in the Bantu-speaking area. The effort falls into three sections. First, I discuss some theoretical issues of style in archaeology as they affect socially conscious interpretations of variation in material culture. My particular focus is upon the behavioral foundation of style as it relates to the process of production. Second, and centering on the complex object which a furnace is, I address the factors that cause stylistic variation in the process of African iron smelting. With the working definition of technological style and a methodology for reading stylistic variation in the iron smelting process, I proceed to suggest how and why iron smelting furnaces exhibit style in the context of MaShona culture in present-day Zimbabwe.

A functional view of style, generally following Wobst (1977) and Wiessner (1983, 1985), is important for probing into some of the relationships between the technology and style of iron smelting furnaces. More specifically, technological style (Lechtman 1977; Lechtman and Steinberg 1979; Steinberg 1977) provides the framework to examine the behavioral underpinnings of style and the cultural influences which structure technological behavior into a form of communication. I define technological style as the formal integration of the behaviors performed during the manufacture and use of material culture which, in its entirety, expresses social information.

The theory of technological style requires that we direct our attention to the iron smelters and the operations they perform. The furnace is merely a physical manifestation of the smelting event and offers a means to reconstruct the behavioral choices made. The position of the master iron smelter in his culture, on the other hand, a person with special

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knowledge and power among most Bantu-speakers (Schmidt 1983; Maret 1980, 1985), significantly affects how the technical process is choreographed. The performance of smelting by the master and his helpers, a unification of all the decisions and actions taken into a formalized and specific technological style, conveys information.

It is important here to distinguish a furnace from a pot or a projectile point as units of stylistic analysis. A furnace is a complex object made up of several components necessary to the smelting operation. Ore and fuel are certainly vital to the smelting process, but a furnace usually consists of several other related parts. Tuyeres (the pipes through which air flows to stimulate fuel combustion in the furnace center) and bellows are often, but not always used by iron smelting groups. A variety of objects are sometimes added to the furnaces during smelting rituals. The music played on various instruments during a smelt are also integral components of the process. A furnace differs from a pot, then, because it involves the covariation and combination of several components and these reflect choices made in different cultural contexts. Its complexity compels us to investigate the different types of behaviors that constitute stylistic variation and the different degrees of consciousness with which the choices are made. We must also examine whether more than one message is transmitted to more than one referent (the individual or group to whom the information is sent and understands it). These are important aspects of the study to be addressed below.

Most of the examples for this discussion come from the ethnographic literature on Bantu-speaking peoples (Fig. 1). I am not suggesting direct historical connections between ethnographic and archaeological cases, but am trying to show the range of influences on smelting processes that we must consider when interpreting archaeological data. Furthermore, I am not looking at the rate of stylistic change or differentiation over time, but at the factors that cause variation. Given the antiquity of African iron smelting, the degree of technological conservatism often exhibited (Maret 1985; Childs 1986), and similar environmental constraints over time in many areas, careful use of ethnography offers an excellent way to add a cultural perspective to our understanding of prehistoric iron smelting.

As a final note, this exercise is intended to inform archaeologists about the potential yield of cultural information available from objects they might typically ignore. Careful excavation of and attention to objects like furnaces, forges, pottery kilns, and granaries can provide archaeologists with new avenues to explore prehistoric behavior and complexity that go far beyond utility and technique.

STYLE

I regard style as active in society and residing in the process of making and using an object. The social messages conveyed result from many

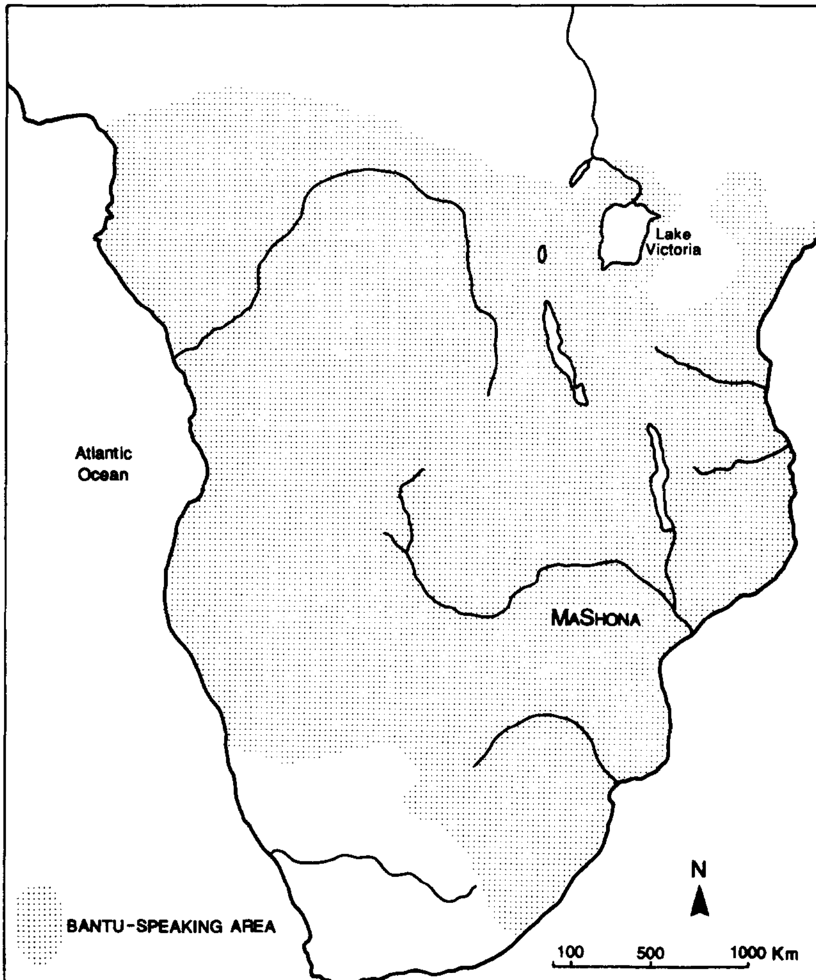


FIG. 1. The present-day distribution of Bantu-speakers in sub-Saharan Africa.

factors that influence manufacturing choice and behavior. Most scholars are interested in the technological context of style. Some of them, however, focus on specific portions of production sequences where they think style is consciously invested (i.e., decoration), while others examine entire technological processes. Some differences of opinion concerning the production of style are debated by Sackett (1977, 1982, 1985, 1986) and Wiessner (1983, 1984, 1985, 1989), briefly examined below. In this discussion, I agree with Wiessner that style has a communicative function that goes far beyond ethnicity to provide us with insights into cultural behavior, but I also agree with Sackett that one must look for style in all the choices made during a technological process. I incorporate aspects of both approaches in my use of technological style below where I attempt to examine the layered complexity of social identity and relationships, including both their latent and active qualities, in the overall design of furnaces.

Sackett is primarily concerned with where ethnic style resides in object forms, not on the behavioral basis of style (1986). He states that "style exists wherever artisans belonging to a given ethnic group make specific and consistent choices among the isochrestic ("equivalent in use") options open to them" (1986:269; parentheses mine referring to Sackett 1982:73). Style occurs at the level of the "banal and essentially ubiquitous" (Sackett 1985:157) since it resides wherever choices are made during all stages of technological process.

When Sackett probes into the behavioral basis of this style, however, he finds that it is latent or passive and lacks conscious intent (1986:270). Socially transmitted craft traditions, developed in specific cultural contexts, dictate decision-making. Traditions provide production with order and predictability, but little or no conscious purpose. I believe the study of cultural process and material variation will be well served by a model of style that explicitly weds isochrestism with the behavioral and cultural underpinnings of craft traditions that are both developmental and stable.

Scholars who support the functional view of style as an active messenger of social information and a tool in strategies of social interaction are directly interested in the behavioral underpinnings of style and how it relates to production.[*,1] Rather than examining an entire technological process, however, they often focus on the conscious or subconscious behavior involved in making and manipulating particular, formal attributes for social ends. This compartmentalization of production minimizes its impact on and relation to style by reducing the number of potential influences on stylistic variation.

Wiessner distinguishes style as being "an updated, current, and dynamic commentary on social relations" (1985:162) with a behavioral foundation in the process of "personal and social identification through comparison" (1984:191ff). By emphasizing the active role of style in developing and renegotiating social relationships, Wiessner relates style to change and to some degree of conscious or subconscious intent. This contrasts with the tradition, stability, and unconsciousness related to isochrestic variation and passive style. It is important to stress, however, that style can be purposely or consciously utilized to communicate and perpetuate continuity, conservatism, and tradition.

* See Notes section at end of paper for all footnotes.

Despite the different foci of isochrestism and active, stylistic behavior, Wiessner acknowledges that both result in material variation with clear ethnic associations. Moreover, these can be difficult to distinguish in archaeological contexts (1985:165). Her tendency to attribute patterned variation to *either* stylistic behavior *or* isochrestism and "passive style" (Sackett 1986:270) does not resolve these problems since we know little about how active and passive behavior interact in the production and exhibition of style.

The proponents of technological style, on the other hand, are concerned with an entire technological process and the formalized sequence of behaviors that are involved. The sequencing and internal structure of individual production choices are seen to constitute an iconography of behavioral symbols. These are formally patterned into a distinct style and communicate social messages (Lechtman 1977:14). Although Lechtman suggests that the production decisions are generally not conscious, but are latent products of the cultural context in which they occur (Lechtman 1977:12–13), I contend that a unique technological style consists of both passive and active behavior involving both unconscious and conscious choices. Technological style is used here as an alternative means to explain the variation of African iron smelting furnaces by examining the functional, communicative role of style in society and the different qualities of behavior involved.

Although it may seem that a symbolic code of behavior is no different from that which is expressed by the material products of the actions, a focus on technological style provides a potentially richer, more inclusive view of cultural variation. This is because studying the integration of a process is not fixed on details of each part or by whether one choice is more or less stylistic, habitual, or distinctive. All the behaviors unified as a technological style are meaningful for what their relationships produce and what they communicate.

Some scholars might question how technological style differs from isochrestism and passive style. It does in two ways. First, whereas both theories deal with the entire production process and regard the parts equally, technological style supports the functional view of style in social relations. It seeks to *explain* how and why all the separate actions are integrated into a coherent, patterned performance and to determine what information is communicated. The theory of isochrestism primarily *describes* the relationships between ethnicity and the material results of production choices dictated by tradition.

Second, any study of technological style must focus on aspects of isochrestic variation, passive style, *and* active style. The unique combinations of some long-term, passive, and traditional behaviors and some short-termed, active, socially informative behaviors yield distinctive technological styles. At different stages of a process, a style of technological behavior might involve conscious attempts to instigate change, while also perpetuating certain traditions. The challenge is to determine how and why combinations of actions interrelate, what is being communicated during the performance, and to whom. This requires probing the technical and environmental factors constraining a technology, as well as the ideologies and cosmologies that provide the basis for symbolic interpretation (Lechtman 1977:14; Hodder 1982, 1986). I attempt to meet this challenge in the following discussion of African iron smelting.

IRON SMELTING IN BANTU-SPEAKING AFRICA

Iron production has a long history in Africa that extends over 2000 years. The origins of African iron production and the nature of its spread have been active topics of debate. The origins question focused on whether iron working developed indigenously (Lhote 1952; Arkell 1962; Schmidt 1981) or was brought to the African continent by foreigners (Mauny 1952; Tylecote 1975; van der Merwe 1980). Scholars are now less concerned with origins because of the incomplete archaeological record, especially the lack of sites along the north African coast and along inland trade routes, and the existence of more interesting questions.

Although its dating and modes of introduction are incompletely understood, the spread of iron working in the southern half of Africa is generally linked to the migration of Bantu-speaking peoples from the grasslands of Cameroon in west-central Africa. Once these groups acquired knowledge of the iron technology, beginning around the fifth century B.C., it became part of their cultural baggage as groups fissioned and moved throughout much of southern Africa.

Questions concerning the nature of this spread are still pursued, often with a focus on the evolution of different smelting techniques and the multitude of furnace types (Kense 1983, 1985; van der Merwe 1980; Friede 1983; Friede and Steel 1985; Sutton 1985). The works are based on the assumptions, common to many stylistic analyses of ceramics, that differences in combined furnace attributes reflect ethnicity and the degree of similarity gauges the amount of cultural contact and transfer of learned behavior between groups. The results of these investigations lacked some success since the study of furnace morphology, without equally important cultural data, yielded few meaningful patterns (Cline 1937; Kense 1983; Sutton 1985).

In recent years, investigations have centered on two other topics. The first concerns the relationships between the iron working technology and the social, economic, political, and ideological systems of African cultures. We must now acknowledge that the functions of iron and the roles that iron makers played in their societies were complex, extending far beyond the realm of utility and rote technology (Schmidt 1978, 1983; Maret 1980, 1985). Second, scholars are documenting the intricacies of specific smelting operations and their products (Friede and Steel 1977; Schmidt and Avery 1978; Avery 1982; van der Merwe and Avery 1985; van Noten 1983; Avery et al. 1988; David et al. 1989), as well as their distribution over the landscape (Killick 1987; Davidson and Mosley 1988). We can now better appreciate the many individual decisions, operations and equipment necessary for a successful smelt. These insights into the iron technology and its relationships to the cultural and environmental milieux in which it occurs provide an impetus to reexamine the variation of African smelting techniques and furnaces from the perspective of technological style.

By restricting attention to the expanse of sub-Saharan Africa presently occupied by Bantu-speaking cultures, I focus on a more limited quantity of data from an area in which I have field experience.[2] More importantly, this narrower compass provides an opportunity to examine variation among many groups of people who are each culturally distinct, yet have common underpinnings. The distant ancestors of present-day Bantu-speaking populations shared a common region of origin, mutually intelligible dialects of a common tongue, and some basic cultural practices (i.e., sedentary village life, root crops, fishing, some animal domestication, ceramic, and, later, iron technologies) beginning only some 3000–4000 years ago (Ehret 1982). This study, then, looks at stylistic variation over a broad area but within the general confines of a language group.

Before examining the range of specific behaviors that affect the design, construction, and operation of a furnace during a smelting performance, we must consider the general position of the technology and its practioners in Bantu-speaking cultures. Iron and the iron producers were important to the existence and vitality of many mixed-economy societies. In specific ecological contexts, farmers, fishermen, hunters, and gatherers took advantage of good-quality iron tools to feed their dependents and, indirectly, to promote population growth. The perpetuation and expansion of local iron technologies, in turn, depended on the demand for iron tools generated from local economic success and enhanced productivity.

Much of the respect given to the master iron worker in Bantu-speaking cultures came from his ability to transform a product of nature, the ore, into a product of culture through the control of fire (Eliade 1962; Maret 1980, 1985). This was a skill of creation and transformation which few people possessed and was eclipsed only by the reproductive powers of women. The iron masters acquired the special, well-guarded knowledge after a long period of apprenticeship and, often, a ritual of personal transformation. When a man became a master iron smelter, he took on a new status that equalled, in many contexts, a chief and/or a spirit medium. Despite the respect afforded to him for his creative talents, he was simultaneously feared for his unusual powers that linked him to the spirit world. The instruments of his work—furnaces, bellows, and anvils—were often portrayed and believed to embody the powers of the spirits, thereby making them potentially dangerous to the uninitiated.

There are three basic types of furnaces used by Bantu-speaking craftsmen to provide a bounded space in which iron ore, fuel, heat, and atmosphere were consciously combined and manipulated to produce iron bloom and slag (the waste product). These include a simple pit, a small above-ground structure with a pit underneath, and a 2- to 4-meter tall, cylindrical structure (Fig. 2). Variation is so great within each type, however, that it has been difficult to distinguish any clear patterns of similarity or difference over the large area of Bantu-speakers.

I propose that this diversity is linked to understanding and demonstrating how iron smelting in a furnace was structured by and therefore reflected aspects of the cultural system and natural environment in which it operated. For instance, since the production and consumption of iron was critical to many local economies, a common ideology which explained the mystery of the process and why the iron masters had special powers would have been important to social interaction and perpetuating economic relationships. The furnace, as the most visible instrument of smelting, may have communicated and reinforced such an ideology among the iron-using villagers. As a vehicle of both utilitarian and social functions, it helped bind together society and technology and perpetuated both.

I examine these ideas in the next two sections. First, I break down the smelting technology into its most basic behavioral components. This pro-

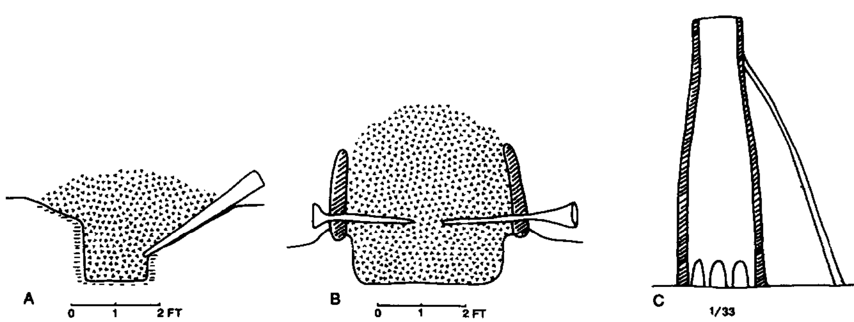


FIG. 2. Three general types of furnaces: (A) The profile of a Bikom pit furnace in Cameroon (redrawn from Jeffries 1952:49). (B) The profile of a BaRongo low-walled, forced draft furnace in Tanzania (redrawn from de Rosemond 1943:80). (C) A 5 to 6-meter tall, natural draft Ouahigouya furnace in Upper Volta, a non-Bantu-speaking area (redrawn from Pole 1985:159).

vides an idea of the cultural, environmental, and technical influences on each part and how these are reflected in the material record. In some cases, it is possible to identify both the traditional or passive and "stylistic" or active constituent behaviors and observe how they interact. The relationships between consciousness, choice, and the referent of some choices are also explored.

The second section examines the mechanisms that unify choices and actions into a specific technological performance with a distinctive style of behavior. This involves looking at the means by which stable traditions and more rapidly changing choices are interrelated and what social messages are communicated as a result. The realities of archaeological data are such that the individual choices and acts forming a distinct technological style must be reconstructed from objects. Many methods, involving careful excavation and laboratory analysis, are used toward this end. Unfortunately, it is difficult to identify the mechanisms that structure ancient technologies when their cultural contexts are incompletely known. The example I use, therefore, is an ethnographic one: the Ma-Shona of Zimbabwe. I selected this Bantu-speaking group because of the distinctive type of furnace they created and used and because the cultural context in which the technology existed is relatively well-documented.

VARIATIONS IN THE IRON SMELTING PROCESS: INFLUENCES, CHOICES, AND FURNACE ATTRIBUTES

Every furnace must contain a reducing atmosphere and temperatures of a least 1150°C to produce an iron bloom.[3] Every successful smelt shares a basic set of operations that include the following:

(1) selecting a smelting site in relation to villages and resources;
(2) selecting and processing clay or other materials to build a furnace;
(3) selecting, mining, processing, and transporting iron ore to the smelting site;
(4) choosing trees, making charcoal fuel from them, and transporting the fuel to the smelting site;
(5) performing rituals prior to a smelt, often while building the furnace structure;
(6) providing a means to bring air into the furnace to stimulate combustion;
(7) conducting the smelt, often with accompanying ritual;
(8) distributing the bloom at the end of the smelt.

These steps are examined below in light of the local factors that influenced choices made by Bantu-speaking iron smelting groups, how those choices were physically manifested on/in the furnaces, the referent(s) of

TABLE 1
THE INFLUENCES ON CHOICE DURING IRON SMELTING

Choice	Influences	Referent	Consciousness
Furnace location	Access to resources	None	?[a]
	Access to spirits	Spirits, villagers	Yes
	Group conflict	Villagers	Yes
	Ideology	Villagers	Yes
Resource selection	Accessibility	None	?
	Technical qualities	None	?
	Labor	None	?
	Transport	None	?
	Symbolic references	Spirits, villagers	?
Pit diameter	Iron yield	None[b]	?
	Labor	None	?
Pit holes	Ritual	Spirits	Yes
Furnace walls	Technical needs	None	?
	Iron yield	None	?
	Labor	None	?
	Space for symbolic expression	None	?
Wall height	Iron yield	None[c]	?
	Method of air draft	None	?
	Labor	None	?
	Raw materials	None	?
	Ideology	Villagers	?
Wall shape	Ideology	Spirits, villagers	Yes
	Labor	None	?
	Technical aspects	None	?
	Group identity	Ethnic groups[b]	?
Wall holes	Technical aspects	None[c]	Yes
	Labor	None	?
	Ideology	Spirits, villagers	?
Wall decoration	Ideology	Spirits, villagers[b]	Yes
	Group identity	Ethnic groups	Yes

[a] ? means once a conscious choice but, often, taken over by tradition.
[b] Used by archaeologists to type furnaces.
[c] Used by outsiders, archaeologists, and other ethnic groups to determine the ethnicity of furnaces.

a choice, and the degree of consciousness with which an act was taken. The principal relationships are summarized in Table 1. The level of consciousness in choice is difficult to represent in this table. By using a question mark, I indicate that decisions were consciously made at one time in the process, but with repetition over time, they often yielded to the subconscious or unconscious level of tradition.

To streamline the discussion, I focus attention on the behavior manifested in seven furnace attributes: furnace location, the presence or absence of above-ground walls, wall height, furnace shape, the number and shapes of holes in the furnace walls, holes in the furnace floor, and exterior wall decoration. These attributes were selected because they are the most likely to be visible in the archaeological record. By understanding the sources of their variation, archaeologists can better interpret and explain the technological styles involved in their creation.

The first step in iron smelting, selecting a site, was affected by environmental considerations, often as they related to the types, availability, and accessibility of nearby raw materials. Most smelting groups chose a furnace location in relation to at least one raw material (iron ore, charcoal, clay, or water). Sometimes other factors such as the force and direction of the wind influenced the location of individual furnaces. This is evident in central Zambia where furnace pairs were always located on one side of large termite mounds to utilize the prevailing wind as a source of natural draft (Fig. 3). Conscious consideration of the local topography, the natural distribution and quality of vital resources, and the quantities needed must have always influenced site selection to some degree. This is well-documented for the variety of smelting operations in the northern Rukuru basin in Malawi (Davidson and Mosley 1988).

Political and economic constraints further dictate location. Smelting groups built their furnaces on land they controlled or obtained permission to use, but these areas could change with political or economic fluctuations. For example, the early Njanja group of the MaShona in Zimbabwe

FIG. 3. A termite mound behind a furnace pair in Chisamba, Zambia.

built their furnaces on land they conquered, but paid a nearby chief to mine the excellent iron ore he controlled. As the Njanja gained power and slowly won the land closer to the ore source, they moved accordingly (Mackenzie 1975:204, 206). Group conflict also influenced furnace location, especially to protect weapon production. Archaeological evidence from western Zimbabwe indicates that 19th century MaShona consciously built their furnaces in hidden, cramped gullys during a time of possible local instability (Prendergast 1978).

Ideology, involving conscious decisions, further influenced furnace location. Most Bantu-speaking smelting groups worked away from villages in isolation or in secrecy from the general public. The BaSakata (Maes 1930), for example, situated their smelting sites some distance from the villages so the nonsmelters could not disrupt or contaminate a smelt. Schmidt (1983) suggests that iron workers actively created and then worked to control an ideology surrounding iron smelting. This might have involved locating their smelting sites in symbolically charged places which also served to elevate the economic prosperity and political position of the iron workers.

In most Bantu-speaking cultures, the power of the head iron smelter was enhanced by his access to the ancestral spirits who had considerable power over the living. The BaUshi smelters, for example, built new furnaces at old smelting sites (Barnes 1929) where they probably sought to emphasize their relationship with the ancestors, as well as to gain and take advantage of the spiritual power. The choice of furnace placement, then, communicated messages to both the ancestors and the nonsmelting villagers.

Once a location was chosen, the raw materials had to be selected, processed, and transported to the smelting site. These often included iron ore, materials (clays, slag blocks) to build the furnace, clay to make tuyeres, trees to make charcoal fuel, and wood and skin to make bellows. There were many influences upon the choices of raw material, but their physical properties during smelting were very important. Ideally, the ores readily reduced to metal with little loss to the slag; the clays resisted thermal shock, were refractory to withstand collapse at high temperatures, and were plastic for easy shaping (Childs 1989); and, the charcoal burned evenly for long periods. In reality, limited access to high-quality resources due to political or economic constraints, the natural availability of resources, the size of the available labor force, transportation costs, and limitations due to overexploitation or deforestation (Schmidt 1978) affected the type of resource ultimately chosen. Some decisions were consciously made when there were sudden changes in resource availability, but many choices were entrenched in tradition.

Another variable that affected resource selection at some level of consciousness was its symbolic associations. For example, the BaNyoro of Uganda mixed two ore types together, a high-quality ore that was hard to break up and a soft ore (Roscoe 1923:218). Notably, the BaNyoro described these ores in terms of their color, black and red, and referred to them as male and female. Such associations were not coincidental since they related to color symbolism and gender-specific imagery on other parts of the furnace. The BaNyoro used two sets of bellows for each tuyere extending into the furnace. Each bellows was explicitly depicted with either male or female genitalia, as well as painted with red and black lines (Lanning 1954). Long-standing tradition may have obscured some of the meaning and conscious intent with which these ores were originally selected, but they were clearly involved in a larger symbolic code surrounding BaNyoro smelting practices. This code conveyed and reinforced a system of beliefs and values that were integral to BaNyoro life and, perhaps, to their relationships with their ancestors.

The process of building the furnace usually began once the necessary resources were gathered at the site. The pit in which the slag and bloom accumulated was the first part of the furnace formed. The desired yield of iron, the size of an above-ground structure, and the number of bellowers influenced pit diameter and depth. Notably, these choices were most often rooted in tradition and were rarely conscious. They provide, however, a quantifiable referent for archaeologists attempting to type furnaces.

As the pit was dug out or after the furnace was completed, one or more holes were sometimes placed in the furnace floor. This was done in concert with rituals to the ancestors to ask for a successful smelt. The BaFipa, for example, performed rituals that consciously involved burying medicines in the furnace bottom (Grieg 1937; Wise 1958b). Although these buried objects usually perished during smelting, the holes are found in the archaeological record (Phillipson 1968; Schmidt and Childs 1985; van Noten 1983).

The decision of whether to build walls around a smelting pit was usually well established by tradition. The original reasons for the choice, however, included craft organization and the required yield of iron. Walled furnaces contain heat and atmosphere more efficiently, have a greater production capacity, and may require less labor and fuel than pit furnaces since they need extra charcoal to create artificial walls. Family groups of AGikuyu in Kenya, for example, smelted in pit furnaces where they produced enough iron bloom for immediate needs (Routledge and Routledge 1910; Kenyatta 1938). An unconscious by-product of furnace-wall construction was a medium for the usual expression of symbols, usually associated with an ideology surrounding smelting or with the identification of work groups, as we discuss below.

Many factors influenced the shape and height of furnace walls. Technically, the choice of shape and height determined the internal volume available to house the smelt and to hold the product of iron bloom. These design attributes sometimes related to the types and quality of resources available. A study of the BaChulu furnaces in Malawi suggests that 2 to 4-meter-tall furnaces were built to smelt low-quality ores (van der Merwe and Avery 1985). These natural draft furnaces depended on wind and the draw of the tall chimneys to slowly process a large volume of low-grade ore into an adequate yield of bloom. We should note that the heights and shapes of natural draft furnaces varied significantly (van der Merwe and Avery 1985).

Furnace size was also influenced by local economic and social phenomenon, such as market demands, long distance trade networks, the use of bride price, and the available labor pool. These were usually unconscious relationships set in tradition within a wide cultural context. Larger furnaces generally yielded bigger blooms, required a larger, more stable work force, and were used in more densely populated regions than short-walled or pit furnaces. Large-scale production was accomplished in furnaces of all sizes, however. The Njanja group of the MaShona, for example, mobilized a large labor force to operate many small furnaces simultaneously (Mackenzie 1975). Other groups used fewer, but larger furnaces with a slag outlet so that a bigger bloom could accumulate in the space left by the tapped slag (Tylecote 1962). This variation in large-scale production suggests that other factors affected wall height and shape.

Local systems of beliefs and values were another influence on furnace shape and height. For example, the relatively low, conical furnaces of the MaShona (Cooke 1959; Robinson 1961), the Machazi (Housden and Armor 1959), the BaTshokwe (Maret 1980:275), and the BaLuba (Burton 1961) were given anthropomorphic attributes of a woman. The breasts and incised lines symbolizing female scarification and/or genitalia related the furnace to a woman and smelting to birthing, analogies we discuss below. The choices involved in modeling these furnaces varied as to the degree to which latent, traditional knowledge shaped decision-making and the level of consciousness applied. The referents for the messages, the spirit world and the nonsmelting members of the society who shared the ideology and values expressed, were clear, however.

In another case, the tall furnace of the BaFipa (Fig. 4) became a fecund bride during a ritual wedding ceremony at the smelting site/residence of the male smelter/husband and became a mother during smelting. Furnace shape had no symbolic function, since furnace = bride was achieved by decoration (Wise 1958a, 1958b; Wyckaert 1914). Furnace height, how-

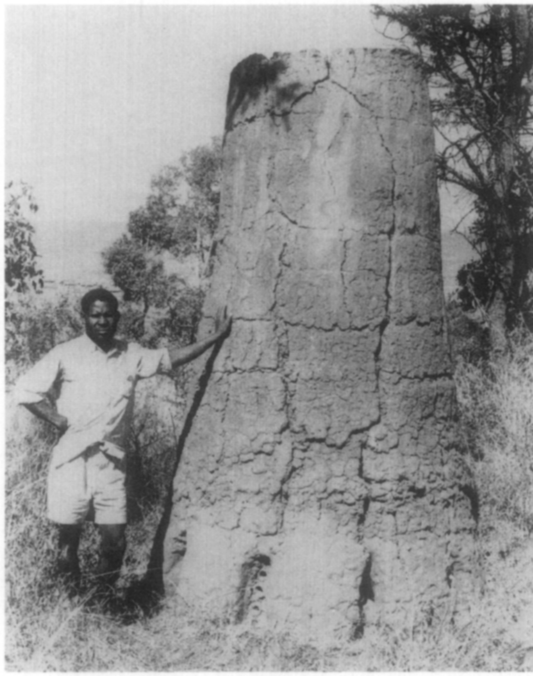


FIG. 4. A BaFipa natural draft furnace in Tanzania.

ever, may have also related to an important aspect of the kin relations established during the rituals. Height is associated with intellect, control, and males among the BaFipa, in opposition to lowness, energy (including sexual), wealth, and females (Willis 1981). Although furnace height functioned to draw up the natural draft during smelting, the evidence suggests it also symbolized the wisdom and control that the master smelter/husband needed to ensure the fertility of his furnace/wife.

As regionally based studies of iron smelting practices arise, it is clear that there can be considerable variability in the size and shape of furnaces used in relatively small areas (Monino 1983; Killick 1987; Davidson and Mosley 1988). A possible reason for this variability may have been strong motivations to keep operations secret in an attempt to curb sorcerers from ruining a smelt (Killick 1987). Such processes of secrecy and sorcery probably related to wider cultural phenomenon such as economic competition. In any event, active attempts at secrecy would have prevented comparison and emulation of form and practice in the area.

Another aspect of wall construction involved leaving certain spaces open or cutting holes into the wall after it was built. The decisions to use any of these orifices always had a technical basis. A chimney hole allowed the escape of gases. One to ten holes at the furnace base provided inlets for tuyeres. A small peep hole allowed the smelters to monitor the smelt. Bloom could be removed at the end of a smelt through a rake hole, and a slag-tapping hole allowed the accumulated slag to drain out of the furnace. The latter three orifices were not always used and the configuration of tuyere holes varied greatly, depending on other design factors. The wide variation in the types of holes used, their number, and shape clearly influenced the morphology of a furnace.

Labor considerations were also linked to the use of these holes. Where tuyeres were used with hand-operated bellows, the size and organization of the work force determined the number of tuyere holes made. In the cases where clay pipes provided an inlet for the naturally induced drafts of taller furnaces, labor was invested in furnace construction, maintenance, and resource procurement, not in bellowing. Furthermore, the use of a rake hole meant that the bloom and slag could be accessed after a smelt without having to demolish and then rebuild the furnace walls. A slag-tapping hole was useful in natural draft furnaces, like that of the BaUshi (Barnes 1929), or when there was sufficient manpower to sustain long, bellows-driven smelts. With periodic recharging of ore and charcoal, these smelts could continue until the bloom size reached the capacity of the furnace bottom.

The formal number, size, and locations of these holes often related to a deep-seated symbolic system associated with smelting iron. Individual names given to each orifice and sometimes to the tuyeres often related to the process of birthing (Smith and Dale 1920; Chaplin 1961). The BaTshokwe, for example, used the same name for the rake hole as for the birth opening of a delivering mother (Maret 1980). The conscious process of naming these furnace attributes (Schmidt 1983) constituted part of a complex message to the spirit world and to the nonsmelting members of the culture.

One of the last actions taken during the construction, but before the operation of some furnaces, was marking or decorating the exterior walls. The variety of incisions and appliques, along with furnace shape, constitute the most obvious attributes for stylistic analysis. It should be clear by now that to understand the variation of these latter attributes and the messages they carry, however, we must relate them to the other decisions taken such as furnace height, the number and location of tuyere holes, and the location of a rake hole.

Furnace wall decoration in many Bantu-speaking societies involved a conscious association with symbols of transformation, particularly as related to procreation and fertility (Herbert 1988). A number of Central African groups, as presented above, shaped their furnaces into women with breasts and incised them to symbolize stomach scarification. The

BaKaonde built their furnaces in human-like forms with a throat, arms, and legs (Chaplin 1961). The MaShona (Cooke 1959:118) and the BaFipa (Wise 1958b), among others, placed objects on the walls to symbolize their new identity as brides or wives.

The archaeological record of the Early Iron Age for eastern and east-central Africa contains considerable evidence of decoration on brick furnaces. Vertical grooves, chevrons, dot-like impressions, and curved forms were used over a widespread area for hundreds of years (Hiernaux and Maquet 1956; Schmidt 1978; van Noten 1983; van Grunderbeek et al. 1983; Schmidt and Childs 1985; Collett 1985; Childs 1986). Not only do these marks indicate some cultural linkages between prehistoric smelting groups, but they may also have communicated ethnic relationships and differences or a widespread belief system that directly influenced iron smelting behavior.

TECHNOLOGICAL STYLE AND THE IRON SMELTING FURNACE: THE MASHONA CASE

In this final section, I examine iron smelting among the MaShona of Zimbabwe. I present this case to show how a specific mechanism(s) structures a production process and creates a distinctive style. I also look at what is being communicated. The study provides an example of how data that might be found in the archaeological record can be analyzed, but the details are not intended to be directly applicable to specific archaeological cases.

The MaShona have not smelted iron for large-scale or consistent production since the turn of the century (Mackenzie 1975). Archaeological evidence shows that some MaShona smelting was relatively small-scale (Cooke 1959; Robinson 1961), while ethnographic observations attest to sizable operations involving considerable manpower (Mackenzie 1975; Bent 1893). The evidence indicates some localized differences or changes in the scale of iron production, while furnace design changed little, if at all. An overriding cultural factor too powerful to allow changes in furnace design coincident with changes in the scale of production is suggested.

What is known about MaShona smelting indicates that several iron workers and their aides met to smelt during the dry season each year. They conducted their work away from their villages, near charcoal and water sources. The work units were mostly tight kin groups of men related through birth or marriage. Women of the Njanja group, however, transported the massive amounts of charcoal and ore that was required for intensive production (Mackenzie 1975). This was probably a change from an entirely male activity coincident with growth in the scale of production. The women were likely excluded from smelting itself due to a common belief among Bantu-speaking groups that their fertility was deleterious to the furnace and its output (Cline 1937; Eliade 1962; Maret 1985).

The location of the mines involved transportation difficulties over considerable distances, as well as the need to pay the local chief a hoe as tribute. Despite the political and economic problems, this ore was valued for its physical characteristics, since its iron content could be easily upgraded and then reduced in the small, MaShona furnaces (Mackenzie 1975). At the height of production, the Njanja operated 10–20 of these furnaces per day at one site and produced up to four blooms in each. Once the smelting season was over, the blooms were distributed among the workers. They took them to their villages for forging or for long-distance trading. Both practices engendered considerable economic gain.

Mackenzie found no evidence for the enforcement of sexual taboos during smelting, such as refraining from sexual intercourse, although he did note the use of sexual imagery during the whole smelting process (Mackenzie 1975:214). Nor did he find that smelting involved secrecy and mystery, often indicated by building furnaces away from villages.[4] William Dewey, however, has recently found considerable evidence for sexually oriented imagery, ritual, and taboo in MaShona iron smelting (1990).

Given this background, how were the decisions and actions displayed by the MaShona iron workers reflected in their smelting furnaces? The furnace was approximately 1 meter tall, conical, and quite squat in shape, and its walls were elaborately decorated (Fig. 5). Prominent wall features included breasts and a series of parallel, horizontal lines underneath. Sometimes an umbilicus, female genitalia (Robinson 1961), and a waist belt or *mutimwi* (Dewey 1990) were portrayed. The waist belt marked a new stage in the life of a Shona woman, the time when she married and embarked upon having children. It also had a symbolic function to "strengthen her sexual power and to safeguard her fertility" (Aquina 1968:4). Lastly, two elongated clay masses were often extended from a central rake hole at the furnace base suggestive of open, human legs at the base of the belly. The parallel grooves above these "legs" clearly represented stomach scarification of MaShona women (see plate, Bent 1893:304 for direct correlations).

The details of the furnaces show a strong association between iron smelting and human parturition. This relationship would have been especially dramatic at the end of a smelt as a bloom was "born" and removed from between the furnace's legs. Mackenzie's emphasis on the economic and political aspects of Njanja smelting, however, does not overtly reflect this relationship. Only the furnace design and an emphasis on the productivity of the furnace might indicate an expressed analogy between iron

FIG. 5. A MaShona forced draft furnace built for a 1942 iron smelting demonstration in Zimbabwe.

smelting and human fecundity. Less obvious ideological factors may have influenced the smelting performance, though, and were consciously or subconsciously expressed as the furnace was built and operated.

We must identify such influences, both active and passive, within the wider cultural system. Analysis of the ethnographic record indicates that two things might have helped structure the smelting process: (1) kinship networks and residence patterns; and (2) the MaShona value on "life" and "strength" achieved through relationships with spirit guardians (Bourdillon 1976:131). Shona prosperity depended upon fertile land, from which the people received "life," and upon reproduction of their own kind. The ancestral spirits, *vadzimu*, who once worked the land, controlled soil fertility for the welfare of their descendents. A person (usually a man) only became a spirit if he produced children during his lifetime (Bourdillon 1976:256). A link existed between the achieved fertility of the ancestral spirit and his ability to control the fertility and productivity of the land.

Dewey's research among Shona artisans (1985, 1986) shows that the ancestral spirits strongly influenced iron smithing. Many of his informants claimed that they received their knowledge of smithing through spirit possession or spirit-inspired dreams (Dewey 1986:66). The spirits provided the craftsman with "the power and impetus to create" (Dewey 1986:64). The products of creation by smelting and smithing included hoes essential to agriculture and to the acquisition of wives through bridewealth transactions. Iron working was therefore linked to success in agriculture and human reproduction, activities that were all controlled by the ancestors.

The MaShona are patrilineal and are concerned with reproducing the male lineage. In precolonial times, a man paid bride wealth of iron hoes to the bride's family and then brought her to his residence. Some of the bride wealth was used to buy a new waist belt or *mutimwi*. It was not until the wife bore her first child that she received her own cooking stones, the symbols of marriage. The couple also achieved full adult status at that time because they proved her fecundity and their combined ability to be productive members of society. Barrenness was deemed shameful and was grounds for divorce.

Mackenzie's (1975) work on the Njanja iron workers shows that the residence rule was sometimes adapted to fit certain production needs, such as when a labor force was needed for large-scale smelting operations. Prominent master smelters sought to expand their influence and industrial productivity through kin networks, specifically by using their daughters to attract neighboring men of different clans as smelting apprentices. Once a man fulfilled his apprenticeship and, hopefully, married a daughter of the head smelter (who bore him many children), he either specialized in an aspect of the technology and stayed in the area or moved away to establish his own operations.

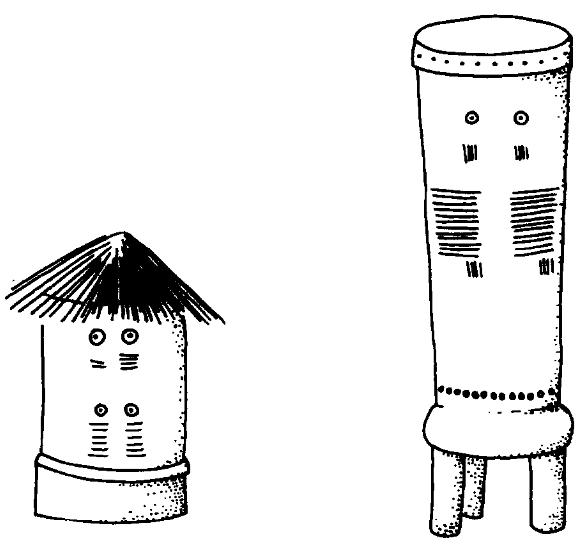
When a master smelter achieved prominence and attained a large labor force, he became the political leader of a new village or, possibly, a small chiefdom. This achievement meant that he had created a political and economic power base through the control of kinship ties and the productive economy. By regulating the production of hoes, he controlled the agricultural and human reproductive potential of his people. Both his success at iron working and his political achievement had to be supported by the ancestors, however, who controlled agricultural, human, and craft production. Upon investiture as a village leader, the ancestors embodied him with new powers that included guarding the "life" and "strength" of his kin—his family, workers, and political supporters. The well-being and productivity of the villagers meant wealth and power for the chief smelter and leader.

An overriding concern of the MaShona was fertility: of their land, their people, and, by necessity, their ancestors. For the land to be most fruitful and for men to find wives, the production of iron hoes and other tools had become important. The analogy between birthing an iron bloom and human child-bearing as depicted by the furnace directly communicated this MaShona concern. The symbolism, however, did not merely objectify MaShona values, but served to legitimize motives for political and economic success (see Schmidt 1983 for an excellent discussion of similar constructs among the Haya of northwestern Tanzania). By using his furnace "wife" (Dewey 1990) to give birth to iron, the iron master capitalized upon symbolic associations and kin ties that not only were culturally acceptable but allowed him to control economic and political domains of society.

The pervasiveness and importance of fertility and social relationships in MaShona society are dramatically reinforced when similar patterns of furnace design are found on other material culture. Breasts and the parallel lines of scarification decorated granaries in which the products of the fertile land were contained (Fig. 6a). The MaShona also used this pattern on their drums (Fig. 6b) which were considered a life force and a means to contact the spirit world. These latter examples reemphasize the symbolic statement that MaShona economic and political success related to control over fertility and production. They also demonstrate the profound effect such cultural ideas have on styles of behavior in several technological contexts.

CONCLUSIONS

The MaShona example demonstrates that African iron smelting furnaces provided both a technical means to produce iron and a medium to



A B

FIG. 6. MaShona objects decorated with the breast and scarification pattern: (A) Granary (redrawn from Bent 1893:46). (B) Drum (redrawn from Bent 1893:78). Scale unknown for both.

express a variety of cultural messages. These messages were sent not only to the living, but to the spirit world as well. We also see that the total performance of iron smelting was very complex and involved many influences on decisions at every stage of the process. Some of those decisions were conscious, while others were set into tradition so that the reasons behind the original choice were not remembered. The contribution of these latter, more passive actions to the technological style exhibited is no less important, however.

Unique technological styles evolved because of the particular combinations of localized influences on choice and the mechanism that structured and unified all the choices. In the MaShona case, it was a world view securely rooted in a value system and cosmology where it effectively, but somewhat covertly, affected decisions and actions. The evidence suggests that the master iron smelters purposely used or created, around their furnaces, imagery and ritual to reflect and communicate the importance of fertility and the perpetuation of the kin group. On another level, the iron workers legitimized their acquisition of economic control and political power in the society by continually expressing and reinforcing those values. Through their control of the process and products of iron working, these craftsmen dominated the critical spheres of food production and kinship (human reproduction). Some of this imagery, however, was also directed to the spirit world, a matter which must be considered more carefully in future discussions of style.

The case study also demonstrates that it will be difficult to identify the mechanisms that integrate prehistoric technologies, but that the potential rewards of trying are many. Since it is usually difficult to reconstruct the cultural context in which a prehistoric technology operates, models cautiously developed from ethnographic sources provide a means for hypothesis-building. Careful work with ethnographic data can yield significant insights for archaeologists, yet it certainly cannot replace the richness of detail provided by primary ethnographic and archaeological fieldwork. We have seen that archaeologists might be able to learn about some aspects of world view through comparison of design decisions in other technologies. Repetition of MaShona furnace design choices on the granaries and drums helped support the finding that fertility and its control were important in MaShona thought. The reinforcement of the ideology in several technological pursuits probably provided the basis upon which the nonsmelters could accept the exclusiveness and power of the iron workers.

Finally, it should be clear that the great diversity of iron smelting furnaces in Bantu-speaking Africa is related to the many localized, cultural influences on the smelting process. These resulted in the evolution of many technological styles. We should now be challenged to probe the potential riches of prehistoric culture in seemingly mundane objects like furnaces. There are still ethnographic and ethnoarchaeological opportunities in Africa to study technological styles of iron smelting. Such research prospects demand immediate attention, however, since only a few African iron smelters remain who remember the technological process and some of the reasons behind it.

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NOTES

[1] For excellent examples, see Wiessner (1983, 1984) and David et al. (1988).

[2] My fieldwork includes excavations of Early Iron Age smelting sites in Tanzania with P. Schmidt in 1976–1977, 1978, 1980, and 1983; excavations at Sanga and ethnographic work on iron and copper manufacture and use among the Luba in southeastern Zaire in 1988; work in the Queen Victoria Museum in Harare, Zimbabwe, in 1988.

[3] For a basic description of the internal dynamics of an iron smelt, see Tylecote 1962 and Avery 1982.

[4] Mackenzie's research focused on economic history. His insights on the sexual aspects of production seem to depend on the observations of others. It is possible that he did not ask the right questions of his informants or they chose not to discuss these matters with him for unknown reasons.

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