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LOST IN THE THIRD HERMENEUTIC? THEORY AND METHODOLOGY, OBJECTS AND REPRESENTATIONS IN THE ETHNOARCHAEOLOGY OF AFRICAN METALLURGY*

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> The people follow the habits of a life which, measured by our standard, would be termed savage, yet the existence of an industry such as is herein described removes from them this stigma. (Bellamy [1904: 99])

> On the fourth day of furnace building, after asking the iron master about the forms of furnace parts and getting usual Dokwaza replies – "That is how it is done in my clan;" "Furnaces are like that" – I finally asked some leading questions. "The shield looks like an upside-down pubic shield, doesn't it? Is not the furnace a woman, and is that not the reason why you do not sleep with your wife while smelting?" I also pointed out the obviously male attributes of the bellows/testicles and tuyère/penis assembly that reach into the "belly of the furnace" (*hwá'd gezla*) where the bloom/baby is made. Besides being a good example of how *not* to question an informant, this interrogation was completely ineffectual. Dokwaza merely laughed and said "If that's the way you Whites want to think about it, you are welcome to do so." (N. David, 1986 fieldnotes)

INTRODUCTION *

It is my purpose in this paper to evaluate the ethnographic study of African metallurgy in terms of its anthropological, but not metallurgical, theory and methodology. Because I deal only with field research, most of which has been carried out by archaeologists with the intention of applying its results to interpretation of metallurgical history and prehistory, I refer to such work as ethnoarchaeological even though its authors may have regarded themselves as practising ethnology, archaeometallurgy, or history. I pay particular attention to the vital question of whether the ethnographic and metallurgical aspects of such research inform upon each other, and conclude that, while we have on the whole failed to establish productive linkages, they do in fact exist. I argue that the anthropology of techniques (Lemonnier 1992) provides the best theoretical and methodological approach to the combination of technical and cognitive-symbolic behaviour that characterizes iron production, and I sketch examples of the benefits to be gained through such work. My analysis, which concludes with some suggestions for the very limited time remaining in which direct studies of smelting will be

* Welcome to the acknowledgements where much critical information about ethnoarchaeological methods and context is customarily tucked away. The field research among the Mafa reported above was carried out in 1986, 1989, and 1990 over a period of about eleven months under authorization from the Ministry of Higher Education, Computing and Scientific Research of Cameroon, and with the support of the traditional and the tolerance of the provincial authorities. I thank my assistant, Emmanuel Isa Kawalde of Mokolo, for his mentoring, guidance, interpreting, and friendship. R.A. (Caesar) Apentiik's research among the Bulsa took place between May and August of 1996, and was authorized by the Ghana Museums Board and approved by the Bulsa District Assembly. Both studies were carried out in the context of the Mandara Archaeological Project which has been financially supported since 1984 by the Social Science and Humanities Research Council of Canada. I thank David Killick for pertinent comments on an earlier draft and Eric Huysecom for inviting me to the Round Table.

p 50: possible, is carried out in terms of a small sample of ethnoarchaeological accounts that includes almost all those that treat both the ethnographic and metallurgical aspects of smelting.

Methodology, subject to theory, guarantees the validity of observations and inferences. While theoretical stances can generally be inferred, it is somewhat surprising that, with rare exceptions, my colleagues have failed to explicate their methodologies or even their methods, all the more so since archaeologists, since the 1960s, have been concerned to ground their methodologies in theory and to specify methods rather precisely. 'We just went out there and did it,' as a distinguished colleague said to me of his—and it applies to my—earlier ethnoarchaeological work. It is noteworthy that only one ethnoarchaeologist has ever written a paper with the word 'methodology' in its title and that is the convenor of this *table ronde*, Eric Huysecom (1993).

Ethnoarchaeologists concerned to study African metallurgy confront a technology that involves complex and non-obvious physico-chemical processes, that calls for mobilization of substantial material and human forces of production, and that requires an equally vigorous engagement with the supernatural. This threefold challenge to explain the physical, the social, and the ideological demands theoretical and methodological sophistication. Let us remind ourselves of A. Giddens's (1982: 12) distinction between the first hermeneutics of natural science which 'has to do only with the theories and discourse of scientists, analysing an object world that cannot answer back,' and the second hermeneutics of social science.

> The social scientist studies a world … which is constituted as meaningful by those who produce and reproduce it in their activities—human subjects. To describe human behaviour in a valid way is in principle to be able to participate in the forms of life which constitute, and are constituted by, that behaviour. This is already a hermeneutic task. But social life is itself a 'form of life,' with its own technical concepts. Hermeneutics hence enters into the social sciences on two, related, levels (Giddens 1982: 7).

While we need not agree with M. Shanks and Ch. Tilley (1987: 107–8) that anthropologists who work in alien cultures are involved in a triple, and archaeologists who attempt to understand alien cultures of the past in a four-fold hermeneutic, ethnoarchaeologists and those evaluating or wishing to use their data should pay special attention to the methodologies employed in their generation.

Now we could have a certain amount of malicious fun in citing examples of bad or insufficiently described theory and methodology in the work of metallurgically-inclined researchers, but my face would, as the second introductory quote to this paper indicates, be as red as those of my colleagues. While some may come close, no scholars combine the talents and expertise required to conduct ethnographic research into metallurgy that is of equal and sufficient competence in both its anthropological and materials science aspects.[1] Therefore we should not be surprised that so few studies combine such skills. We may, however, ask:

1. How useful or valid are studies that fail to integrate the humanist and scientific components?
2. What information is required for proper assessment of the anthropological aspects of field methodology? (I leave assessment of metallurgical aspects to scientists.)
3. What are the functions of the symbolic and ritual aspects of metallurgy? Do they merely accompany the technical process, or are there mutually informative linkages between the two sets of procedures.

[1] If only because the academic discourse regime inhibits the development of such a specialization. While anthropologists may work with one village, scientists are supposed to apply themselves at least on a continental scale.

p. 51: 4. What theory might we mobilize to improve our understanding of African metallurgy from both humanist and scientific perspectives?

5. Where do we go from here?

In what follows, I limit myself to consideration of smelting, focusing wherever possible on cases that have been studied from both a scientific and a humanist perspective (**table 1**). Restrictions of space, combined with insufficient data, prevent me from extending this analysis to smithing.

Group	Country	Date smelting abandoned	Years smelts observed	No. of smelts	Primary references
Dime (Dimi)	SW Ethiopia	1973 or after	1973	1	Todd 1979, 1985
Cewa of Chulu; Phoka	C and N Malawi	~1930; 1930s	1982, 1983	1; 2	Van der Merwe–Avery 1987; Killick 1990
Hausa	S Niger	~1976	1965, 1967	2	Echard 1983
Bassari	Togo	early 1950s	1985	2	Goucher–Herbert 1996; Saltman *et al*. 1986
Fipa; Pangwa	WC and S Tanzania	early 1960s; before late 1960s	1990–91; 1995	3; 2	Barndon 1996a and b*
Gbaya-‘bodoe	W Central African Rep.	1943	1977	2	Moniño 1983
Haya	NW Tanzania	~1925	1976–84	9	Schmidt 1997
Barongo	W Tanzania	~1951	1979–84	9	Schmidt 1996
Mafa	N Cameroon	late 1950s	1986, 1989	2	David *et al*. 1989

* Supplementary information kindly provided by Randi Barndon in e-mail of 17 March 1999.

Table1. The African smelting technologies considered in this paper.

NATURALIST APPROACHES [2]

It is held by some that science and social science are realms apart, and that, just as we can investigate Africans’ social—and particularly mental—worlds without reference to their science, so we can understand African science without reference to African culture. J. A. Todd’s (1979, 1985) research on Dime (or Dimi) smelting takes such a resolutely naturalist (or modernist) position. Were it not for her references to D. M. Todd’s dissertation, *Politics and Change in Dimam* (1975), and paper (1977) on caste in Africa, which tells us that the Dime are organized in chiefdoms and have casted smiths, one might infer that she had been randomly parachuted into south-west Ethiopia, where in 1973 she became the last observer to have reported on smelting carried out not for the benefit of Western researchers or as a folkloric attraction, but in earnest, to obtain iron. (It is now known that iron smelting continues to be practiced by the Dime: Haaland et al. 2000.) The Dimam region was at that time some 110 km distant over mountainous terrain from the nearest source of metal scrap. Her report is couched in the strictest scientific terms, and while there was communication between observer and observed, the reader is given no idea as to how this took place. Curiously, despite any mention of magic or ritual, one gains the impression, reinforced by the anonymity of the smelters, that for Todd smelting itself constituted the performance of a utilitarian rite, a Dime custom handed down unchanged through the generations. In order to counter common misconceptions of a pristine, primitive, or unchanging Africa, it is essential

[2] For the terms ‘naturalist’ and antinaturalist’ see David and Kramer 2001: 37-8.

p. 52: that we situate our research, minimally by providing the kinds of information listed in Appendix 1.

In their paper 'Science and magic in African technology: traditional iron smelting in Malawi,' N. J. van der Merwe and D. H. Avery (1987) contrast the 'materialist and the missionary positions.' They quote H. Kjekshus's (1997: 91) characterization of the second as tending 'to see "the manufacture of iron as a by-product of the magico-religious needs of the East African peoples".' Explanations for the magic associated with metallurgy indeed 'range from simple dismissals of superstition to elaborate functional explanations,' such as J. Bronowski's (1973: 171) argument that precise ceremonial can substitute for a technical manual. The most that the materialist Kjekshus (1977: 91), cited in van der Merwe and Avery (1987: 144), is prepared to grant is that ritual supports 'a type of trade-union secrecy aimed at maintaining monopoly over an important economic enterprise.' Van der Merwe and Avery are impressed by the universality of the association of 'magic'—glossed as 'the combination of ritual and medicines'—with smelting in Africa and the repeated presence of certain themes: propitiation of supernatural forces, the contribution of technical and magical knowledge to the special status of smelters, and sexual symbolism and taboos. The authors, an archaeologist and a metallurgical engineer, biased, in their own words, towards technical explanations, undertook to investigate the relationship between the technical and magical aspects of iron production through their analysis of reconstructions, after a gap of half a century, of smelting among the Cewa of Chulu village in the Kasungu district of central Malawi and Phoka living on the slopes of the Nyika mountain massif in the north of the country.

Their study is a model of concise description. The two groups studied and their two-stage smelting process, in large induced and small forced draft furnaces, are set in historical and technological context. The research methods, including the involvement of local chiefs and others in the selection of smelters, are clearly specified, as are the relations between the researchers and the smelters. The researchers participated in some rituals and bound themselves to observe the same taboos as the smelters. It is not, however, clear how and in what languages van der Merwe and Avery communicated with the smelters. The entire smelting cycles from construction of the furnaces to resmelting of the product in the smaller furnaces are summarized, followed by descriptions of Chulu and Phoka ritual and medicines. These are supplemented by appendices that describe the (mainly plant) medicines used, giving their names in the local languages and, in most cases, in Latin, and their placement in relation to the furnace. Given that the Cewa of Chulu used 27 medicines and the Phoka 56, these are impressive documents in themselves.

In addition to the empirical account of both smelting and its attendant magic, van der Merwe and Avery also draw attention to interrelated metaphors of human reproduction and heat/danger that are particularly evident in the practice of Phoka smelting. Their concluding discussion denies the validity of either the materialist or the missionary position, and specifically 'Kjekshus's contention that the ritual component of smelting is of secondary importance, at most a type of trade union secret' (p. 164). Neither in the cases observed did magic 'provide an organising force, … [in that] a sequence of rituals may order a technical process. … the rituals merely punctuate the successful completion of various preparatory phases (p. 165).' Rather they incline to the Malinowskian view that magic relieves anxiety in the face of the unknown and the unpredictable. Their conclusion is succinctly stated in their introduction:

> Our perceptions of the importance of the magical evidence in smelting increased substantially as we were progressively introduced to its mysteries. The investment of time and effort in smelting magic is large and the expertise required is extensive: it is a technology in its own right, with its own body of knowledge and network of personal and commercial relations. We did not find that magic has a scientific

contribution to make to iron smelting technology,

p. 53: but nevertheless concluded that smelting could not be conducted without it, because it is too important to the smelters (p. 144).

This is a fine, and engagingly written, piece of work, but one that is deficient in two major respects. First, as is only too often the case, the authors' brief exposure to the Cewa prevents them from fully situating smelting in its social and cultural context. Second, and partly as a consequence, the technical and magical aspects of smelting are treated in the text and in practice as separate domains between which there appears to be only metaphorical linkage. The scientists offer a coherent account of the technical process of smelting, but their knowledge is insufficient to attempt the same for its magical aspects. They realize that the ethnobotany of smelting magic is a study in itself, and were unable to 'pursue [the symbolism of smelting] outside the confines of the smelting camp' (p. 144). Thus their rags and patches conclusion regarding the disorganization of the magic may be correct but must remain undemonstrated until the possibility that it comprises one or more coherent and interlinked domains has been investigated. This would involve, among other things, achieving deeper understanding of the metaphorical substitutions that are realized in the course of the process, and researching the probable metonymic links between particular plants and the effects they are believed to produce.[3] I do not suggest that a single magical 'text' is reread each time smelting occurs—though it may be rewritten in the case of reconstructions—but rather that each smelting 'performance' draws on a relatively stable but nonetheless evolving fund of ideas about the nature of the world and the ways that it may be manipulated. No doubt such performances were routinized in the days of industrial smelting; however, in the context of reconstructions the elements of improvisation and collage are very obvious—as in the case of the smelters of Chulu who are clearly drawing on both Christian and longer-held beliefs to compose their magical technology.

It should be added that van der Merwe and Avery's work at Chulu is substantially complemented by D. Killick's doctoral thesis (1990) which sets out to reconstruct the history of smelting in the Kasungu district from documentary history, oral accounts, field archaeology, and metallographic and petrographic study of smelting residues. Information on methods is provided in exemplary fashion and, as the title indicates, the author is concerned to understand not only the technological and economic, but also the social and ideological aspects of the iron industry. Extensive interviews with nine former smelters aged between 70 and 80 were recorded in ciCewa and ciTumbuka, transcribed and translated—an only too rare occurrence in ethnoarchaeological work. These provide much valuable information on practical matters, such as the choice of clays, ore, and trees for charcoal, and on socio-cultural aspects. Information was thus obtained on, for example, the division of labour, sexual proscriptions, and explanations of the reasons for smelting magic, primarily the need to avoid both ancestral displeasure and human sorcery. The interviews also reveal remarkable variability in furnace design due in part to the lack of cooperation between smelters. However, while a great deal was learned from these indigenous explanations of smelting, disappointingly little in the way of mutually informative linkages between technical and magical aspects became apparent, partly no doubt because none of the old men had smelted on their own account.

> As the master smelter alone knew the composition of the antisorcery medicines, he was the 'owner' of the furnace and had undisputed control of all aspects of the smelting process (Gordon–Killick 1993: 269).

[3] Metonymy is defined by the Oxford English Dictionary (Compact edition) as "a figure of speech which consists in substituting for the name of a thing the name of an attribute of it or of something closely related." Magic involves the metonymic transfer of attributes from one thing to another.

p. 54: ANTINATURALIST APPROACHES

The third class of cases to which I draw your attention is one in which researchers, unlike the previous two, emphasize more the social and mental construction of technology than its mechanical and physico-chemical aspects. An early and excellent example of such work is the late N. Echard's 1968 film *Noces du Feu*, but I shall focus rather on her paper 'Scories et symboles …' (1983) in which she re-presents with additions material from some of the last smelts ever carried out by Hausa smiths in southern Niger. Echard was an ethnologist with a long history of work among the Hausa of Niger, whose language she spoke fluently. In 1983, she was writing expressly for archaeologists with the intention of 'demonstrating which social practices and techniques observed by the ethnologist end up by leaving, from the making of iron, traces similar to those found on certain archaeological sites' (p. 211, my translation). The first part of the paper sets the smiths and smelting in their cultural and historical context and describes a unique form of cooperative labour organization, whereby numbers of smiths from diverse settlements gathered in the bush far from villages and roads in order to smelt with induced draft furnaces under the leadership of a master smelter, the *sarkin zangon tama* (chief of the iron camp). Echard witnessed two smelts in the Ader region, one in 1965 and the other in 1967, but provides no information regarding the relationship between the smelters and her team. Despite the progressive collapse of the industry reported in the earlier part of the paper, her description of smelting, which conflates the two smelts observed and other information gathered, makes it appear a practice fixed by custom.

While her account offers no technical metallurgy, it is rich in social and cognitive data. Her description of the spatial organization of the smelting camp shows that this is structured as much by ideology as by practical considerations. She also provides a timed log of the smelting process, emphasizing the many different kinds of 'work' the master smelter must undertake: speech acts, orientation of operations in space, ritually prescribed circulation within the furnace area, orchestration of workers and things, and gestural and other physical tasks. Her description is especially noteworthy for the insights gained, through analysis of the master smelter's 'black words' or magical utterances, into his conception and management of a reduction process that can only be glimpsed through the tuyères and peepholes in the furnace wall, through the sounds it makes, and through examination of slag. These are in almost all respects, allowing for differences between furnaces, the clues that the last American bloomery smelters used in the Adirondacks up to December 1900.

> To judge what was happening within the hearth, the bloomer observed the color of the flame, the color and fluidity of the slag, the feel of the bloom as tested with a long iron bar, and the sounds made by the fire in the hearth (Gordon–Killick 1993: 253).

How the Adirondack smelters conceived of the process we do not know, but for the Hausa the imagery is richly sexual and the ruling metaphor explicitly one that links pregnancy and gestation of the foetus with the formation of the bloom within the furnace. Certain actions of the master smelter such as the emptying of baskets of ore into the furnace shaft from different positions at ritualized intervals are explained in terms of Hausa concepts of gestation, but are surely of practical significance. Others of the black words specify the product desired: iron that is shiny, in a circular bloom, large and round, covered with small excrescences, hard, and with the capacity to swell in the forge. Echard brings out these informative linkages between the technical and symbolic aspects of smelting, but is interested more in its social aspects and in the symbolic inversion of genders. In mythic time smelting was women's work; the sounds of a successful smelt in process are of frying, a method of cooking associated with women. The master smelter's magical words 'establish the coincidence, term for term, of the making of metal and biological reproduction, to the point that obstetrics is considered to be

p. 55: knowledge peculiar to the smiths' (p. 221, my translation), although they do not in fact practice even as midwives. Curiously, Echard pays no attention either to medicines or to sexual taboos associated with smelting.

A concern both with gender and sexual prohibitions is very evident in the Bassari smelting re-enacted for and filmed by C. Saltman, C. Goucher, and E. Herbert (1986) in Togo, and reported by Goucher and Herbert (1996). These authors, who describe themselves as historians, situate themselves and their work in historical and cultural context, give an account of their negotiations with the chief of Banjeli and the smelters, and make explicit their reliance on interpreters in the field and subsequently in translating portions of the film soundtrack. The building of the induced draft furnace and accompanying rituals are briefly described, including the use of seven plant and animal medicines. A concise account of charcoal making and the smelting process follows, ending with a discussion of its only partial success, widely attributed to participants having violated the taboo against sexual relations. The remainder of the paper consists of a cognitive-symbolic study of Bassari conceptualization of smelting, particularly as it relates to gender.

> In preindustrial societies a constant point of reference is the human, the live world of the body and of social relationships. Because these are genderized, gender becomes a means by which the world is experienced and categorized. The analog of human processes becomes the bridge to understanding the natural world (Goucher–Herbert 1996: 52).

The authors argue that to the Bassari the furnace is brought to life as a young woman through ritual, and that the master smelter, at first her father, and then later one, with the other smelters, of her husbands, sees her through a 45-hour pregnancy leading up to 'the thud of the bloom falling to the base of the furnace, which, like the fetus dropping in the womb, would signal that the smelt was complete' (p. 50).[4] While recognizing that the reasons for exclusion of premenopausal women, and especially menstruating women, from the smelting site and the prohibition against sexual activity on the part of the smelters are complex and multiple, Goucher and Herbert associate these customs with the concept of the furnace as a pregnant wife, to whose child her own or her husband's adultery poses the threat of abortion. They conclude that 'smelting represents a symbolic usurpation of female reproductive capacities' and that

> Iron smelting reflects simultaneously both positive and negative views of femaleness—creativity and danger. By enforcing the exclusion of women from smelting, the male smelter reaffirms his control over productivity and reproductivity (p. 54).

It is not my purpose here to critique Goucher and Herbert's view, but rather to point out that it elegantly subsumes many features of the furnace and several aspects of ritual, including the beating of a young boy, under the theory of metaphoric social reproduction. This, together with an appeal to the ancestors for assistance and the driving off of bad spirits, would seem to account for all or most of the rituals associated with Bassari smelting. In this they go somewhat further than van der Merwe and Avery, though we learn equally little about why particular medicines are used for particular purposes.

In the same volume, Barndon's (1996a) paper on smelting among the Fipa of Tanzania (whose practice is close to that of the Cewa and Phoka) addresses this last question in a little more detail. There the master smelter's basket contains

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[4] The analogy is not drawn, at least explicitly, by the Bassari, but by the researchers themselves (Herbert 1993: 62.

> **p. 56:** items such as pieces of skin, nails, shells, or bark [which] are not curative but instead possess the quality ascribed the idioms—the animal or stone the item represents. Thus the transferred qualities of these magic items will procure benefits and prevent harm during the smelting. Explaining why a piece of an elephant's ear is used, the smith said, "Even when the elephant sleeps his ears are moving. We apply a piece of the ear since we want the fire inside the furnace to burn continuously" (pp. 65–6).

Such metonymic transfer of attributes appears as a fundamental theme in African smelting magic.

Barndon (1996a**:** also 1996b) wishes to counter the tendency towards polarization of technology and symbolism by invoking Lechtman's concept of technological style**:**

> technological behaviour is characterized by the many elements that make up technological activities, for example, by technical modes of operation, attitudes towards materials, some specific organization of labour, and ritual practices and observances—elements that are unified non-randomly in a complex of formal relationships (Lechtman's (1977: 15).

However, in this short paper Barndon deals mainly with the metaphorical aspects of smelting (which she insightfully suggests extend to the structuring of smelting space), interpreting them in a manner similar to Goucher and Herbert, and greatly expanding in the second paper (in which she also contrasts Fipa two-stage with Pangwa single-stage smelting in a forced draft furnace) on the basis and elaboration of the reproductive metaphor. The non-random unification of technological and symbolic elements in a complex of formal relationships remains, however, a matter of faith rather than of demonstrated fact.

A MISSING COPULA?

The first of the five cases discussed ignores the ritual sphere; the second treats the technical and ritual components of smelting as worlds apart; the third finds linkages between them, while the fourth and fifth argue for their integration but cannot be said to have achieved their synthesis. Broadly representative of recent ethnoarchaeological studies of metallurgy, they provide an adequate basis for answering the first of my questions. How useful or valid are studies that fail to integrate the humanist and scientific components of metallurgy? The question conceals another within it: whether we are presented with sufficient evidence to be able to estimate the security of the information provided.

There is no doubt that Todd's (1979, 1985) papers on Dime smelting contain much valuable information, especially when the author is describing a technical process that she herself has observed (not to mention the results of laboratory analyses [Todd–Charles 1978]). But we learn nothing of Dime conceptualization of their technology and must regard even simple attributions of knowledge to the smelters, e.g. 'he could tell that the iron was ready from …,' as somewhat questionable, due to insufficient information regarding the conduct of her fieldwork. Half the story is missing. Van der Merwe and Avery's account of smelting in Malawi presents substantial but compartmentalized data on both the technical and magical-ritual aspects of iron making. The detailed account of their interactions with the smelters is grounds for some confidence in the validity of their observations. However, their interpretation of the disassociation of science and symbolism must be regarded as unproven and, in the light of other work, exaggerated, if not entirely mistaken. Echard, Goucher and Herbert, and Barndon regard the technological and symbolic elements as possessing much greater cohesion, and demonstrate both the social construction of technology and the existence of overarching metaphors that bond a large proportion of the symbolic, magico-religious behaviours observed. Goucher and Herbert are also forthcoming, Echard less so, and

p. 57: Barndon only in her 1992 thesis,[5] regarding the conduct of their fieldwork, but we can again have a comfortable overall level of confidence in their data, especially in the case of Echard whose work is eloquent testimony to her linguistic competence and long-term familiarity with Hausa culture.

What I find missing in all these papers except Echard's is a demonstration that there exist linkages between technical practice and mental representation that mutually inform upon both. Or in other words proof that the naturalist scientist has something more to learn about the science from understanding the native's symbolic behaviour, and that the humanist's cognitive-symbolic studies can benefit from a better grasp of technical practice. Let me illustrate with a personal anecdote. When Killick, other members of my Mandara Archaeological Project team, and I were working with Dokwaza, the Mafa iron master whose smelting and smithing are described in an article (David *et al.* 1989) and two films (David–LeBléis 1988; David 1995), one of my tasks was to document the ritual aspects of smelting. At one point Dokwaza introduced into the furnace via the tuyère a medicine, *madzaf nngurlele*, fleshy roots forming a series of adjoining white nodules of a small plant with a white flower and lanceolate leaves. It was only much later that we learned that *nngurlele* is the Mafa term for the droplets of cast iron that Killick identified as one constituent of the heterogeneous bloom mass. The addition of *nngurlele* constitutes metonymic proof of the intentional and no doubt regular production of cast iron droplets by Mafa smelters, and indeed this now appears to have been a quite common feature of iron making within and far beyond the Mandara Mountains (Killick, pers. comm. 1990; Schmidt–Childs 1995).

THE ANTHROPOLOGY OF TECHNIQUES

The anthropology of techniques, as the French term *technologie culturelle* is glossed by P. Lemonnier (1986, 1992), the spokesman most easily accessible to anglophone audiences, is concerned both with actual objects, artefacts, and technical processes, and with the mental objects (social representations) that refer to them.[6] While the underlying theory generally tends, not surprisingly, towards structuralism, this is not inevitable and there is room for alternative modelling. A theoretical premise is that there is a sense in which any one culture's techniques form a system (1986: 154) with some degree of coherence in that they are underlain by a relatively coherent body of knowledge (e.g., genetics and chemistry are related disciplines that are underpinned by atomic physics), and are apprehended according to one or a limited number of paradigms (e.g. scientific versus creationist explanations of the world). Technical 'signs' may thus be said to participate in a signifying system that produces meaning,[7] although 'we remain a thousand leagues from a theory of material culture as an ensemble of signifying traits' (pp. 172–3). The best that can be done at present is to bring to light some of the underlying relationships between actual objects and the social

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[5] Randi Barndon has very kindly made available to me a copy of the thesis she wrote for her Ph.D. candidature (Barndon, Randi. 1992. "Traditional ironworking among the Fipa: an ethnoarchaeological study from southwestern Tanzania." Cand. Phil. Thesis, University of Bergen). Her chapter on field methods is both thoughtful about the relationship between observer and observed and clear about her activities in the field. However, as her materials are still being worked up, I have preferred not to anticipate her own full publication of her research, which is very definitely worth waiting for. I hope in the meantime that editors of ethnoarchaeological articles and chapters will begin to insist that authors incorporate a basic statement setting out the circumstances and methodology of field research.

[6] As Barndon argues, Lechtman's concept of technological style also interrelates the technical and the symbolic aspects of technologies, and, as she recognizes, Lechtman's ideas and those of the Francophone school of *technologie culturelle* have much in common. However the latter is rather more developed in theory and ethnoarchaeological practice (but see Childs 1991).

[7] At least this is part of what we think Lemonnier (1986: 172-3), elsewhere critical of others' formulations, intends to mean in a very difficult passage invoking Lévi-Strauss, myth and bricolage.

p 58: representations that refer to them. Lemonnier provides an example. The Anga of Papua New Guinea wear skirts or capes of beaten bark, the women's normally made of a particular wild fig species, while men's are of cultivars. However, when the wild species is the only fig tree available, it is '"defeminized": the women no longer have access to it for making their skirts and the men use it only when cultivated.' (p. 178). Thus bark and its cultivated or wild origin is used to express differences between men and women—and in lowland tribes where the hierarchy of the sexes is less marked there is also less distinction in dress materials. Surely in metallurgy comparable social representations must similarly influence technical processes, and vice versa.

This brings us to the methodology of the anthropology of techniques, and to the analytical tool, the *chaîne opératoire* or operating sequence, that lies at its heart, and which has most to offer the ethnoarchaeological study of metallurgy. According to this school of thought, technical processes involve a series of decisions that are 'embedded in, and conditioned by, social relations and cultural practice' (Dietler–Herbich 1998: 235). Techniques constitute 'the mediating process between things and society, and the key to understanding their reciprocal relationship' (p. 236). O. Gosselain's (1992) study of ceramic technology among the Bafia of Cameroon, and Dietler and Herbich's (1989) paper on Luo ceramic technology and style exemplify ethnoarchaeological uses of the *chaîne opératoire* approach. In order fully to comprehend a technical process one must distinguish between those technical choices that are cultural or 'discretionary' and those that are otherwise determined. Thus Gosselain (1992, 1994a and b, 1995) incorporates scientific analyses into his pottery study that assist in determining the extent to which material and environmental factors determine the potter's behaviour, and which decisions express 'free' cultural choice. Ethnoarchaeologists have an extraordinary advantage over archaeologists in that they can watch the unfolding of *chaînes opératoires*, demarcate what is determined by raw materials and physico-chemical constraints versus the areas of potential cultural choice, and document the interrelationships of the technical, social, and symbolic domains, for to observe the forming of a pot or the smelting of iron, even the flaking of an adze, is to be offered simultaneous access to all three, though to greatly varying degrees.

APPROXIMATING OPERATING SEQUENCES

A *chaîne opératoire* is a complex and sensitive record of patterned human behaviour, but if this methodology is to be applied to a process as complex as smelting we should not underestimate the commitment required on the parts of the researchers and the researched. T. Childs' (1991) paper on furnaces in Bantu-speaking Africa, couched in the terminology of technological style, brings out very clearly the number of influences, and therefore the number of choices, involved even in the building of a furnace (**table 2**). An operating sequence of a complete smelt will certainly require a monograph rather than an article. We should not therefore be surprised that no one has described such a sequence in full.

RECONSTITUTING GBAYA SMELTING IN THE C.A.R.

Y. Moniño's (1983) description of *reconstitutions* by Gbaya (Gbaya-'bodoe) of two smelts in 1977, 34 years after abandonment of the industry, is written from a theoretical perspective aware of and akin to that of the anthropology of techniques, although Moniño, an ethnological linguist who had previously studied world view and initiation among the Gbaya, does not actually describe *chaînes opératoires*. His account is similar to Echard's in its combination of extensive and intensive approaches, in its cultural and historical contextualization of smelting, and in its concern to interrelate sociological and cognitive aspects. There is a thoughtful discussion of formal and productivity variation in Gbaya furnaces. These comprise several

styles of both forced and, significantly in areas of lower population density, induced draft furnaces.

p. 59:

Choice	Influences	Referent
Furnace location	Access to resources	None
	Environmental factors (e.g. wind, shade)	None
	Political constraints and group dynamics	Villagers
	Ideology	Villagers
	Access to spirits	Villagers, spirits
Resource selection	Accessibility	None
	Technical qualities	None
	Labor	None
	Transport	None
	Symbolic references	Villagers, spirits
Pit diameter	Iron yield	None
	Labor	None
Medicine orifices	Ritual	Spirits
Furnace walls	Technical needs	None
	Iron yield	None
	Labor	None
	Space for symbolic expression	None
Wall height	Method of air draft	None
	Raw materials	None
	Labor	None
	Ideology	Villagers, spirits
Wall shape	Technical aspects	None
	Labor	None
	Group identity	Ethnic group
	Ideology	Villagers, spirits
Wall holes (chimney, shaft, tuyère, peep, etc.)	Technical aspects	None
	Ideology	Villagers, spirits
Furnace decoration	Group identity	Ethnic group
	Ideology	Villagers, spirits

Table 2. Influences affecting furnace building (extracted with modifications from Childs 1991: table 1).

Like Echard again, Moniño's account conflates the two smelts observed. With the validity of the reconstitution very much in mind, he provides a comprehensive account of his research methodology and of the conditions of observation. The social relationships, including his own apprenticeship, and the transactions involved in the smelt and in smelting in general are explained in detail. This is followed by a brief but informative description of the building of the smelting house and of the furnace within it, of the various plant medicines utilized, and of the progress of the smelt, which (presumably in one instance?) produced 5.5 kg of spongy bloom from 30 kg of roasted limonite ore.[8]

While materials scientists will no doubt be disappointed with the overall lack of technical information, they will be interested in the Gbaya-Kara device of placing a piece of glowing charcoal at a small vent high in the shaft that, when it reacts with the gases to produce a blue

[8] The preparation of ore and charcoal are discussed earlier in the paper.

flame, calls for a strong draft from the bellows (p. 289). Moniño's linguistic and ethnological knowledge and interests allow him to sketch a richer and more nuanced description of the cognitive-symbolic aspects of the technology than any of the papers discussed above. The

p. 60: Gbaya are indeed of particular interest among African iron smelters in that (a) their traditional lineage-based social structure is less complex than those of other smelting groups studied in recent years, and (b) their smelters were not in any way set apart from the rest of society. While smelting knowledge could be bought and sold, Moniño shows it to be symbolically complex. Thus, for example, there are not one but two overarching metaphors, of childbirth and of hunting, and female initiation is also implicated. Rather than being husbands of the furnace, the smelters are assimilated to it; they are mothers (and not apparently midwives) who give birth to iron. The disruption of the natural order that this involves demands that the smelters ritually deny their act of creation, *Fer, je ne t'ai pas inventé* (p. 306). Furnaces, sometimes equipped with ears 'to hear well what one tells them to do,' are among the Gbaya-'Biyanda made in male and female pairs with oval and diamond-shaped shaft cross-sections respectively. Among the Gbaya-'bodoe the set of three bellows is regarded as male, but they are referred to individually as the young mother, the mother, and her male child. The single short tuyère into which they direct the air flow is conceptualized not as a penetrating penis but as the furnace's vulva. Iron itself has a harmful and dangerous property liable to call down a spell upon those who work with it, and against which they protect themselves by a magical pharmacy of plants. In short, if Moniño's research, considered as an example of the anthropology of techniques, achieves limited success in establishing informative linkages between objects and social representations, it serves as an eloquent warning to those who would oversimplify and overinterpret the latter.

HAYA REINVENTION AND BARONGO RE-ENACTMENTS OF SMELTING IN TANZANIA

There is one example of a study that, although it does not use the terminology of the anthropology of techniques, is close to it in spirit, even to its structuralist approach to social representations. I am referring of course to the long-term archaeological and ethnoarchaeological research of P. R. Schmidt and his colleagues, notably S. T. Childs and D. H. Avery, among the Haya of north-eastern Tanzania, the fullest account of which is given in Schmidt's recent monograph *Iron technology in East Africa: symbolism, science and archaeology* (1997*).* This is complemented by and contrasts with the same trio's work among Barongo (Schmidt 1996), a category of ironworkers of multi-ethnic origins, who live further south in Tanzania, and among whom nine smelts were conducted.

Schmidt's declared and ambitious purpose is 'to recuperate the history of African iron technology,' an aim that requires discovery of 'the cultural beliefs or ideologies that interpenetrate the operation and control of the productive economy during the last two thousand to twenty-five hundred years on the western shores of Lake Victoria, a region today known as Buhaya' (p. 1). He recognizes the need to develop an interpretative methodology that draws on oral traditions, ritual, myth, and other sources of cultural information, but which is combined with a materialist approach such that 'the end product is a marriage of interpretation and science …' demonstrating 'that science has a central role to play in the development of a more humanistic archaeology …' (p. 9). He is conscious that 'his project arises out of a Western belief that a scientific approach is an appropriate tool ….' and cautions, 'Such a methodology demands a critical posture that continually examines the assumptions of Western scientific practice as the project unfolds' (p. 10). We should also note that he is passionately eager to challenge the 'myth of inferiority,' Africa's reputation as a technologically

impoverished continent. All in all, the approach is compatible with that of the anthropology of techniques.[9]

p. 61: Schmidt has great credibility in Haya studies, and his multidisciplinary work there, going back to 1966, combines studies of oral tradition, politico-religious history, major programs of archaeology, historical ecology, and ethnoarchaeology. The results are published in three monographs (Schmidt 1978, 1981, 1997) and numerous papers and chapters by himself and his collaborators. The ethnoarchaeological research of concern here was carried out between 1976 and 1984 and involves no less than nine smelts, not including two experimental ones carried out at Brown University in 1975 that were unsuccessful in producing a bloom but which provided valuable insights into the process (Childs–Schmidt 1985). Schmidt, who conducted numerous interviews and collected life histories, provides a full and frank account of his relations with the smelters and of their often fractious relationships with each other. They communicated mainly in Swahili, the Tanzanian *lingua franca*, and although Schmidt understands much of the related Haya language he relies on M. M. Mulokozi, a Haya scholar, to assist in the interpretation of esoteric and symbolic materials such as are incorporated into the songs sung during the smelts.

A gap of just over a quarter of a century had intervened between the forced cessation of regular smelting by the Barongo and 1979 when Schmidt initiated a series of smelts that can reasonably be described as re-enactments. The Haya on the other hand had not smelted for half a century, and Schmidt rightly emphasizes the experimental nature of the process — characterized as bricolage—as the Haya (re)invented a smelting tradition in both its technical and ritual aspects. Aware that the presence of observers influences the behaviour of the observed, particularly when the former employ the latter, he and Avery restrain themselves, at times with difficulty and at the cost of tiffs (p. 87), from the temptation, almost but not quite always resisted (p. 96), to direct. This is sophisticated work, giving a rich account of technical, social, and ideological process, particularly of the first, unsuccessful, smelt. The Haya smelters' failures in furnace construction and the unfortunate effects of damp charcoal—examples could be multiplied—not only help to define the limits of cultural choice but also stimulate ritual activity that is reported in detail. The disputes reported between the Haya master smelter, the smiths, and other Haya authorities are also informative, and the insightful description of social and ritual matters is integrated with that of the technical process. The team's account of the latter includes detailed quantitative and qualitative data, for example on temperatures measured by thermocouples and optical pyrometers, characterization of the ores, and discussion of the implications of valveless bellows, different charcoals, and more or less refractory clays for the tuyères.[10] The reader is carried along with the narrative and cheers when the last of six smelts conducted in 1976 produces over 4 kg of bloom, a success to be bettered in 1979.

Schmidt proceeds to develop a model of the Haya bloomery process based upon his colleagues' analyses of ores, charcoals, tuyères, temperature readings, slags, and blooms, and attempts a structuralist interpretation of the symbolism. The Haya certainly win the prize for

[9] Schmidt's one reference to Lemonnier occurs in a note (1997:297, note 8) that suggests he has misunderstood the *chaîne opératoire* concept.

[10] More detailed information on some of these matters is sometimes available in others of Schmidt and his colleagues' publications.

sexual content, overt and covert, in smelting, and the dominant metaphor evident in songs and other acts is of the impregnation of the furnace which is assimilated to a fecund womb.[11]

Schmidt's 1996 account of his team's work among the Barongo is comparable but condensed. He notes important differences between Haya and Barongo smelting and its social representations, with an overarching metaphor among the Barongo that links the themes of

p. 62: reproduction and transformation to young women's puberty rites. During the course of the nine smelts the ironworkers never achieve their former levels of production.

> But their bricolage shows a remarkable conjunction of ritual and technological fabrication that is richly interwoven and that leads to empirical solutions, illustrating that any attempt to analytically separate the two domains is meaningless and misses the point: experimentation is both ideological and procedural (p. 119).

While the last phrase is entirely justified, it does not necessarily follow that analytical separation of the two domains is meaningless. Can we, in the Schmidt team's long-term, multi-ethnic, well-documented, and ambitious work, find evidence that Haya and Barongo objects and social representations are influencing and causing modifications in each other in the manner that Anga representations of gender cause wild fig-trees to be cultivated in certain parts of their territories?

LINKING OBJECTS AND SOCIAL REPRESENTATIONS

The fact that technical and ritual processes are, in Schmidt's words, 'richly interwoven' is not in dispute; the vital question for materials scientists and anthropologists alike is whether they inform upon each other or whether they are at bottom separate enterprises that can be analyzed independently without significant disadvantage or loss. Of course there are relevant linkages. One such is the effective proscription in most, though not all, cases of women's labour. Another, inadequately studied, is the influence of beliefs on the spatial attributes of smelting, both as regards the location of furnaces and the layout of furnace sites. Barndon (1996b: 768) finds that smelting sites 'in Ufipa were spatially structured in accordance with practical and symbolic dimensions in iron smelting. This 'expressive space … structures not only thought but also action.' The same is true of Hausa, Gbaya, and Pangwa sites. In contrast, 'The spatial organization of the Haya work space … varied from smelt to smelt. … There is no discernible belief or preference that determines where particular activities will be performed' (Schmidt 1997: 192), but one wonders whether, since it had been so long since the Haya had last smelted, and since 'Division of labor and hierarchy based on craft skill and authority are clearly read on a Haya smelting site as the activities occur' (p. 193), patterned structuring of space might not have (re?)emerged had smelting again become routinized. A third linkage, emphasized by Schmidt and of considerable import both to scientists and anthropogists, concerns site-formation processes and in particular the treatment of the by-products of iron manufacture. Slag is frequently recycled, whether, as in the Haya and Barongo cases, for furnace construction, or for 'use as building material, use as tempering material in pottery, and use as fertility charms and fertility medicine …' (p. 194). Indeed one may wonder whether the use of crushed slag in pottery and especially in forge tuyères is not itself a practice influenced at least as much by beliefs in the powers of slag as by any possible utilitarian superiority of

[11] A scene in the film *Tree of Iron* (directed by O'Neill and Muhly 1988) that shows Schmidt peering up a furnace vent through an optical pyrometer led me to turn to my neighbour and whisper that Schmidt and Childs were in truth the Masters and Johnson of metallurgy.

slag over grog temper. A fourth kind of linkage involves practice modelled on metaphor. It seems almost certain in the Hausa case that not only does the master smelter conceive of the reduction process in terms of gestation, but that certain of his actions with practical effects on the course of the smelt are predicated upon these beliefs.

In the examples just cited, social representations influence objects and processes. In contrast, Schmidt's discussion of the Barongo case would seem to indicate that their conception of menses not as waste but as intimately involved in the production of children may well be correlated with a smelting process that involves the production of iron-rich slag that is then resmelted to produce sponge-iron blooms. Here it would seem most likely that metallurgical practice has led to a reassessment of human physiology, and not vice versa. Unfortunately the argument seems largely founded on analogy with practices and beliefs of

p. 63: the Nyakyusa, who live some 650 km to the south, and M. Wilson (e.g. 1959: 153, cited by Collett 1993: 504) is not to be relied on in metallurgical matters.

Another area of linkage that has been far too little studied is that of the animal, vegetable, and mineral medicines used in smelting. Van der Merwe and Avery (1987) astutely recognized several groups of medicines used in the more traditional Phoka smelt. These included medicines (a) against witchcraft, epidemics, and venereal diseases (likely caused by the attacks of jealous humans and of spirits, ancestor and others), (b) that promote fertility and plenty, and (c) a group that 'symbolizes the desired qualities of strength, toughness, hardness, wiliness and speed—qualities one wishes to impart to the smelting and its product' (p. 160). Further information was obtained by Killick (1990) although he did not delve deep into the ethnobotany. Working through a trained interpreter with Dokwaza, I found a similar range of medicines, and in 1989 was in many cases able to elicit their specific intended functions (see Appendix **2**). The first group is protective, and although the relation between signifier and signified is generally obscure, the range of dangers feared—sorcery/witchcraft and the consequences of inappropriate sexual relations—is revealing. The last medicine in the group might, rather than being protective in function, better be regarded as a purgative, cleansing the personified furnace. The second group of only two plants calls both metonymically and metaphorically for an abundant outcome of the smelt. The functions of most, if not all, of the medicines in the next two groups are to teach the furnace by metonymic example how to digest its food—ore and charcoal—and to transform them into slag, most of which is removed through the furnace vent, and iron of varying characteristics. When asked to explain the utility of the plants in the third group, Dokwaza replied 'If you eat, don't you shit?' These roots look like desiccated turds; slag is called *ziy zuyda*, 'shit of iron.' The furnace is being offered an example, a model of behaviour indicative of an equivalence being drawn between bodily and technological processes. We have earlier mentioned *madzaf nngúrlélé* as proof that the Mafa desired metal with the high carbon content of cast iron, and the second and probably the third medicines in this group also provide the furnace with metonymic specifications of the desired products; the fourth is problematical, while the fifth seems intended to encourage the hissing (frying) noises and white sparks that, emanating from the vent at the base of the furnace, are believed to indicate that iron is forming. There is, it may be noted, some similarity between the widespread African theory of contagious magic (or metonymic transfer between orders of reality) and the Western theory of the role of catalysts in reactions; in both the introduction of an extraneous material provokes and speeds a transformative process.[12] Beeswax performs a comparable role in the last set of medicines.

[12] However it would seem that the non-Western theory implies a potential for learning and intelligent response in the system. This reminds me that some Western scientists have noted that, after a chemical

However imperfect and limited, these data are of significance for scientists, in that they provide evidence of smelters' intentions, and clues as to iron masters' understanding and control of technical processes that are often difficult to elicit in societies in which questioning of seniors by juniors is deprecated—especially when the master is engaged in seeing through a complex process—and where teaching is rather by practical example than verbal exposition (cf. McNaughton 1988; Keller–Keller 1996).[13] Despite this, and despite the perhaps consequent unwillingness of key informants to be reinterviewed (e.g. Schmidt 1997: 107), I am certain that neither I, nor any of my ethnoarchaeological colleagues (other than Killick)

p. 64: have spent nearly enough time pursuing with the most expert artisans the bases of their various expertises. We could have learned a lot more from Dokwaza than we did. Take his ideas about sparks.

> When you strike quartz with metal it gives off white sparks; in this and in its hardness it is like iron, which in the furnace and forge also gives off white sparks. So that when white sparks are driven out of the furnace vent you can tell that iron is forming. [Metonymy.] White sparks should be avoided in the forging of iron—except during welding when extra heat is needed to achieve the weld—as they diminish the quantity. [Practical knowledge; white sparks are indeed produced by iron oxidizing at high temperatures.] Scrap metal from vehicles diminishes rapidly in the forging, while smelted iron even increases in quantity as you forge it. [Romanticizing the past or humbugging the inquirer?][14]

There are excuses—pressure of time and money and a general bias among ethnoarchaeologists and funding agencies in favour of science—for us not having sufficiently plumbed the knowledge of master craftsmen and craftswomen, but these are not sufficient reasons. Echard and Moniño, despite being confined to article-length descriptions, amply demonstrate how much there is to be learned through analysis of oral texts and other acts about bloomers' understanding and control of the reduction process.

A legitimate criticism of some anglophone researchers is that they have tended to rush in (where many anthropologists fear to tread) to interpretation of the symbolic 'armatures' of smelting, and have engaged in their own academic bricolage in the process of botching together symbolic schemes, 'validated' by their plausibility to Western colleagues. I am not denying that there is likely a substantial measure of truth in these constructions—Herbert (1993) did not labour in vain to produce her *magnum opus*—but the complexity of symbolic relationships and the interpenetration of metaphorical assimilations, for example of reduction to gestation, warfare, cooking, and hunting (whether simultaneously or variably at different stages) can be very great. Moreover, even when conceptions of, say, the relationship between woman and furnace are identical, the behavioural consequences may be very different—as is evident in the following diagram, taken from S. Bekaert's (1998) posthumously published study of multiple levels of meaning in the iron technology of Bantu Africa. Bekaert had carried out field research on Sakata (D. R. Congo) smithing.

Woman and Furnace	Must go together	Do not go together

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compound has with great difficulty been manufactured somewhere in the world for the first time, subsequent syntheses become quite easy. They suggest that once the model exists, the World learns.

[13] Videography, combined with replay in the field to artisans of their performances, is a precious tool for studying crafts. Unfortunately, I had hardly begun working with Dokwaza when my TV failed; no other sets in Mokolo were compatible.

[14] A compilation of several of Dokwaza's statements to N.D. in 1989

Are the same	possible option	Sakata option
Are opposites	possible option	possible option

I shall follow Herbert's lead in making four methodological points:

1. that, in order to instantiate models of a symbolic realm, in-depth study of its manifestation among a particular group or people is required; this involves the search for parallels in other practices in order to elucidate underlying theories, metaphors, and analogies;
2. the practice of patching interpretative holes with questionably relevant material from other peoples, even neighbours, must be abandoned unless candidate analogies have been subjected to 'source- and subject-side strategies for establishing relevance' by 'expanding the bases of interpretation and elaborating the fit between source and subject' (Wylie 1985: 100–1);

p. 65:

3. apparent conflicts and inconsistencies in data should be followed up, preferably in the field; for example it would appear dangerous to transfer the concepts of the jealous wife and of the dangers of adultery from the social to the smelting arena in order to explain sexual taboos without also considering how, in societies that abhor the idea of polyandry, the furnace can be the bride of several husbands; and
4. researchers should seek validation of their work in a number of ways, by showing that their interpretations in one area are consistent with and can explain behaviour in others, for example cooking or hunting, by citing informants' statements that, directly or indirectly, corroborate their interpretations, and by submitting them to the criticism of intellectuals of the groups studied.

I shall briefly illustrate the benefits of in-depth study by reference to a recent Calgary MA thesis on the Bulsa of Northern Ghana by R. A. (Caesar) Apentiik (1997), himself a Bulsa, who consciously maintains a dual viewpoint, that of the native and of the Western-trained ethnographer, in order to document the embedding of ceramic and ironworking technologies in the matrix of Bulsa cosmology and ideology. His research is of particular interest here because it leads to a coherent explanation of the sexual taboos associated with metallurgy that have so fascinated ethnoarchaeologists. Three principles of Bulsa thought can be inferred to underpin social representations in the social and technological domains.

1. Things and behaviours that are out of place are fraught with danger.

Dirt, *dangta* in Buli, is matter out of place and 'offends against order' (Douglas 1966: 2). What we define as pollution the Bulsa also call *dangta*, an offensive quality of behaviour out of place that is sanctioned because 'the ideal order of society is guarded by dangers that threaten transgressors' (p. 3). To the Bulsa adultery is sex out of place, while menstrual blood or that from a wound is blood out of place and therefore dirty/polluting. *Dangta* angers gods, bringing misfortune, sickness, and other evils.

2. Symbolic and magical action have (via metonymy) practical effects.

A sorcerer sticks a needle into food and calls the name of his victim; the victim eats food and dies. Rituals and taboos of potting and ironworking are believed in this way to be instrumental in producing a good result.

3. Metaphorically similar things act on each other metonymically.

There is a pervasive thermodynamic metaphor regarding heat and cold. The ideal for people is to be neither hot not cold—a concept for which there is no lexeme. Polluting behaviour causes people to become hot. Certain activities (warfare, hunting, giving birth, and ironworking) are also considered as hot, inherently dangerous, associated with blood and pain—though not necessarily bad—and they transmit these qualities to those who participate in them. Persons involved in them require special protection, as do people of certain ages or in certain states, for example fertile women who, being at risk, should avoid hot things. Thus when a woman is giving birth (seen as engaging in a good form of warfare, defending life), other potential mothers should not be present. Nor should women see animals giving birth.[15]

This is the primary reason—and not adultery, even though the furnace has female attributes—why fertile women should not be present during smelting. And since 'hot' and 'cold' things have additive and subtractive metonymic effects, two things classed as hot should not be brought into contact as too much heat will be generated. In the heat of the forge,

p. 66: the smith should not pronounce hot words (e.g., discuss sex or become angry). The union of smiths, hot during smelting, and women puts both at risk, and the smith's enterprise also, especially if the woman is cold from menstruation.[16] Similarly, amongst the Dogon balm 'cools' wounds, and should therefore not be brought near the furnace (Huysecom–Agustoni 1997).

This is not the place to pursue further an example that, itself incomplete, here dangerously simplified, and validated only for the Bulsa, is (for once!) intended as a cautionary tale.

CONCLUSIONS AND PROSPECTS

Ethnoarchaeologists and their metallurgical colleagues have, over the past three decades, made enormous progress in analyzing both the technical and the cognitive aspects of smelting in Africa. There can be no doubt that any well-conducted study of either aspect produces valuable information, even though our ability to evaluate it is too often impaired by lack of information on the conduct of research, as can be quickly established by checking any ethnoarchaeological source against the criteria set out in Appendix 1. In addition, poor validation procedures have led to inadequate instantiation of inferences regarding the cognitive and symbolic realms.

The theoretical approach associated with the primarily francophone school of the anthropology of techniques that is concerned both with techniques as techniques and with their social representations is ideally suited to the study of African metallurgy. Its prime methodological tool, analysis of the operating sequence, can also serve to orient research, even though it is almost certainly beyond any team of researchers to develop, in the sense of determining the reasons for each technical choice, a complete *chaîne opératoire* for any single smelting sequence. The research of Schmidt, Childs, and Avery, as reported in Schmidt's 1997 monograph, comes closest and represents the fullest and best synthesis of any African metallurgical industry to date. It is also exemplary in its insistence upon and demonstration of the value, indeed necessity, of repeated experimentation. However, even this research remains open to criticism, as I have indicated above with regard to symbolism, and as can be seen from the continuing controversy regarding preheating. I am not qualified to pronounce on the latter

[15] I suspect that chickens laying eggs are regarded as cool, and therefore no danger to women, because the process is so easy. Among the Bulsa as elsewhere, the egg is a powerful symbol.

[16] It should be emphasized that the Bulsa and British concepts of metaphorical heat and cold are not identical; cold-moist, which has many metaphorical connotations, is differentiated from chilled, the latter a primarily physical state. A menstruating woman is cold-moist. While putting two hot things together increases heat, and putting a cold-moist thing with a hot thing cools the hot thing, putting two cold-moist things together has no additive effect.

but would raise the question of whether Schmidt's laudable desire, mentioned above, to challenge the Western stereotype of African technical inferiority has not in fact resulted in his making 'new factual claims about [ethno]archaeological [data that] are isomorphic not with the political vision of their authors but with the hegemonic constructs to which they are opposed' (Fotiadis 1994: 548). In other words his concept of technical sophistication may be, despite a critical and self-reflexive stance only too often lacking in ethnoarchaeological research, at bottom an inappropriately Western one, whereas others would argue that the greatest achievements of African metallurgists were to manufacture iron out of ores that Europeans, Chinese, and others regarded as unworkable (Gordon–Killick 1993), and through alternative social arrangements to render unnecessary the emergence of an alienated proletariat (David 1996). We should indeed practice reflexivity.

The symbolic, ritual, and magical aspects of smelting have several functions: creating and relieving the stress of a demanding enterprise, serving to channel and control knowledge, and legitimation of iron masters' status. They also assist in conceptualizing and in managing a complex and highly variable process of reduction that takes place out of sight in furnaces that

p. 67: Killick rightly characterizes as 'black boxes.' I have argued that even in the best ethnoarchaeological work there has been insufficient investigation of the ways in which the technical and the cognitive aspects of metallurgy inform upon each other. The medicines employed in smelting mediate between the technical and cognitive realms and offer a point of entry into the study of linkages between them that has great, but as yet largely unexploited, potential. As van der Merwe and Avery (1987) observed, the ethnobotany of metallurgy is a study in itself, and similarly a comparison of Apentiik's work in the cognitive-symbolic area with that of Western others raises the question of the level of linguistic and cultural competence required for exegesis of African ritual process. We have, I suggest, reached the point where the complexity of the subject-matter exceeds the capabilities of any two scholars to unravel it, and yet the addition of members to research teams will of itself progressively modify the behaviour of the observed.

There are perhaps some partial solutions to this dilemma. The advantages of long-term fieldwork and exposure to the culture(s) studied is very evident in the work of Echard, Moniño, and Schmidt. Longer-term fieldwork also allows for the repeated experiments and observations that the last-named scholar has proved so critical to a well-rounded understanding of technology in the making. But it is not necessary that team members should all be in the field at the same time. For example, an ethnobotanist interested in symbolism could no doubt return to the Nyika massif and study the pharmaceutical properties and social representations of the medicines whose use in the Phoka smelt was so carefully documented by van der Merwe. Second, both for purposes of discovery and validation, there must be much more participation in ethnoarchaeology of native scholars who, like Apentiik, are trained in anthropology, or who, like C. Kusimba (e.g. 1996) are qualified archaeometallurgists. They, at least among their own people, cannot be lost in a third hermeneutic.

The time fast approaches when the study of first-hand, let alone expert, experience of smelting and of the additive process of forging bloomery iron will no longer be possible anywhere in Africa. The Haya smelters, Dokwaza, and almost all the others whose work is discussed in this paper have achieved the status of ancestors. Can anyone now complete the study of Dime metallurgy? [This question was posed rhetorically in 1999. Haaland *et al* [2000] give us hope that the answer to the question may yet be yes.]

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APPENDIX 1.

Information required for assessment of field methodology and methods.

1. Research context
Location
Cultural and historical context of group or groups studied
Duration
Investigator's knowledge, including linguistic competence, of the group and its language
Political context of research, including situation of the researcher, and funding

2. Anthropological methods and techniques
- Sampling of group:
  - settlements/households/individuals
  - classes/ranks/statuses/roles/genders
- Research methods
  - participatory observation
  - interviews
  - questionnaires
  - other, including reenactments and experiments
- Assistants (paid)
  - qualifications and situation vis-à-vis informants
- Informants
  - categories and how recompensed
- Recording techniques
  - visual and sound recording
  - written materials

3. Scientific methods and techniques

APPENDIX 2

Medicines (*mádzáf*) used by Dokwaza, a Mafa iron master, during smelts in 1986 and 1989. Mafa terms in bold italics have been checked against Barreteau and Le Bléis's (1990) *Lexique Mafa*; this however reports the central Mafa dialect while Dokwaza spoke the western dialect.

Group 1. Medicines that provide protection

mádzáf zay:	'Medicine (as common as) shit', *Cissus quadrangularis* (Vitaceae), a succulent creeper that, placed on the furnace and tuyère, provides them with general protection from evil. The logic would appear to be that this plant is so common that it and anything associated with it is unlikely to attract notice, an apotropaic principle similar to common practice of naming children by unprepossessing names like Dungheap.
m. dáy:	A larger species that fends off attacks by sorcerers.
mandasl:	Largest of the *Cissus* spp. and used for the charm placed beneath the base of the furnace, together with *m. sak*. *Mandasl* was also crushed on the bloom mass before this was broken up.
m. sák:	'Medicine + leg' an onion-like bulb—the leaf of this plant is also used medicinally—that protects against impurity (e.g. participants in the smelt having engaged in sex the night before). A piece of the bulb was stuck into the *mandasl* placed beneath the furnace shaft, and Dokwaza chewed a piece of the bulb for self-protection.
m. mehoyeged:	Root (tubercule/tuber?) of a broad-leafed plant.
m. mágásár:	'Medicine + the "thief" of a married woman', onion-like plant that is crushed and included in the daub used for the final plastering of the furnace shaft, it protects against danger to the social fabric, and thus the smelting enterprise, caused by

p. 69: adultery (*magasar* = two men having sex with one woman or 'les rivaux' as my assistant E. I. Kawalde describes it).

zag duwak: In 1989 Dokwaza told me that the series of crosses marked on the tuyère during the 1986 smelt were not made with *madzaf mbeza*, grease medicine (see below), but with a mixture of *m. mágásár, m. dáy, m. sák* and *zag duwak*, and were intended to guard against impurity or sorcery that might cause tuyère breakage. *Zag duwak* may not itself be a medicine but rather be added for its mucilaginous properties.

mesleki'd watsak: '? + chicken', a yam-like tuber, from a fruiting bush with widely spreading roots that produce these tubers at intervals, that was crushed and placed in final shaft plaster. It was said to clean the furnace of bad or dirty things, 'saletés', its effect being 'like windshield wipers'. Rather than protection this medicine might better be regarded as a purgative, cleansing the personified furnace.

Group 2. Medicines that promote productivity

m. mbeza: 'Grease medicine', the rhizome(?) of a peony-like plant crushed into the final shaft plaster. *Mbeza* means animal fat, symbolizing plenty.

mérézl: *Ponogarthria squarroza* (Poaceae), a grass producing very many tiny seeds, seed heads of which were stuck into the bust on top of Dokwaza's furnace shield in 1986, as they are into other furnaces and into the spikes on threshing floors.

These two plants represent abundance of meat and grain, the two most desirable foodstuffs, and thus in the outcome of the smelt.

Group 3. Medicines that promote slag formation, 'pour amener les scories'.

mbokum duwak: '? + monkey', fibrous orange roots, eaten by children in the bush.

tsapok or *tsapaw*: Fibrous tuber of a plant with long narrow leaves.

nsletitdayo: Long tubers produced by a bush.

All these (and at least one other plant mentioned above, *zag duwak*) were dried, crushed, and mixed into the final shaft plaster.

Group 4. Medicines promoting iron formation, 'pour amener le fer'.

m. nngúrlélé: Cast iron medicine, small plant with a white flower, lanceolate leaves and fleshy roots that form a series of adjoining nodules (?tubercules) added down tuyère (perhaps together with others of this group, also with ore through the charge hole) to promote the formation of cast iron—and thus proof of regular and intentional production of cast iron droplets and small nodules by Mafa smelters.

menjigedef: Similar to the former in nodules (?tubercules) and leaves, and in function.

kú'déc zhoengwaya: 'Testicles of panther/leopard', a flattish, iris-like tuber or rhizome from a plant with long lanceolate leaves about two fingers wide. Added in the same way to promote iron production.

m. hútsá'd: 'Medicine + brine', the latter produced by pouring water through ashes of cattle/sheep/goat dung, a swollen watery tuber or rhizome, white inside, used in the same way as the previous one. *Hútsá'd* also means leprosy, but I doubt that is signified here.

wasawa: Flowers and roots of a grass or sedge that when added down the tuyère makes a hissing sound, 'sh-sh-sh', and white sparks.

Group 5. Other medicines

nghwogwogumay: A manioc-like tuber, dark exterior and pink exterior, that, when added down the tuyère, lightens the work. (*Lexique* has *nghwonokw*, a plant of the Loranthaceae.)

m. mazlaray: 'Medicine + tape worm', a compound of crushed rotten granite, *Cissus* sp. and *Euphorbia* sp. sap that is thrown into the forge fire to prevent accidents, for example the burning of self or others.

tókw vongwam: 'Glue + honey', beeswax, added to crucibles in forge in order to assist the iron fragments to weld together.

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BIBLIOGRAPHY

Apentiik, R. A. 1997. *Bulsa technologies and systems of thought* (M.A. thesis, University of Calgary).

Avery, D. H. *et al.* 1988. 'The metallurgy of the iron bloomery in Africa', in: R. Maddin (ed.), *The beginning of the use of metals and alloys* , 261–82.

Barreteau, D.–Le Bléis, Y. 1990. *Lexique Mafa: langue de la famille tchadique parlée au Cameroun*.

Barndon, R. 1992. *Traditional ironworking among the Fipa: an ethnoarchaeological study from southwestern Tanzania* (Cand. Phil. thesis, University of Bergen).

Barndon, R. 1996a. 'Fipa ironworking and its technological style', in: P. R. Schmidt (ed.), *The culture and technology of African iron production*, 58–73.

Barndon, R. 1996b. Mental and material aspects of iron working: a cultural comparative perspective', in: G. Pwiti–R. Soper (eds.), *Aspects of African archaeology. Papers from the 10th Congress of the PanAfrican Association for Prehistory and Related Studies*, 761–71.

Barndon, R. 2001. *Masters of metallurgy - masters of metaphor: iron working among the Fipa and the Pangwa of SW-Tanzania*. Bergen: Department of Archaeology, University of Bergen.

Bekaert, S. 1998. 'Multiple levels of meaning and the tension of consciousness: how to interpret iron technology in Bantu Africa', *Archaeological Dialogues* 5 (1) 6–29.

Bellamy, C. B. 1904. 'A West African smelting house' (with an appendix 'Analyses of specimens' by F. W. Harbord), *Journal of the Iron and Steel Institute* 64–65, 99–126.

Bronowski, J. 1973. *Ascent of man*.

Childs, S. T. 1991. 'Style, technology, and iron smelting furnaces in Bantu-speaking Africa', *Journal of Anthropological Archaeology* 10, 332–59.

Childs, S. T.–Schmidt, P. R. 1985. 'Experimental iron smelting: the genesis of a hypothesis with implications for African prehistory and history', in: R. Haaland–P. L. Shinnie (eds.), *African iron working: ancient and traditional*, 121–41.

Collett, D. P. 1993. 'Metaphors and representations associated with precolonial iron-smelting in eastern and southern Africa', in: T. Shaw *et al.* (eds.), *The archaeology of Africa: food, metals and towns*, 499–511.

David, N. 1995. *Black Hephaistos: exploring culture and science in African iron working*. Video recording (48 mins). Calgary: University of Calgary, Department of Communications Media.

David, N. 1996. 'A new political form? The classless industrial society of Sukur (Nigeria)', in: G. Pwiti–R. Soper (eds.), *Aspects of African archaeology. Papers from the 10th Congress of the PanAfrican Association for Prehistory and Related Studies*, 593–600.

David N. *et al.* 1989. 'Between bloomery and blast furnace: Mafa iron-smelting technology in North Cameroon', *African Archaeological Review* 7, 183–208.

David, N.–Le Bléis, Y. 1988. *Dokwaza: last of the African iron masters*, 50 minutes Calgary: University of Calgary, Department of Communications Media.

David, N., –C. Kramer. 2001. *Ethnoarchaeology in action*. Cambridge: Cambridge University Press.

p. 71: Dietler, M.–Herbich, I. 1989. 'Tich matek: the technology of Luo pottery production and the definition of ceramic style', *WorldA* 21, 48–64.

Dietler, M.–Herbich, I. 1998 'Habitus, techniques, style: an integrated approach to the social understanding of material culture and boundaries', in: T. Miriam Stark (ed.), *The archaeology of social boundaries*, 232–69.

Douglas, M. 1966. *Purity and danger: an analysis of the concepts of pollution and taboo*.

Echard, N. 1983. Scories et symboles: remarques sur la métallurgie hausa du fer au Niger. In *Métallurgies africaines: nouvelles contributions*, N. Echard (ed.), pp. 209-24. Mémoires de la Société des Africanistes, 9. Paris: Société des Africanistes.

Fotiadis , M. 1994. 'What is archaeology's "mitigated objectivism" mitigated by? Comments on Wylie', *American Antiquity* 59 (3) 545–55.

Giddens, A. 1982. *Profiles and critiques in social theory*.

Gordon, R. B. –Killick, D. J. 1993. 'Adaptation of technology to culture and environment: bloomery iron smelting in America and Africa', *Technology and Culture* 34 (2) 243–70.

Gosselain, O. P. 1992. 'Technology and style: potters and pottery among Bafia of Cameroon', *Man* 27 (3) 559–86.

Gosselain, O. P. 1994a. 'Clay exploitation strategies among potters south of the Adamawa massif (Cameroon)', *Archaeomaterials* 7 (2) 1994.

Gosselain, O. P. 1994b. 'Skimming through potters' agendas: an ethnoarchaeological study of clay selection strategies in Cameroon', in: S. T. Childs (ed.), *Society, culture and technology in Africa*. *MASCA Research Papers in Science and Archaeology, Supplement to Volume 11*, 99–107. .

Gosselain, O. P. 1995. *Identités techniques. Le travail de la poterie au Cameroun méridional. Description des chaînes opératoires* (Thèse de doctorat en Philosophie et Lettres (2 vols), Université Libre de Bruxelles).

Goucher, C. L.–Herbert, E. W. 1996. 'The blooms of Banjeli: technology and gender in West African iron making', in: P. R. Schmidt (ed.), *The culture and technology of African iron production*, 40–57.

Haaland, R., G. Haaland, and D. Dea. 2000. Ethnoarchaeological research on iron smelting in southwest Ethiopia. *Nyame Akuma* 54: 6-12.

Herbert, E. W. 1993. *Iron, gender, and power: rituals of transformation in African societies*.

Huysecom, É. 1993. Ethnoarchäologie - Methodologie und Perspektiven. *Ethnographische-Archäologische Zeitschrift* 34: 241-50

Huysecom, E.–Agustoni, B. 1997. *Inagina, l'ultime maison du fer*. Geneva: Huysecom, Agustoni, and PAVE, Videorecording (52 mins) (1997), film.

Keller, C. M.–Keller, J.D. 1996. *Cognition and tool use: the blacksmith at work.*

Killick, D. J. 1990. *Technology in its social setting: the ironworkers of Kasungu, Malawi, 1860–1940* (Ph.D. thesis, Yale University).

Kjekshus, H. 1997. *Ecology control and economic development in East African history*.

Kusimba, C. 1996. 'Social context of iron forging on the Kenya coast', *Africa* 66 (3) 386–410.

Lechtman, H. 1977. 'Style in technology—some early thoughts', in: H. Lechtmann–R. S. Merrill (eds.), *Material culture. Styles, organization, and dynamics of technology*. *Proceedings of the American Ethnological Society 1975*, 3–20

p. 72: Lemonnier, P. 1986. 'The study of material culture today: toward an anthropology of technical systems', *Journal of Anthropological Archaeology* 5, 147–86.

Lemonnier, P. 1992. ‘Elements for an anthropology of technology’, *Anthropological Papers of the Museum of Anthropology* 88.

McNaughton, P. 1988. *The Mande blacksmiths: knowledge, power and art in West Africa*.

Moniño, Y. 1983. ‘Accoucher du fer: la métallurgie gbaya (Centrafrique)’, in: N. Echard (ed.), *Métallurgies africaines: nouvelles contributions. Mémoires de la Société des Africanistes*, 9, 281–309.

O’Neill, P. O.–Muhly, F. 1988. *The Tree of Iron*. Videorecording (57 mins) Watertown, MA: Documentary Educational Resources.

Saltman, C. *et al*. 1986. C. Saltman–C. Goucher–E. Herbert., *The blooms of Banjeli: technology and gender in West African ironmaking*. Watertown, Mass: Documentary Educational Resources.

Schmidt, P. R. 1978. ‘Historical archaeology: a structural approach in an African country’, *Contributions in Intercultural and Comparative Studies* 3.

Schmidt, P. R. 1981. ‘The origins of iron smelting in Africa: a complex technology in Tanzania’, *Research Papers in Anthropology* 1. Providence, RI: Brown University.

Schmidt, P. R. 1996. ‘Reconfiguring the Barongo: reproductive symbolism and reproduction among a work association of iron smelters’, in: P. R. Schmidt (ed.), *The culture and technology of African iron production*, 74–127.

Schmidt, P. R. 1997. *Iron technology in East Africa: symbolism, science and archaeology*.

Schmidt, P. R.–Avery, D. H. 1978. ‘Complex iron smelting and prehistoric culture in Tanzania’, *Science* 201, 1085–9.

Schmidt, P. R.–Childs, S. T. 1995. ‘Ancient African iron production’, *American Scientist* 83, 524–33.

Shanks, M.–Tilley, Ch. 1987. *Re-constructing archaeology*.

Todd, D. M. 1975. Politics and Change in Dimam (Ph.D. thesis, University of Kent).

Todd, D. M. 1977. ‘Caste in Africa?’, *Africa* 47 (4) 398–412.

Todd, J. A. 1979. ‘Studies of the African Iron Age’, *Journal of Metals* 31 (November), 39–46.

Todd, J. A. 1985. ‘Iron production by the Dimi of Ethiopia’, in: R. Haaland–P. L. Shinnie (eds.), *African iron working: ancient and traditional*, 88–101.

Todd, J. A.–Charles, J. A. 1978. ‘Ethiopian bloomery iron and the significance of inclusion analysis in iron studies’, *Journal of the Historical Metallurgy Society* 12 (2) 63–87.

Van der Merwe, N. J.–Avery, D. H. 1987. ‘Science and magic in African technology: traditional iron smelting in Malawi’, *Africa* 57, 143–72.

Wilson, M. 1959. *Communal rituals of the Nyakusa*.

Wylie, A. 1985. ‘The reaction against analogy’, *Advances in Archaeological Method and Theory* 8, 63–111.