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Iron production in second millennium AD pastoralist contexts on the Laikipia Plateau, Kenya

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Abstract

Iron has played an important role within east African pastoralist societies for many hundreds of years, yet the means by which iron was produced or obtained by these communities has not been thoroughly documented. The bulk of our understanding is presently based on a limited number of ethnographic and artefact studies, which have tended to focus on the functional and symbolic nature of iron objects themselves. We argue that the research presented here has provided the first opportunity to add to this narrow knowledge base by reconstructing the iron production technologies of pastoralist communities in Laikipia, Kenya using an archaeometallurgical approach. Seven furnaces and one iron-production refuse area were excavated at two discrete workshop sites in Laikipia, central Kenya that dated to the second half of the second millennium AD. The recovered archaeometallurgical materials were analysed using optical microscopy, SEM-EDS and ED-XRF. These revealed that the smelting technologies in question were complex and sophisticated and utilised titania-rich black sands and lime-rich charcoal. Whereas the technical approach and raw materials were found to be similar at both sites studied, there was striking stylistic variation in furnace design for no apparent functional reason, which might suggest nuanced differences in the socio-cultural affiliations of the smelters that worked at these sites.

This paper explores some of the possible reasons for these differences. In particular, by integrating archaeological data with existing ethnographic and ethnohistoric research from the region, we discuss the technological choices of the past smelters and what this might tell us about their identities, as well as considering how future research should best be targeted in order to develop a greater understanding of the organisation of production within pastoralist central Kenya.

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Introduction

The current knowledge of the iron production technologies of sub-Saharan Africa is reasonably extensive, both geographically and through time, based on archaeological data supplemented by a large body of ethnographic research (Childs and Herbert 2005; Humphris and Rehren 2013). One noticeable omission however, is a lack of focused research on the use and production of iron in Africa's pastoralist communities. Within such societies – which have a predominant (though not necessarily exclusive) reliance on domesticated livestock for subsistence – iron production would presumably have developed in response to different needs from those of their more sedentary, agricultural counterparts, and would have been structured by different cultural values and higher mobility. Nevertheless, in east Africa at least, iron was no less of an important resource to pastoralist groups. Certainly in the recent, ethnographically documented past, iron production and iron working activities were often imbued with complex social and political meaning, and iron was used to create implements with symbolic importance.

The disparity in research focus can perhaps be attributed to the early trajectory of studies of African iron metallurgy. Nineteenth and twentieth century European settlers and visitors often identified more readily with local populations of farmers and traders, rather than the more transitory and 'alien' lifestyles of pastoralists. The indigenous trades and crafts that they documented, including blacksmithing and smelting, also tended to be from farming communities rather than pastoralist ones, despite their frequently stated admiration of the military prowess and weaponry of the latter (e.g. Routledge and Routledge 1910). This initial bias seems to have influenced the development of academic interest in the subject, which remained primarily concerned with the smelting and smithing technologies of agricultural populations. Research foci on the earliest incidences of iron smelting in the region, and the spread of that technology across the continent (often considered in relation to the spread of early Bantu languages, see for example Oliver 1966; Phillipson 1976; Eggert 2005; de Maret 2013) again prioritised the smelting technologies of farming communities. The role of iron within pastoralist societies was comparatively overlooked.

Archaeometallurgical studies of iron production across eastern and central Africa have also tended to focus on early farming sites, in particular those associated with Urewe Early Iron Age ceramics (e.g. van Noten 1979; van Grunderbeek et al. 1982; Schmidt and Childs 1985, 1996). Ethnoarchaeological, ethnohistorical and ethnographic accounts and discussion have generally been similarly focused (e.g. Roscoe 1911, 1915, 1923; Childs 1991, 1998, 2000; Reid and MacLean 1995; Schmidt and Mapunda 1997; Barndon 2004; Haaland 2004, among many others). There exist only a limited number of studies that discuss pastoralist metal production and metal working in eastern Africa from either an archaeological or ethnoarchaeological perspective. Targeted research is limited to Roy Larick's pioneering work with Maa-speaking pastoralists of Samburu District, northern Kenya (1985, 1986a, 1986b, 1991), Jean Brown's comprehensive documentation of iron working practices across Kenya (1995), Chris Spring's discussion of African weaponry (1993), and Ian Hodder's examination of the material culture of Samburu, Marakwet and Tugen blacksmiths in central Kenya (1982: 59-67). Most recently, Grillo (2012: 83-84) has documented an abandoned area associated with Samburu blacksmiths. Freda Nkirote M'Mbogori's recent archaeological research of iron working sites around Mount Kenya may also relate to pastoralist communities, although this has not yet been conclusively demonstrated (Nkirote 2006, 2013). Rare nineteenth and early twentieth century descriptions of pastoralist smelting and smithing (e.g. Schweinfurth 1875; Hollis 1905; Merker 1910; Leakey 1930; Galloway 1934) provide useful descriptions of pre-colonial iron technologies, as well as insights into the social organisation of production at this time. When supplemented by similar texts dealing with the metal technologies of nearby agricultural populations (e.g. Routledge and Routledge 1910), a fuller picture of the more recent local iron industries can be formed. Pastoralist iron objects held in museums (cf. Spring 1993; Brown 1995; Elsen 2003) provide a further resource that lies, as yet, mostly untapped, especially from a metallurgical perspective. Anthropological studies are also limited, yet have provided invaluable information as to the role of iron production and iron producers within pastoralist communities in more recent times (e.g. Galaty 1979, 1982).

As a consequence of the limited nature of these studies, there remain large gaps in our knowledge concerning many aspects of pastoralist iron production covering geographical, economic, social and technological factors. These include furnace design and operation, raw material procurement, the scale and organisation of production, and the spatial location of smelting sites. Furthermore, although the advent of iron production is often considered a significant contributor to major socio-political change within agricultural communities, the impact of the adoption of iron, and the circumstances surrounding that transition, are yet to be fully considered within a pastoralist context. Equally, our understanding of east African iron metallurgy more generally, both past and present, is currently almost entirely based on what is known about iron producing activities among a single economic category – farming communities.

This paper seeks to begin to redress this by trying to fill some of these knowledge gaps using data from an archaeometallurgical study of iron smelting remains associated with the Pastoral Iron Age on the Laikipia Plateau, Kenya. More specifically, various avenues of investigation were chosen as part of this study in order to unravel the technological approaches employed by these past smelters, their technical skills and limitations, and to determine the choices they made in implementing these important technologies. Ultimately, these excavations and analyses provide a small-scale reconstruction of the smelting technologies of this area, and can provide suggestions as to the methods of iron production practiced on the Laikipia Plateau in the latter half of the second millennium AD.

Pastoralist metalworking in Kenya

The timing and mechanisms of the adoption of metal technologies by east Africa's various pastoralist communities remain poorly understood, despite the widespread academic usage of iron-related chronological markers that suggest otherwise, as encapsulated in the distinction drawn between the Pastoral Neolithic (PN) and the later Pastoral Iron Age (PIA)[1]. Unlike farming populations of the eastern highlands and coastal stretches of Kenya, which are thought to have been using iron as early as two thousand years ago (Soper 1967; Helm 2000), current data regarding the pastoralist communities of the central Rift Valley suggests that they began to take up the use of iron rather later (Sutton 1993; Ehret 1995/6). This is most clearly indicated at the 'main site' on Deloraine Farm, near Rongai to the north-west of Lake Nakuru in Kenya, where iron-working remains (slag and tuyère) are present in association with PN Elmenteitan pottery and flaked obsidian blades dating broadly to the second half of the first millennium AD[2] (Collett and Robertshaw 1983; Ambrose et al. 1984). This site also contains evidence for mixed agriculture and pastoralism, and may well represent a development of earlier Elmenteitan traditions (Collett and Robertshaw 1983: 108). Radiocarbon dating of archaeological horizons marking the boundary between the Elmenteitan and PIA at the rock shelter site of Enkapune ya Muto in the Rift Valley gave broadly similar dates[3] (Ambrose 1998: 380). Ultimately however, many more dates from across the region are needed if this transition is to be understood more fully.

At a wider regional scale, iron working remains associated with pastoralist sites are known from the area east of the small settlement of Aitong in the Lemek-Mara region of south-west Kenya. These include the sites of GuJe 32, with a roughly triangular furnace with one bowed side and tuyère ports in each corner (Siiriäinen et al. 2009), and GuJf 4 where surface scatters of smelting debris – slag and tuyères – were found. Both sites were situated at the western footslopes of the nearby hills. In the Lemek Valley, the remains of a smithing site (GuJf 46), comprising fire-hardened clay and dense scatters of charcoal but only a single piece of slag, has also been excavated (Robertshaw et al. 1990: 44). Elsewhere in the area, a number of sites with surface scatters of iron slag in association with twisted-string roulette are known, both from the Loita Hills (Robertshaw and Cable 1990: 267-78) and on the adjacent plains (Robertshaw et al. 1990: 44). A smelting site (GuJf 105) reportedly associated with the Loitai section of the Maasai and in use before the arrival of Purko Maasai, was also located during these surveys (ibid.).

Sutton (1973) mentions several sites (such as Kayoyon Farm in the Elgon foothills, and Muringa on the Moiben escarpment) with evidence for iron working on the Uasin Gishu plateau in the western highlands of Kenya, some of which may have been associated with the Sirikwa, the agro-pastoral proto-Kalenjin (Southern Nilotic) inhabitants of western Kenya. A small, non-tapping bowl furnace – the remains of which measured approximately 20 cm in diameter and 20 cm deep – has also been excavated recently in the northern Cherangani Hills. This site is situated immediately outside a large rockshelter (Morpus North), and charcoal from the base of the furnace yielded a date of post-1661 cal. AD (Davies 2008: 357)[4]. The shape and type of this furnace contrasts with the dome furnace used more recently by agricultural Pokot (Brown 1995: 48, 59-61), who currently occupy the area around Morpus. A much larger furnace, potentially similar to that described by Brown (1995), occurs a short distance downslope from the Morpus rockshelter (Davies 2008). This was excavated in 2010 (Walmsey 2014). Although badly eroded, the surviving base measured c. 1 m in diameter and c. 0.1 m deep, and retained a cluster of tuyère remains in the southeast quadrant. The furnace centre contained a thick, ashy layer sealed by a layer of baked clay slabs that could well represent the remains of a collapsed superstructure (M. Davies pers. comm. 2014). Ceramics excavated from the same general area are of the 'Rangi-type', provisionally associated with Later Iron Age populations (Davies 2008).

Traces of iron smelting activity have also been recorded at various locations on the Laikipia and Leroghi plateaus (see below; other Laikipia localities include Laikipia Nature Conservancy, Kathleen Ryan pers. comm. 2006) and in areas to the north. These typically occur in association with Kisima ware, a PIA pottery type first identified and defined by Siiriäinen (1977) on the basis of surveys and excavations at and around Porcupine Cave on Kisima Ranch, and which he tentatively associated with Laikipiak Maasai incursions onto the Laikipia Plateau (Siiriäinen 1984: 65-67, 93-94; see discussion in Lane 2013). Additionally, Larick (1986a) identified seventeen smelting sites in Samburu and southern Marsabit districts, which he classified into three broad groups: mountain base sites, plains oasis sites and mountain ridge sites. A few of the furnaces located by Larick were excavated, and are described as 'semi-subterranean bowl type[s]' with 'an exterior ramp or apron to facilitate charging, cleaning, and recharging' (1986a: 170). There was some variation between different furnaces in terms of their surface diameter (c. 30-50 cm), depth (c. 20-40 cm) and number of tuyère ports (2-3). One illustrated example (Larick 1986a: 172, Fig. 4) appears to have been square in plan, with a central pit, or post-hole, with near vertical sides and three tuyère ports. More recently, three badly eroded furnace- or forge-bases have been excavated at a site near Baawa, c. 30 km south of Maralal, Kenya (Fig. 1; Lane et al. 2007). These remains were located immediately adjacent to a large, open PIA settlement with associated Kisima ware pottery, and dated to between 1296-1405 cal. AD[5]. Since full details of Larick's excavations do not seem to have been published, and archaeometallurgical analysis of the material from Baawa is also still pending, it is not possible yet to draw comparisons with the smelting remains discussed here.

Regardless of how and when iron production arose in the region, once adopted, iron became well established within the pastoralist way of life, despite a continuing use of lithic technology[6]. However, although iron became the material of choice for the tools of many daily activities, iron artefacts are only rarely encountered archaeologically. Nevertheless, there have been a few examples: a fragment of a hoe was excavated from at an earthwork associated with the Sirikwa at Lanet, near Nakuru (Posnansky 1967), and multiple iron objects were excavated from Hyrax Hill Site 1 (Leakey et al. 1943), a series of Sirikwa-derived stone-wall stock enclosures (Sutton 1987), and Deloraine Farm (Sutton 1993). Iron implements (including an iron ring and a spearhead) were also recovered from Sirikwa hollows at the site of Muringa (dated to the mid-fifteenth century AD or later[7]) on the Moiben escarpment, Uasin Gishu (Sutton 1973: 128). No metallurgical or stylistic analysis has been carried out on any of these items.

Within ethnographic and ethnohistoric contexts it is well known that spears, in particular, took on a wide range of important functions that were both symbolic and practical. In their capacity as a means of protection for individuals, homes and herds, and as weapons by which to acquire cattle in offensive raids on other communities, spears were imbued with significant social value, and they played an important role in the acquisition of economic and political power. Spears have also been shown to convey considerable cultural information, actively indicating an individual's social position and status, while also providing the knowledgeable observer with information regarding the bearer's ethnicity and identity, through stylistic cues embedded within the formal attributes of these objects (Larick 1985, 1986b, 1991; Spring 1993; Brown 1995).

Galaty's (1979, 1982) discussion of the social organisation of Maasai society and especially the notions of 'pollution' and 'taboo' associated with Il-Kunono (Maasai smelters and smiths) is of particular relevance, given the likely association of the excavated sites discussed here with Maa-speakers. As early observers and ethnographers noted (e.g. Hollis 1905; Merker 1910; Huntingford 1931), blacksmiths among the Maasai constituted a distinct, specialist sub-group[8]. Although most Maasai sections had blacksmiths affiliated to them[9], they were socially isolated from the main body of pastoralist society, and occupied a liminal and ambiguous status. On the one hand, pastoralist Maasai respected blacksmiths for 'producing the most potent and mysterious of all substances, iron,' a product, as transformed by the smith, on which 'all human processes ultimately rely' (Galaty 1979: 805). Yet, on the other hand, blacksmiths were perceived to produce their highly desirable and symbolically loaded products 'through a degrading form of labor, which contrasts with the pastoralists' own dignified and leisurely activities of herding' (ibid.). Blacksmiths and their families were thus regarded as potent and powerful, able to make iron from stone and even instil it with curses (Galaty 1982), yet they were also seen as sources of pollution.

One consequence of the ritual impurity attached to blacksmiths in Maasai culture is that smelting and smithing areas were located outside settlements. Similar attitudes toward blacksmiths, with greater or lesser emphasis on segregation, have been noted among other pastoralist groups in the region, including the Maa-speaking Samburu (Lokop or Loikop), and the Rendille, who are Cushitic speakers living to the north of the Samburu. Among the former, Spencer (1973: 118) noted that 'blacksmiths are normally expected to live in a settlement of their own, whereas Rendille blacksmiths are dispersed among the settlements of most clans'. According to Larick, Samburu smelting settlements 'tended to be large and complex as many workers were needed to complete the series of specialized tasks' (1986a: 170). There are several distinct smithing clans among Samburu, some with Rendille affiliations from whom they purportedly originally learned their craft (Brown 1995: 155, 181), while others acknowledged familial links with foragers or hunters, attributed to the proscription of marriage between blacksmiths and herders (Larick 1991: 305). Tugen, a southern Nilotic Kalenjin people who occupy areas between Lake Baringo and the eastern escarpment of the Rift Valley in Kenya, also regarded smiths as anomalous individuals, simultaneously respected for their technical skills and feared on account of their potential powers and impurity (Hodder 1982: 60). Similar ambivalence has been reported within the eastern Nilotic Kuku in what is now South Sudan (Poggo 2006).

Perhaps because of these attitudes, early observers of pastoralist smelters tended to perceive them as reviled outsiders. Cline, for instance described Maasai smelters as ‘the classic example of a despised smith caste’ (1937: 114), and Huntingford categorised them as ‘serfs’ under the ‘strictest subjection’ of the Maasai (1931: 263). Nevertheless, this greatly over-simplifies and underestimates the complexities of their multifaceted roles within pastoralist society. Both Larick (1986a) and Galaty (1979, 1982) provide more detailed discussions of the responsibilities of smelters and blacksmiths in pastoralist life and present them from more complex perspectives. Historically, blacksmiths were indeed often physically marginalised, operating in areas away from the main herder settlement, yet they were highly respected and recognised as an essential element of pastoralist life, both for their material products and in their ritual roles, which include performing circumcision, a central rite of passage within pastoralist societies. As physical outsiders, the status of smiths and smelters also shares some similarities with the warrior age-grades of pastoralist communities, who also spend much of their time away from the main settlement, tending the herds. This affords both of these sub-groups unique opportunities to forge links with populations outside their own ‘ethnic’ group, in turn instilling both blacksmiths and warriors with the power to negotiate changes in style and form to the spears that are adopted by each new age-set, enriching the stylistic repertoire of both spear-producers and spear-users (Larick 1991). As Larick observed, ‘blacksmiths have been indispensable to East African pastoral society, both as makers of essential tools and as leaders in sacred ritual’ (1986a: 166).

Iron working sites on the Laikipia Plateau

Between 2002 and 2005, the British Institute in Eastern Africa (BIEA) undertook an interdisciplinary programme of research entitled Landscape and Environmental Change in Semi-Arid Regions of East and Southern Africa: developing interdisciplinary approaches, carrying out fieldwork in three geographical locations:

the Laikipia Plateau in Kenya, Malilangwe in Zimbabwe, and Kabwe in Zambia (Lane 2005). The archaeological work in Kenya was mostly restricted to land bound within three privately owned ranches in Laikipia District – Mugie, Lolldaiga Hills and Borana ranches, with more limited work on Chololo, Mpala and Jessel ranches (Fig. 2). Over 50% of the archaeological 'sites' located during surveys within these ranches were stone cairns or complexes of stone cairns. Another five percent were rock art sites, virtually all of which contain only so-called 'Late Whites', which in this part of eastern Africa are closely associated with PIA and more recent pastoralist societies, particularly in connection with 'meat feasting' (Gramly 1975; Smith et al. 2004). Several other rock shelters with similar art are known elsewhere in the wider Ewaso Basin, of which Laikipia forms a part, and many appear to have remained important places in the pastoral ritual landscapes of the area (Chamberlain 2006).

Of the remaining sites, roughly six times as many (29% versus 5%) are of probable PIA date compared to those associated with the earlier Pastoral Neolithic. The traces of PN remains include both Elmenteitan (c. 3300-1300 BP) and Akira wares (c. 1900-1200 BP), and in some cases have been found associated with mixed wild and domesticated fauna (Siiriäinen 1984; Lane 2011; see also Causey 2010). Large open PN sites comparable to those encountered further south in the Rift Valley and the Loita-Mara plains (cf. Robertshaw 1988) have still to be located. The higher proportion of PIA to PN sites may well reflect a steady increase in human activity and presence on Laikipia during the last millennium. Nevertheless, it is also possible that a proportion of the older sites have yet to be detected because they lie buried beneath colluvial and alluvial sediment that has accumulated along valley floors (cf. Kuehn and Dickson 1999), and/or that the dense vegetation in some of the surveyed areas has made the archaeological detection of this class of site problematic (see Causey and Lane 2005; Causey 2008).

PIA sites on the Laikipia and Leroghi Plateaus on the eastern side of the Rift Valley are associated with Kisima ware (Siiriäinen 1984), including the Maasai Plains site on Mugie ranch, occupied between 1400-1480 AD (cf. Fig. 1; see Lane 2011 for further details). Mili Sita, an open settlement site on Lolldaiga Hills ranch also associated with Kisima ware, dates to post mid-17th century AD (see below). Both the Mili Sita and Maasai Plains sites are large, open-air pastoralist settlements with landscape features such as ash mounds and circular patches of nutrient-rich grasses that are typical of pastoralist sites in this landscape (Causey 2010; Lane 2013).

The Lolldaiga Hills ranch, situated in the south-eastern part of the Laikipia Plateau and covering an area of just under 20,000 hectares (cf. Fig. 2), was the only locality that showed high potential for archaeometallurgical research, indicated by the presence of slag, tuyère and furnace remains. Surveys on Mugie ranch failed to locate similar remains, although a limited level of archaeometallurgical material was present on Borana and Mpala ranches. On Lolldaiga, intensive systematic transect survey, complemented by opportunistic survey was initially undertaken by the BIEA in 2004 across much of the central part of the ranch. This was supplemented in 2006 by further opportunistic surveys (Iles 2006) and systematic transect surveys (Causey 2008, 2010). As a result, a total of 135 sites ranging in date from the Late Stone Age (LSA) to the Pastoral Iron Age (PIA) were recorded on Lolldaiga, including several sites that yielded archaeometallurgical remains, among them two distinct areas of iron-smelting activity at the sites of Mili Sita and Cattle Dip (cf. Fig. 2).

Iron production sites at Lolldaiga Hills Ranch

The Mili Sita site (Fig. 3) is located on a low col toward the end of a northward-trending ridge in the Lolldaiga Hills, and appears to have been used as an area of pastoralist settlement. On either side of the ridge, gentle to moderate slopes run roughly east and west to alluvial valley floors. At the centre of the col is a large grass-covered area with several discrete concentrations of archaeological material, some of which represent the remains of rubbish dumps, while others have been shown by excavation to mark the site of former dwellings or stock enclosures. Features possibly associated with smithing were excavated there in 2004 (Figs. 4 and 5), close to the top of the hill at the northern extent of the site. These remains include a large flat-topped stone, bearing some similarities to the anvils seen in the modern blacksmithing area illustrated in Grillo (2012: 84). To the south of the main settlement area there are at least 55 stone cairns, one of which has been excavated and shown to have been used for human burial (Lane et al. 2007: 43), but this remains undated and it is possible that none of the cairns are coeval with the adjacent PIA settlement remains. Nearby this cluster of cairns are two flat stone slabs, each with parallel rows of small ground hollows, similar to known variants of 'mankala' or 'bao' gaming boards. There is also a line of cairns running at right angles to the ridge at its northern end. About 300 m northeast of the central settlement zone, is a heavily eroded area on the upper slopes of the ridge virtually bare of grass cover and with only a sparse covering of low acacia thorn trees. Scattered across this area, and clearly set slightly apart from the other archaeological features are numerous distinct scatters of iron slag mixed with tuyère fragments and the remains of several smelting furnaces associated with surface scatters of fragmented Kisima ware pottery.

In 2004, one cluster of these (Cluster A) was mapped, and two furnaces and a smelting-refuse dump were selected for excavation. During the 2006 fieldwork season, an additional cluster of furnace bases was identified (Cluster B), of which two were excavated. Also in 2006, further remains of iron smelting lying approximately 3 km to the NNW of Mili Sita were mapped. This site was in proximity to a functioning cattle dip, therefore at high risk from heavy erosion, and was subsequently referred to as the 'Cattle Dip' site. A group of four furnaces, and another outlying cluster of at least two, more heavily eroded furnace bases were located at this new site, and three of the furnaces in the main cluster were selected for excavation (Figs. 6 and 7). These various surveys have also recorded other traces of iron smelting activity in the form of slag, tuyère fragments and at least one other furnace base (subsequently destroyed by routine grading of the track on which it lay) elsewhere on the Lolldaiga Hills ranch and immediately adjacent properties. Where diagnostic pottery occurred in association, all of this was of the Kisima type, from which it is inferred that the majority, and perhaps even all, of the iron processing evidence thus far encountered on Lolldaiga has a PIA affiliation. The surface evidence from all of these suggest iron-working occurred routinely but at a low intensity compared with the scale documented at some localities associated with farming communities, and in the absence of absolute dates for any of these other traces it is possible that the available evidence for the processing of iron in the Lolldaiga Hills spans several centuries. This in turn raises the possibility that different groups of smelters, perhaps of different origin or cultural affiliation were involved at different times, a point we return to below.

The iron production technologies: analysis and discussion

Technological aspects of past smelting episodes and how they were organised were reconstructed through an examination of the available archaeological remains at both of the excavated Lolldaiga Hills sites. In addition to the excavation records, information concerning the smelting technologies was generated by applying a combination of analytical techniques to samples of slag, tuyère and furnace lining recovered from the excavated features and local environs. The bulk chemical compositions of selected samples were acquired through polarising energy-dispersive X-ray fluorescence (ED-XRF) of powdered samples of slag, ceramic and ore. Selected samples were also prepared as polished blocks for reflected light optical microscopy and scanning electron microscopy with energy dispersive spectrometry (SEM-EDS) in order to examine the distribution and chemical composition of mineral phases within the samples. The combined results enabled operating parameters and raw materials to be inferred. A comprehensive report of the analytical results has been published elsewhere (Iles and Martinón-Torres 2009), and a summary is presented below.

Furnace design

The Lolldaiga furnaces were all shallow bowl furnaces (cf. Kense 1983: 42), and were relatively small in size, ranging between 30 and 40 cm in diameter. However, furnace design varied significantly and strikingly between the three clusters. Of the furnaces from Mili Sita, those in Cluster A were all circular in plan, with irregular walls and steeply-tapering in profile, and partially lined to a depth of between 5 and 8 cm (Figs. 8 and 9). In contrast, the furnaces comprising Cluster B at Mili Sita were roughly square in plan, with flattened areas of ceramic at each of the corners, which are thought to be four tuyère ports (Figs. 8 and 10). Not only do these ports indicate the number of tuyères used to supply these furnaces with air, they also provide an approximation of the original depth of the furnace pit. The furnaces in this cluster were also lined to a depth of approximately 5 to 8 cm.

The furnaces at Cattle Dip were circular and funnel-shaped, with small, circular pits with near-vertical sides cut into their bases (Figs. 8 and 11). The entire upper portions of the furnaces were lined, although the lower pits were unlined. The pits in the base of the furnaces contained the remains of very small grass stems, charred in-situ. Although this might be suggestive of ritual practice, there was insufficient evidence to determine the role of these pits here. The deposition of ritual items has been well documented in similar pits under smelting furnaces of agricultural groups in eastern Africa, but there is currently no evidence to suggest that this was a technique commonly employed in pastoralist smelting. Nevertheless, such a function cannot be ruled out.

This striking stylistic variation in furnace design was unexpected, and is indicative that these furnaces are not the remains of a single technological approach. Two of the stylistic features were of particular note: the near square-shaped furnaces of Cluster B, Mili Sita, and the circular pits dug into the bottom of the furnace bases at Cattle Dip. These distinctive features had both previously been recorded, combined in a single example of a pastoralist furnace in northeastern Samburu District (Larick 1986a). It is of interest that these features occur separately in the furnaces of this study, and the possible significance of this will be addressed in more detail below.

Technical approach

Archaeometallurgical analysis of the slag, tuyères and furnace walls from all clusters and sites showed that despite variation in furnace design and construction a remarkably similar technical approach was employed at all three smelting locales. Raw material selection and utilisation appeared to remain broadly uniform, which contrasted with the variation in furnace design.

The tuyères from both Mili Sita and Cattle Dip were all very similar in macroscopic and microscopic appearance, as well as in chemical composition. Several tuyères were recovered almost intact, which showed clearly the flared design of one end, somewhat trumpet shaped. Given the small internal diameter (c. 2.7 cm), it is probable that bellows were placed at the flared end to propel air into the furnace, as has been ethnographically documented in many areas of eastern and central Africa (e.g. Cline 1937; Brown 1995). At the turn of the twentieth century, Kalenjin smelters in Keiyo to the west were using furnaces that employed a varying number of bellows depending on the number of smelters that were to work the furnace (Galloway 1934);

agricultural Kikuyu smelters to the south-east of Laikipia are also known to have used bellows to power their furnaces (Routledge and Routledge 1910; see also Huntingford 1961).

It is possible in many cases to see hollows on the surface of the tuyères from where grassy materials had been burnt out during firing or use, indicative of the use of plant materials as temper. Adding materials such as chopped grass, or grass in the form of dung, would have improved the workability of the clay (Freestone 1989: 156). Frequent quartz grains, angular and regular in size, were also visible in all the samples, suggestive of a deliberate addition of crushed quartz. Their presence would have improved the stability and temperature resistance of the clay by decreasing the likelihood of fatal cracking. Although quartz dominated the mineral inclusions of all of the studied tuyère samples, comprising on average approximately 25-30 area% of the sample area, other mineral inclusions included biotite, ilmenite and zirconium crystals, all naturally occurring in the local area (Wanjogu et al. 2000).

Chemical analysis demonstrated that all the sampled tuyères from Mili Sita and Cattle Dip were very similar in chemical composition and were fairly refractory. Small SEM-EDS area analyses of the clay fabrics, avoiding inclusions, indicated that they contained approximately 55 wt% silica and 26-30 wt% alumina. This high alumina, in conjunction with between 9 and 12 wt% iron oxide (see Iles and Martinón-Torres 2009), meant that these ceramics would have been capable of withstanding the temperatures of the smelts, rather than melting and contributing in significant volume to slag formation.

The furnace walls were slightly more variable in composition than the tuyères, suggesting perhaps a less systematic selection or processing strategy for these clays, although clay with a very similar chemical signature had been used for both purposes. The major variant from the tuyères were slightly elevated silica levels in the furnace lining samples, which might suggest the addition of further sand or the use of termite mound earth. Ethnographic examples have shown that termite mound earth, which tends to be higher in quartz due to the separation of the clay and sand components of the soil by the termites, can be specially selected for the construction of the furnace wall and lining to satisfy both socio-cultural and technical concerns (Cline 1937: 53; Schmidt and Avery 1978; Brown 1995: 49; Humphris 2004: 37).

The slag collected as part of this study all appeared from an initial visual inspection to be furnace slag as a result of smelting activity, and their macro-morphologies indicated that the slag had formed and cooled within a furnace, rather than having been tapped from it during a smelt. Several slag samples from Mili Sita were circular in plan and plano-convex in profile, with a smooth lower surface marked by plant impressions. These slag blocks reflected the size and shape of the excavated furnace bases from this site.

What was most striking in the slag samples from all clusters were similarities in chemical compositions and microstructures: no patterns distinguished the slag from each cluster or site. Some minor compositional variation was present, but this is likely to be due to slight variations in smelting procedures, possible time lapses between smelts or localised variations in background geology. Multiple samples taken from within a single slag block also showed some compositional variation, which probably relates to the fluctuating conditions thought to occur within smelting episodes (David et al. 1989; Paynter 2006; Humphris et al. 2009), especially likely in shallow bowl furnaces (Th. Rehren pers. comm. 2008). Of particular interest were the high levels of lime (CaO, up to 10 wt%) and titania (TiO_2, up to 12 wt%) in the slag samples (see Iles and Martinón-Torres 2009), which will be discussed in more detail.

In order to explain the high levels of titania in the slag, the composition of locally available ores was immediately considered. Four possible ore sources had been identified at or near the sites under examination and had been subsequently sampled, although no systematic examination of locally available raw materials was undertaken. ED-XRF analysis revealed only one that contained enough iron oxide to be a viable ore. This was a sample of magnetite sand, black in colour and strongly magnetic. The presence of partly reduced magnetite grains visible during microscopy in some of the slag samples provided a positive link between the archaeological smelting activity and a magnetite sand similar to the one sampled. Furthermore, compositional analysis revealed that this ore sand had an ilmenite component, and thus was titania-rich, linking it more strongly to the archaeological slag. The presence of titania in the ore would have facilitated a greater chemical reduction of iron oxides to iron, potentially increasing the metal output of the smelting system, and indeed, the slag samples showed consistently low levels of iron oxide in the bulk chemical analyses, as well as particularly low proportions of iron metal droplets and wüstite when examined microscopically.

Smelting of titanium-rich iron ores has not been commonly documented within the African continent, nor globally (although Japanese Tatara steel is a well known example, see Kitamura et al. 2002; Tanii et al. 2014). Several archaeometallurgical studies in Africa have discussed the use of titania-rich ores in South Africa (van der Merwe and Killick 1979; Friede et al. 1982; Killick and Miller 2014), Nigeria (Ige and Rehren 2003) and northern Tanzania (Iles 2011; Iles et al. in prep.). There are also several ethnographic examples, a number of which are close to the Laikipia study area. Cline (1937: 27-29, 39) notes a limited number of instances where titania-rich ores were used, of which a particularly relevant example is Kikuyu smelting to the south of Mount Kenya. Here also, black ilmenitic magnetite sands were used, which had washed from decomposed granite (cf. Routledge and Routledge 1910). A more recent ethnographic study of Embu smelting, also to the south of Mount Kenya, again revealed the use of a magnetite sand with a notable titania content (Brown 1995). It is likely that the Laikipia black sand derived from a similar geological origin as these other nearby examples. Brown’s ethnographic investigation suggests that Gaturi in the Ithanga Hills was a well-known source of iron sand for Kikuyu, Mbeere and Maasai smelters alike.

The second distinctive characteristic of the slag to be expounded is the elevated lime content. The presence of lime at the levels seen here would have encouraged slag formation and facilitated the physical separation of the slag from the forming iron bloom. Several possible factors could plausibly explain these high levels of lime, but most can be ruled out. There was no evidence for the use of crushed shells as a flux, as has been seen in Mbeere smelting to the south of Mount Kenya (Brown 1995: 55), nor were the lime levels in the technical ceramics high enough to account for the levels in the slag. A further possibility was the addition of a calcareous or dolomitic rock as a flux, yet there are no significant geological sources for such a material in the local area. The most plausible explanation seems to be that the raised lime content derived simply from the use of a lime-rich charcoal as fuel (for a detailed description as to how this conclusion was reached, see Iles and Martinón-Torres 2009; cf. also van der Merwe and Killick 1979; Killick and Miller 2014). Although no wood species identification was carried out on charcoal excavated from the furnaces, it is likely that Acacia spp. would have been likely candidates to be used as fuel, as they are hardwood savannah trees frequently used for smelting and forging (e.g. Goucher 1981; Whitelaw 1991; Thompson and Young 1999). Chemical analysis of a sample of modern Acacia charcoal appears to support the argument that the fuel could make a significant lime contribution. The charcoal sample was prepared from wood taken from a live tree on the Lolldaiga Hills ranch, visually identified in the field as an Acacia species, and made into charcoal using the traditional 'earth burn' method. ICP-MS analysis undertaken at the ALEC lab, University of Arizona in 2014 identified the high lime content of the charcoal: CaO, present at c. 3700 ppm, was the highest concentration of 46 measured analytes, and comprised 42 wt% of the sample when normalised to 100%.

Pollen records from Loitigon Vlei, close to the Maasai Plains site on Mugie ranch, indicate an expansion of Acacia spp. after c. 1900 BP until approximately 1700 BP (141-384 cal. AD). This was subsequently followed by a reduction in Acacia bushland and an expansion of fire-adapted grassland, probably in response to burning – a trend that accelerated after the 13^{th}-14^{th} centuries AD (Taylor et al. 2005). The authors suggest that this burning is linked to pastoralist activity as well as interspersed periods of reduced rainfall. Burning may have been used as a means by which to expand grasslands and reduce insect-born disease (e.g. trypanosomiasis), but this does not exclude the exploitation of Acacia species for fuel. A similar trend is recorded in the pollen records from the Ewaso Narok and Marura swamp, although the timing of the onset of the decline in Acacia spp. is slightly later, commencing at around 300 cal. AD, with open disturbed savannah becoming widely established by c. 850 cal. AD (Muriri 2008). If Acacia spp. were indeed the preferred tree for smelting fuel, these trees would likely have been available to the smelters on Lolldaiga.

Dating

Three radiocarbon dates were obtained in order to provide a broad indication of the chronology of the sites and the related metallurgical activity. These, along with their calibrated date ranges are shown in Table 1.

Site	**Sample location**	**Sample type**	**Radiocarbon age (years BP)**	**2-sigma range (cal. AD)**	**Beta lab Number**
Mili Sita	Stake hole (Context 007, Trench A04)	Charcoal	200 ± 40	later than 1642	189981
Mili Sita	Furnace pit (Cluster A, Furnace B)	Charcoal	170 ± 40	later than 1655	212297
Cattle Dip	Furnace pit (Furnace A)	Charcoal	250 ± 50	later than 1483	218135

Unfortunately, these radiocarbon dates fall at a time of multiple intercepts with the IntCal13 calibration curve (OxCal 4.2, Bronk Ramsey 2009; Reimer et al. 2013), which means that there is a relatively wide range of statistically viable absolute dates (Guildeson et al. 2005), and it is not possible to assert whether these furnaces were in operation contemporaneously or not. However, although inconclusive, these dates make it possible that these furnaces, and the site of Mili Sita as a whole, are broadly associated with Maa-speaking Laikipiak settlement of the area prior to the eighteenth century as recorded in regional oral histories (see Lane 2013 for further discussion).

Discussion and conclusion

The analytical data presented here has indicated that the technical processes of iron production undertaken at all the smelting clusters appear to be very similar. Tuyères from both sites were consistently formed from the same clays, and would have withstood the high temperatures of the furnace. The chemical compositions of all the slag samples were also fairly uniform, indicating that the same raw material sources were probably utilised in each and every smelt. Titania-rich magnetite ore sands (most likely readily available from the floors of the deep erosion gullies found across the

Lolldaiga Hills, as is still the case today) were used alongside a lime-rich fuel, which resulted in repeated successful outcomes with the likelihood of good yields of iron. Minimal labour would have been required to gather and beneficiate the ore sands, unlike a mined ore. However, although these groups utilised the same resources, they applied their own, slightly different individual modus operandi in terms of building and using furnaces, and the stylistic variation in important technological elements of these Lolldaiga furnaces (furnace shape, number of tuyères) may suggest that the smelting episodes that occurred at each site were performed by different groups of smelters.

The identity of these smelting groups is difficult to positively determine. The most common type of bowl furnace in Kenya – found throughout northern and eastern Kenya east of the Rift Valley – is round, approximately 30-35 cm in diameter and 20-30 cm deep, often clay lined and with hollows around the circumference for the insertion of up to four tuyères (Brown 1995: 45-46), similar to the furnaces excavated at Mili Sita Cluster A. However, the particular stylistic features of the other Lolldaiga furnaces – the square shape in plan of the furnaces at Mili Sita Cluster B, and the funnel shape of the Cattle Dip furnaces – contrast with the ethnographically-documented furnaces of agricultural groups in the Mount Kenya region and pastoralist furnaces to the west of the Rift Valley, and instead bear strong similarities to a pastoralist furnace recorded at Nkuronit (or Ngurunit) (Fig. 12. From Larick 1986a: 172), which Larick associated with Samburu blacksmiths.

The available ethnographic data from this region suggests a trend for the use of smaller furnaces by pastoralist or semi-pastoralist communities, and the use of larger furnaces with more substantial superstructures by agricultural populations (cf. Brown 1995). It is tempting to relate this observation to the convenience of smelting with a smaller furnace, which required less time and labour for construction, and to a lower demand for iron. However, mobility and subsistence vary widely even within pastoralist and agriculturalist groups (cf. Robertshaw and Collett 1983), and several agricultural groups in the Mount Kenya region also use small, bowl-type furnaces, while some pastoralist groups use large furnaces with a built-up superstructure. It is also relevant to note that pastoralist blacksmiths, as outsiders and specialists, may themselves have been less mobile or transitory. Further research is required before these issues might be resolved.

Unlike the furnaces described here, the Kikuyu of the Mount Kenya region have been documented to use a furnace that is a distinctive oval shape, approximately 60 cm by 30 cm with a depression at each end to fit two tuyères, and around 45 cm deep with a clay lining that extends above the ground surface to form a rim about 5 cm high (Brown 1995: 46 and Fig. 46.2; Routledge and Routledge 1910: 84 and Plate LIV; Leakey 1977: 304). To the southeast of Mount Kenya, Embu and Mbeere smelters have been found to use more typical round bowl furnaces. Brown provides illustrations of both an Embu furnace – a clay-lined, circular bowl furnace approximately 25 cm deep and 28 cm in diameter, with fairly straight sides and a flat bottom, and with three tuyère ports scooped out of its circumference (Brown 1995: 47, Fig. 46.1) – and an unlined Mbeere furnace (1995: 47, Fig. 46.3) – roughly circular, 23 cm deep and 35-37 cm in diameter. A second furnace used by the same Mbeere smelter measured c. 30 cm deep and 45 cm in diameter. To the west of the Rift Valley, Kalenjin and Masaai smelters are recorded as having used much larger dome furnaces (Brown 1995: 46; Galloway 1934: 501; Hinde and Hinde 1901: 86-87). Hinde and Hinde (1901: 86-87) describe a furnace used by Elgunoni Masaai smelters that measured around 3 to 3.5 m in diameter, and between 1 and 1.75 m high, with clay walls that sloped slightly into the centre of the furnace and between 10 and 15 bellows. From this brief review of the current literature on furnace style in the region, it is apparent that the closest stylistic parallels to the Lolldaiga furnaces are those documented by Larick.

However, even with these stylistic affiliations, it cannot be definitively asserted that these smelters were themselves pastoralists, despite the fact that these furnaces are associated with pastoralist sites. Certainly the Laikipia Plateau is known from linguistic and oral historical evidence to have supported a mosaic of different, and periodically fluid, subsistence and ethnic groups at the time of initial European contact (e.g. Herren 1987) and so it is entirely conceivable that iron smelting was undertaken by groups other than pastoralists. Moreover, Kisima pottery, although abundant on PIA sites and often associated with the documented iron working remains, could well have been made by neighbouring non-pastoralists[10], and exchanged with Laikipiak for other products. Similarly, this may also have been the case with iron, and it is certainly possible (if unlikely) that non-pastoralist smelters travelled between pastoralist communities as itinerant specialists. It is difficult to address this scenario without relying too heavily on the ethnographic record. However, Brown (1995: 49) suggests that it was smiths rather than smelters who were in a position to take their trade further afield, and that these smiths tended to expand into areas which were lacking in sources of ore in order to find a ready market for their iron. Hodder's (1982: 59-68) ethnoarchaeological work around Lake Baringo also reminds us that pastoralist smiths traded with farming communities in the early 1980s, and in some cases their products spread quite widely geographically, even though his data suggest that specific ethnic communities generally preferred the products of their own smiths over those from adjacent communities. The possibility that pastoralist smiths were suppliers of iron products to farming groups in the past, therefore, should not be ruled out. Taking all this into account, we argue that the furnaces excavated in Lolldaiga are likely to be associated with the pastoralist populations present in Laikipia in the later centuries of the second millennium AD. Considering the limited volume of comparative material that is currently available regarding pastoralist iron smelting technologies, it is not possible to conclusively link these furnaces with one or more pastoralist groups, however, the dating of the sites to the second half of the second millennium AD means that an association with Maa-speaking Laikipiak is possible.

The function of the small pits in the furnaces at Cattle Dip is not clear, and it is presumed that they served no technical purpose regarding the physical reduction of the iron ore. Without the presence of medicine pots or other suggestive associated finds, it is impossible to know for certain whether these pits were used for ritual purposes, although as yet no sub-furnace pits have been recorded ethnographically as having any other purpose (Killick 2004). Unfortunately, many of the materials that have been recorded as being used as ritual medicines in the context of smelting, such as blood, bark, leaves, milk and so on, would often leave little trace in the archaeological record. If these pits are believed to be receptacles for ritual medicines, it is interesting that they occur at only one of the two sites under discussion here, especially considering the sites' close geographical and temporal proximity to each other, and the technical similarities that have been dealt with above. The critical importance of ritual activity to the outcome of a smelt has been well documented ethnographically (e.g. van der Merwe and Avery 1987; Goucher 2014), and it seems unlikely that ritual elements would only be undertaken intermittently by a group of smelters. However, Schmidt (1997: 245) notes in his ethnographic study of Buhaya smelting practices that there were sometimes disagreements about how rituals were to be executed, and that the extent of ritualisation depended on the perceived threat of failure and thus could vary from smelt to smelt.

One possible explanation of the diversity of furnace types and potential ritualisation found on Lolldaiga might be that they represent evidence for the presence of blacksmiths drawn from different clans or sections during the course of the 17th to 19th centuries. The variation apparent here might thus be a reflection of the possibility for individual discretion in terms of technological style and in the application of ritual behaviour. Clearly, however, a much larger sample of sites needs to be investigated across a larger region to assess such a hypothesis. Finally, it is worth noting that the spatial location of smelting activities away from areas of settlement is consistent with ethnographically recorded practices. However, with such a small sample and a lack of additional contextual data it is too early to tell whether this structuring of space carried the same symbolic load as has been documented among contemporary and recent pastoralists.

Overall, this study has demonstrated high levels of iron working skill in terms of the production of iron in the Laikipia region at a time when pastoralist groups are known to have been expanding across the plateau and adjacent lowland areas (e.g. Waller 1985; Galaty 1993). These processes eventually culminated in a series of intersectional wars in the latter part of the nineteenth century (Weatherby 1967; Sobania 1993), which presumably would have heightened demand for iron weaponry for the purposes of both defence and attack, although research on changing patterns of iron production in pastoralist contexts is at too early a stage to determine what kinds of archaeological signatures such an increased demand might have generated. Nonetheless, by documenting aspects of both the technical and the cultural processes of iron production, the research reported here has, at least, offered a glimpse into what was surely a significant technology prior to the increasing reliance on easily obtainable, commercially-produced mild-steel in the twentieth century (Brown 1995: 45). Hopefully this study will have provided a foundation for future research aimed at gaining a greater understanding of the complexities of pastoralist iron production technologies on a technical basis and also in terms of the economic and social contexts of production. Together, these would add to the emerging picture of the diversity of technological approaches to iron production across pre-colonial Africa.

[1] Although there is debate about the suitability of the terminology 'PN' and 'PIA' (cf. Robertshaw and Collett 1983), these terms are used here to provide a broad socio-economic context of the sites discussed (cf. discussion in Lane 2013).

[2] Based on two dates obtained on charcoal, 1070 ± 110 BP (N-652) and 1300 ± 140 BP (GX-5543) (Ambrose et al. 1984: 83), calibrated to 690-1185 cal. AD (IntCal13) / 768-1224 cal. AD (SHCal13), and 431-1017 cal. AD (IntCal13) / 500-1127 cal. AD (SHCal13) respectively. Other radiocarbon dates on bone apatite and collagen are also available for the site. All dates in the text have been calibrated using OxCal v4.2, with either IntCal13 and/or SHCal13 depending on location relative to the equator (Bronk Ramsey 2009; Hogg et al. 2013; Reimer et al. 2013) and are cited at 95.4% probability (2 sigma). All uncalibrated radiocarbon ages are presented as years BP; calibrated dates are reported as cal. AD.

[3] 1295 ± 140 BP (GX-9936) (Ambrose 1998: 381), calibrated to 431-1019 cal. AD (IntCal13) / 524-1130 cal. AD (SHCal13).

[4] 179 ± 24 BP (OxA-18884), calibrated to 690-1185 cal. AD (IntCal13).

[5] 607 ± 30 BP (Wk-24682), calibrated against IntCal13.

[6] Indeed, obsidian is still used in ritual contexts by the Maasai (J. Galaty pers. comm. 2010).

[7] 300 ± 80 BP (Y-1395) and 300 ± 60 BP (Y-1396), calibrated against IntCal13.

[8] While not identical, this bears some similarity to the iron-working craft castes found in many parts of West Africa (see e.g., Tamari 1991, 2012; Baroin 2012) and the Horn of Africa (see e.g., Finneran 2003; Haaland et al. 2004).

[9] In some areas they constituted distinct clans, such as the Kipuyoni (Hollis 1905: 330; Huntingford 1931: 263).

[10] Such as Mukogodo, who are known historically to have been specialist hunter-gatherers (Mutundu 1999), and ethnographically to have supplied Samburu with pottery that is quite similar to Kisima ware (Brown 1989: 77-8). For an account of recent pottery manufacture by 'Dorobo' groups on the adjacent Leroghi Plateau, see Grillo (2012).

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