Chapter 2
Origins and Development of Africa's Preindustrial Mining and Metallurgy

Introduction

From antiquity, Africa has been simultaneously a continent of similarities and differences. Geographically and to some extent culturally, Africa can be divided into discrete regions: West, Central, East, and Southern Africa, as well as the Horn and North Africa including Egypt. Egypt, North Africa and the Horn have a long history of participation in the metallurgical, ceramic, glass and other high temperature technological traditions of the Near East and the Mediterranean worlds. Other regions, primarily in sub-Saharan Africa, form a distinctly different area, which, although interacting with North Sahara, particularly after 500 BC (see Stahl 2014a and references therein), forms a distinct cultural and technological block.

Egypt and adjacent regions closely mimic the metallurgical trajectories of the nearby Middle East. Egyptian metallurgy started with the working of copper around 4000 BC. By 3000 BC, the Bronze Age was fully established with iron appearing much later in the last millennium BC (Scheel 1989). Because Egypt had cultural interactions with regions to the south of the Nile, metallurgy was established in Nubia by 2600 BC (Emery 1963). Iron smelting appeared much later in Egypt (c. 600 BC; Scheel 1989) when compared to the rest of the Middle East and was established even later (c. 500 BC) at places such as Meroe in the Sudan (Rehren 2001). In North Africa, the Phoenician settlements at Carthage were established by 600 BC (Fig. 2.1). The development of metallurgy in Carthage is not clearly understood, but it is clear that by 600 BC or shortly after, Carthaginians worked iron, copper and bronze (Alpern 2005).

Sub-Saharan Africa differs from this picture in that metallurgy in this part of the continent began with the working of iron and in some cases iron and copper (Holl 2009). This is especially true in West Africa, Central Africa, East Africa and Southern Africa. The advent of metallurgy in sub-Saharan Africa is a highly contentious topic because for every possibility, there are two or more contradictions (Craddock 2010). Metallurgy in West, East and Central Africa began sometime between 800 and 400 BC in the radiocarbon black hole created by fluctuations in atmospheric concentration of radiocarbon (Clist 2013; Killick 2004a). In Southern Africa,

S. Chirikure, *Metals in Past Societies,* SpringerBriefs in Archaeology,
DOI 10.1007/978-3-319-11641-9_2

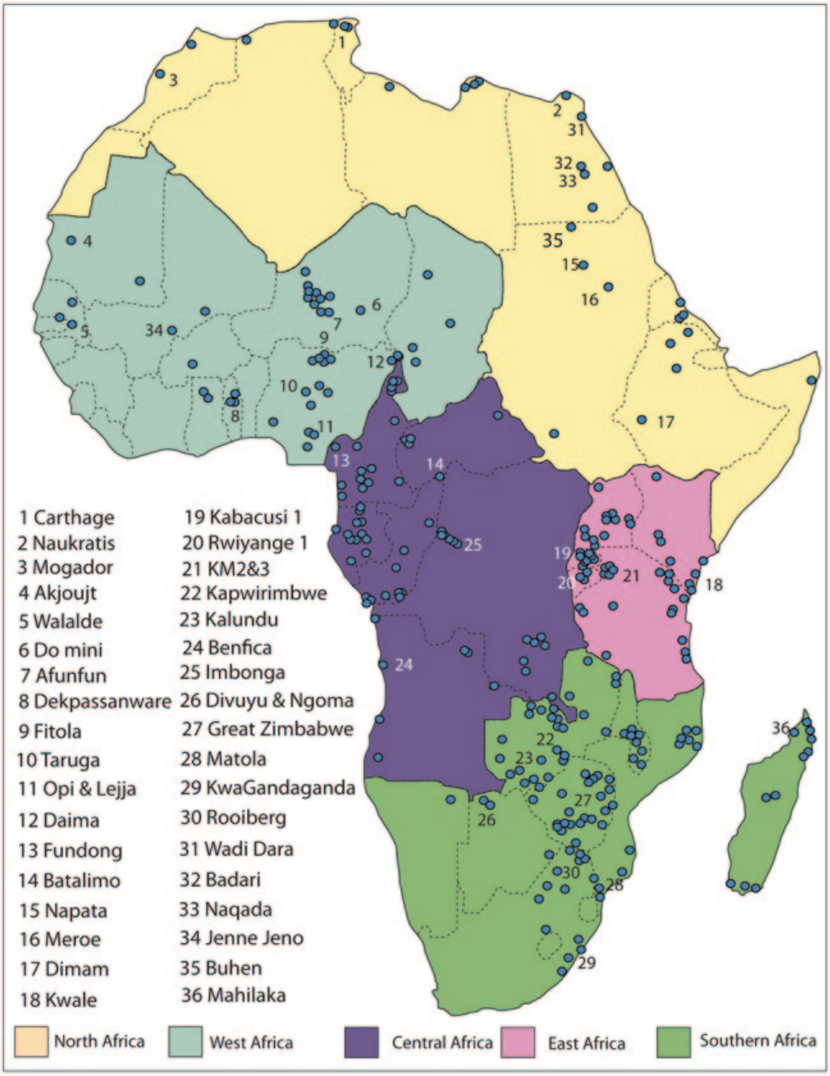

Fig. 2.1 Map of Africa showing metalworking sites with some of the most important highlighted by number

metallurgy only appeared with the advent of agriculturalists early in the first millennium AD (Phillipson 2005). After almost a thousand years, bronze and gold made their appearance in sub-Saharan Africa when the region was directly integrated into the Islamic trade via the Sahara and the Indian Ocean littoral. This difference with the picture north of the Sahara precipitated the development of a raging and largely unresolved debate regarding the origins of sub-Saharan African metallurgy, particularly whether it is local or external in origin (Alpern 2005). Whatever the case maybe, the differences in the adoption of metallurgy in Africa's different regions provide important lessons for innovation, technology transfer and cultural interaction. Once established, metallurgy was neither static nor homogenous throughout antiquity. It developed locally and regionally, creating a very richly varied history of local innovation and cross-cultural borrowing.

Origins of Metallurgy in Egypt and Adjacent Areas

The earliest evidence for metallurgy in Africa comes from the Nile Delta in Egypt and is associated with the Maadi culture dating between 4000 and 3200 BC (Killick 2014a; Scheel 1989). Evidence suggests that copper substituted for flint as the raw material for making heavy-duty tools during this period. The paucity of copper deposits in this area coupled to its proximity to the Sinai Desert and Southern Jordan presents a persuasive but untested hypothesis that the copper of the Arabah Desert was used by Maadi people. Elsewhere in Egypt, rare ornaments and implements of copper metal were recovered in the middle Nile during the Badarian period (ca. 4400–4000 cal BC). However, no archaeometallurgical studies were carried out to determine whether they were made of smelted or native copper (Killick 2014a). Still in the middle Nile, although copper oxides were used in the Naqada I period (4000–3500 cal BC), heavy-duty copper tools such as axes and blades were more common during the Naqada II phase (3500–3200 cal BC) (Scheel 1989). The ore used to make these objects probably came from the lower Nile near Nubia. Gold and silver also appear at low frequency in Naqada II graves (Midant-Renes 2000). It is possible that some if not all of this gold came from the Eastern Desert and later from Nubia (Klemm et al. 2003).

Copper and gold artefacts initially appeared in lower Nubia (the region between the First and Second Cataracts) in graves of the Middle A Group, which are dated from ca. 3600–3300 cal BC (Killick 2014a). These are associated with Naqada pottery and other items of Egyptian provenance, suggesting that they too were imported. By 3000 cal BC, copper beads, awls and pins were found as far south as the Third Cataract. Interestingly, it appears as if all cutting implements were still made of stone. The earliest evidence of the production of metals in Nubia is from Old Kingdom contexts (ca. 2600 BCE) at Buhen (Emery 1963) and within the temple precinct further upstream at Kerma, in contexts dated by radiocarbon to 2200–2000 cal BC. Ancient Egyptians forged meteoric iron (iron in its native state) from c. 3000 BC onwards to produce beads and other decorative items (Rehren et al. 2013). Indeed, sporadic iron objects were found at Egyptian sites, but it is generally accepted that iron smelting began in Egypt after its invasion by the Assyrians in 691 BC. Iron smelting then gradually filtered down the Nile to Kerma, Meroe and other places and was well established by c. 500 BC. Craddock (2010) argues that given the antiquity of its metallurgy, Kerma is a possible source of sub-Saharan metallurgy but more research is required to substantiate this thinking.

The Phoenicians are credited with introducing knowledge of metallurgy to North Africa, particularly to modern-day Tunisia and Libya. Around 1101 BC, the Phoenicians established the trading port of Utica in Tunisia and by 814 BC had established Carthage nearby (Alpern 2005). There is a great deal of debate regarding the metallurgical history of Carthage, but it is clear that iron was worked together with copper and bronze by 300 BC. Alpern (2005) cites unsubstantiated reports of iron smelting at Carthage dating to 800 BC. Unless corroborated by written texts, this dating too may be affected by the radiocarbon 'black hole' where the calibration curve flattens between cal 800 and 400 BC resulting in uncertain dates (Killick 2014a) and, like similar dates elsewhere in Africa, must be treated with caution. Seemingly, Phoenician ventures into the western Mediterranean were motivated by a desire to identify sources of gold, silver, copper and tin for trade purposes. This was crucial because the Egyptians had virtual monopoly over the gold from Nubia and the Eastern desert. Although copper is available at Akjoujt in Mauretania and tin in Niger's Aïr Mountains, it seems that Phoenicians never knew of these sources, preferring the tin of Cornwall that is believed to have featured in Carthaginian trade (Alpern 2005). Carthage features strongly in debates over origins of sub-Saharan metallurgy, with proponents of external origins speculating that it may have been a conduit in knowledge transfer. I return to this point after presenting the evidence for early metallurgy in sub-Saharan Africa.

Ethiopia and Eritrea are poorly understood as far as the development of metallurgy is concerned (Mapunda 1997; Phillipson 2005). It has been suggested that the Horn of Africa follows the progression witnessed in Egypt, Nubia and Arabia. As such, gold, copper, and silver and bronze were known in Ethiopia by the last centuries BC. Aksum witnessed the height of its power from the early first millennium AD and minted its own coinage in gold and silver (Phillipson 2005, p. 230). The beginning of iron working in Ethiopia was also late relative to adjacent regions, starting around cal 300 BC (Mapunda 1997). Indeed, the available evidence suggests close interaction between the Kingdom of Kush in its various stages and the Horn of Africa on the one hand and Egypt and the Mediterranean world on the other via the Red Sea trade.

Metal from Somewhere: On the Origins of Metallurgy in West, Central and East Africa

In the studies of Africa's later prehistory, no topic evokes as much debate and emotion as the origins of sub-Saharan metallurgy (Alpern 2005; Zangato and Holl 2010 and responses therein). When compared to the Middle East and the adjacent Balkans, which are widely believed to be independent centres of metallurgy (Radivojević et al. 2010), sub-Saharan metallurgy started simultaneously with the working of copper and iron (Van der Merwe and Avery 1982) (Table 2.1 & Fig. 2.1). The pathway to metallurgy in Middle Eastern and Balkan centres of metallurgical origins, as well as in Egypt, began with the intentional heating of oxide and carbonate copper

Table 2.1 shows some of the earliest dates for the appearance of metallurgy in Africa. Calibrated using OxCal version 4.2.3 Bronk-Ramsey (2013) and IntCal13 (Reimer et al. 2013)

Site name	Lab nos.	Uncalibrated dates	Calibrated dates at 95 % confidence interval	Sources
Termit Massif, Niger				
Do Dimmi 16 a M Do Dimmi 15 a F	UPS IFAN	2590 ± 120 2630 ± 120	978–404 BC 1031–410 BC	Person and Quenchon 2004, p. 122
Gara Tchia Bo 48 E	Pa 810	3260 ± 100	1770–1290 BC	Person and Quenchon 2004, p. 122
Gara Tchia B 48 W	Pa 811	3265 ± 100	1775–1294 BC	Person and Quenchon 2004, p. 122
Tchire Ouma 147	Pa 320	3300 ± 120	1895–1370 BC	Person and Quenchon 2004, p. 122
Termit Ouest 96 b M	Pa 481	3100 ± 100	1611–1107 BC	Person and Quenchon 2004, p. 122
Termit Ouest 8-b	Pa 688	2880 ± 120	1322–819 BC	Person and Quenchon 2004, p. 122
Nsukka Region, Nigeria				
Opi	OxA-3201	2305 ± 90	596–166 BC	Okafor 1993, p. 347
	OxA2691	2170 ± 80	396–40 BC	Okafor 1993, p. 347
	Oxa3200	2080 ± 90	361 BC–70 AD	Okafor 1993, p. 347
Lejja	Ua 34416	1715 ± 35	244–398 AD	Eze-Uzomaka 2013
	Ua 34417	2370 ± 40	545–380 BC	Eze-Uzomaka 2013
	Ua 34415	4005 ± 40	2631–2458 BC	Eze-Uzomaka 2013
Taruga	BM938	2541 ± 104	846–403 BC	Calvacoressi and David 1979
Taruga	BM942	2291 ± 123	596–98 BC	
Togo				
Dekpassanware	Beta 252674	2970 ± 40	1297–1051 BC	De Barros 2013
Cameroon				
Olinga	Beta 31414	2820 ± 70	1131–827 BC	Essomba 2004, p. 140

Table 2.1 (continued)

Site name	Lab nos.	Uncalibrated dates	Calibrated dates at 95 % confidence interval	Sources
	Ly4978	2380±110	792–347	Essomba 2004, p. 140
	Ly4979	1954± 250	544 BC–590 AD	Essomba 2004, p. 140
	Beta 31412	1860±70	2–345 AD	Essomba 2004, p. 140
Central African Republic				
Obui	Pa 2223	3645±35	2136–1921 BC	Zangato and Holl 2010
Obui	Pa 2130	3635±35	2058–1903 BC	Zangato and Holl 2010
Gbabiri	Pa 1446	2670±40	898–797 BC	Zangato and Holl 2010
Rwanda				
Rwiyange	HV 1296	2250±125	593–20 BC	Van Grunderbeek et al. 2001
Mozambique				
Matola	R1327	1880±50	19–246 AD	Huffman 2007, p. 163
	St8546	1720±110	70–550 AD	Huffman 2007, p. 163
South Africa				
Silver leaves	Pta 2360	1760±50	137–386 AD	Huffman 2007, p. 163
	Pta 2459	1700±40	246–416 AD	Huffman 2007, p. 163
Broederstroom	KN 2643	1600±50	344–569 AD	Huffman 2007, p. 163
		1350±80	547–880 AD	Huffman 2007, p. 163
Zimbabwe				
Mabveni	SR79	1380±110	425–886 AD	Huffman 2007, p. 163
Gokomere	SR26	1420±120	386–886 AD	Huffman 2007, p. 163

ores in temperature- and environment-regulated apparatuses to gain a usable product (Craddock 1995; Pernicka et al. 1997; Radivojević et al. 2010; Scheel 1989). The Bronze Age started with the working of arsenical copper followed by the alloying of tin with copper to produce bronze, with the more complicated iron appearing around 1500 BC (Tylecote 1976; Craddock 2000). Egypt and areas under its influence along the Nile broadly followed this trajectory of copper, bronze and iron transition. Gold and other metals such as lead were also worked during this time, such that a long-distance trade had evolved by 2000 BC. Despite its advantages, iron was not universally accepted in the Middle East because Egypt only fully embraced it around 700 BC, more than six centuries after its adversaries, neighbours and trading partners adopted it (Craddock 2000; Holl 2000). The Cushite Egyptian Pharaohs were defeated by iron-armed Assyrians in 691 BC. This supports the argument that the adoption of metallurgy, such as technology in general, is culturally mediated; no matter how many perceived advantages there are, society determines what is and what is not acceptable.

The path to metallurgy in the Middle East and adjacent regions indicates that discovery and innovation followed the easiest methods through which the very first metals could be worked (Craddock 2010). Such a picture partly intersects with the laws of physics and chemistry as summarized by the Ellingham diagram (Fig. 2.2) which presents the temperature at which oxide ores are reduced to metal in relation to the levels of carbon monoxide sufficient for reduction. According to Killick (2014b), pioneer metals such as copper and tin could be easily reduced at low temperatures, while latecomers such as iron required much higher temperatures and delicate control of furnace atmosphere to reduce their ores. Following a technical logic, this seems to account for why copper and tin were smelted earlier than iron. However, it is not just a temperature issue, but also one of redox–carbon monoxide is not strong enough to reduce 'modern' metals (Th. Rehren pers comm 2014).

The Ellingham diagram does not fully explain the sequence of metallurgical innovation in antiquity (Killick 2014b, p. 35). For example, metals such as cobalt and nickel (Fig. 2.2) have a lower melting point when compared to iron and are reducible at even lower temperatures. Yet, they were only smelted in the nineteenth century. In fact, nickel is more abundant than copper in the earth's crust, while cobalt is more abundant than lead (Killick 2014b). There are many possibilities that account for why nickel and cobalt were not smelted in the known centres of metallurgical origins. The most important one is that nickel and cobalt oxides are quite soluble in water and thus are almost never found in gossans (intensely oxidized, weathered and exposed/upper part of an ore deposit or mineral vein), making the fact that nickel and cobalt oxides are relatively easy to reduce irrelevant and there were no oxide or carbonate ores of these elements available (Killick 2014b). This also demonstrates that laws of physics and chemistry do not always fully explain the evolution of cultural phenomena. In fact, the laws themselves are cultural phenomena which were discovered at various points, explaining why most metals were discovered much later, and most of them not in any order that respects the known affinities between them.

In sub-Saharan Africa, tin, bonze and gold were worked more than a millennium after iron and copper were introduced. This period coincided with the integration of the subcontinent into the fledging long-distance trading network rooted in the Persian Gulf and the Indian subcontinent (Miller and Van der Merwe 1994). The big question, therefore, is where did knowledge of metalworking in sub-Saharan Africa

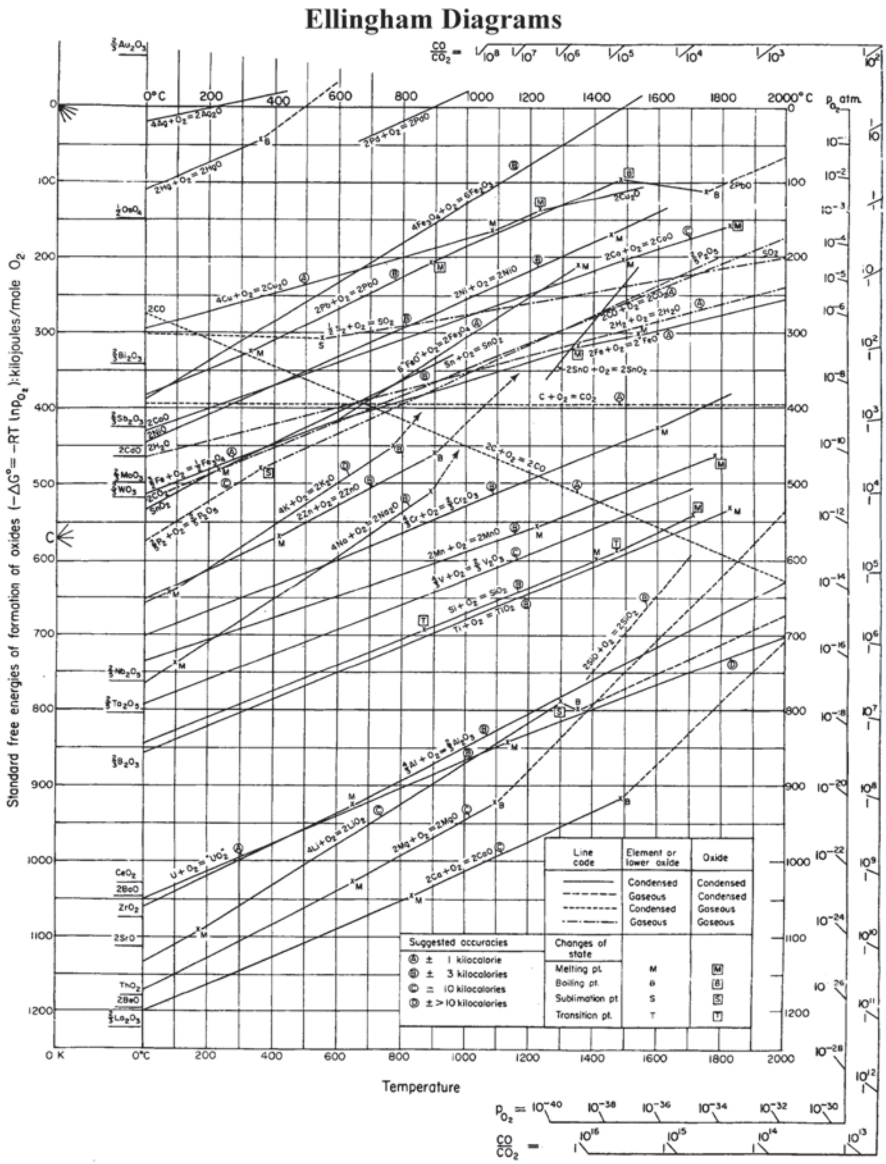

Fig. 2.2 Ellingham diagram shows the ease with which metals and sulphides can be reduced. The position of the line for a given reaction on the Ellingham diagram shows the stability of the oxide as a function of temperature. Reactions closer to the *top* of the diagram are the most 'noble' metals (for example, gold and platinum), and their oxides are unstable and easily reduced. Moving towards the *bottom* of the diagram, metals become progressively more reactive and their oxides harder to reduce

originate? Is it local or external in origin? As a follow on, what are the mechanisms for the dispersal of knowledge of metallurgy across the sub-Saharan latitudes? Based on thermodynamic theory and the lateness with which the continent embraced metallurgy in comparison with regions such as the Middle East (Fig. 2.2), one school of thought argues that knowledge of West and East African metalworking was external in origin (Killick 2004a; McIntosh and McIntosh 1988; Phillipson 2005).

The fulcrum of this position is that it is very difficult to start smelting a technically complicated metal such as iron without exposure to easier metals or comparable pyrotechnology as illustrated by the Middle Eastern trajectory (Craddock 2000; Killick 2014a). Furthermore, there are technical problems with early dates for West and East African metallurgy which may have been affected by the old wood problem (Alpern 2005) and the problems with calibration for dates falling between 800 and 400 BC. The old wood problem emanates from the fact that some of the trees in sub-Saharan Africa lived for long periods due to the gradual desertification of the Sahara between 4500 and 2000 BC (Childs and Herbert 2005; Killick 1987). If charcoal from old wood was used for smelting and subsequently dated by archaeologists, the dates produced reflect when the trees died and not necessarily the metalworking episodes. This has led to a rejection of most of the early dates for African metallurgy, some of which were additionally compromised by uncertainty of contexts (Clist 2013). Then there is the fact that the calibration curve flattens between 2300 and 2600BP which gives a very long tail between 800 and 400 BC and with that a great deal of uncertainty (Alpern 2005). It has long been advocated that researchers must use alternative dating techniques such as luminescence dating (Killick 2004a) though few have heeded the call (Darling 2013).

If West, Central and East African metallurgy emerged from outside, as posited by the external origins theory, what transmission routes did it follow? The site of Akjoujt in Mauritania has yielded copper working objects dating to 800 BC, suggesting a possible introduction from Morocco and a copper to iron transition (Miller and Van der Merwe 1994). However, earlier thoughts suggested that Egypt and Carthaginian settlements in North Africa were possible conduits for a north-to-south transmission of knowledge (Childs and Herbert 2005). Alpern (2005) believes that iron working was well established at Carthage by c. 800 BC, making it possible that West African metallurgy diffused from there. The only problem on the basis of current knowledge is that the dating is not universally agreed on and that iron became established in Egypt after the invasion by Assyrians in 691 BC (Scheel 1989). Furthermore, the evidence for the appearance of iron in Carthage postdates that of the supposedly receiving areas of West Africa (Darling 2013: 158; Eze-Uzomaka 2013, p. 4). Another conundrum is the many outward differences between the furnace types used in Egypt, Carthage and other possible source areas when compared to those utilized at places such as Taruga in Nigeria (Tylecote 1975). If the sub-Saharans obtained knowledge of metallurgy from Carthage, Egypt or somewhere, then the rapidity with which they adapted the technologies to the local situations, without evident experimentation, thereby distinguishing their technology from its sources at the same time they were adopting it, is remarkable.

These anomalies became fodder for viewpoints that consider African metallurgy to be local in origin. The local origins hypothesis contends that because Africa has always been a centre of technological development throughout human history, there is no reason why metallurgy could not have been independently developed here.

More importantly, various communities on the African continent were aware of the transformative potential of fire since the middle Pleistocene times. The local origins viewpoint seemed to gain momentum in the late 1970s and early 1980s when Danilo Grébénart and his team excavated significant sites with evidence of early metallurgy in the Agadez region of Niger (Grébénart 1987). The dating evidence, when combined with archaeometallurgical analyses of remnant furnaces and slags, seemed to indicate that there was an earlier Copper Age, named Copper 1 (2000–1000 BC), followed by a later Copper 2 (1000 BC) phase. According to Grébénart (1987), iron working started in the Copper 2 period, suggesting that in similar fashion to other areas in the Old World, African metallurgy started with an apprenticeship phase of copper working, followed by smelting of the more technically complicated iron. This seemed to refute the argument that Africans could not have developed metallurgy independently because they lacked experience with an easier metallurgy. However, a meticulous re-investigation of the Agadez material by Killick et al. (1988) demonstrated that what were thought to be remnant furnaces associated with Grébénart's Copper 1 period were vitrified tree stumps. The re-examination further highlighted that all reliable evidence of metallurgy dated to the Copper 2 period, later than 1000 BC. For a while, the critique of this evidence seemed to tilt the pendulum into the direction of external origins.

More recently, indications from the work carried out by Zangato and others in Central Africa seem to challenge again the external origins thinking. Excavations at places such as Ôboui in the Central African Republic revealed artefacts and forges which were dated to a much earlier time period, between 2300 and 1900 cal B.C.—long before the Anatolians were working iron (Zangato and Holl 2010). Archaeometallurgical studies of the microstructure of iron objects revealed that they were made of bloomery iron. This Central African evidence generated intense debate, with critics arguing that although the dates formed a nice cluster, they were probably from old wood. Furthermore, it was argued that given the acidic nature of soils in tropical Africa, the iron objects seem remarkably well preserved for their age (Clist 2013). Other authorities such as Craddock (2010) dismissed the possibility that Africa started its own metallurgy with iron, suggesting that this is about as likely as a baby walking without first crawling.

While scholars continue to debate the relevance of these dates, a set of dates from the Leija sites in Nsukka Nigeria has not yet been considered in full. These dates are Ua-34415, 4005 ± 40, and Ua-37422, 3445 ± 40 (Eze-Uzomaka 2013). The Leija date Ua-34415 calibrates to the second millennium BC and was obtained from charcoal embedded in slag in a stratified context over a meter deep. Clist (2013) notes that the Nsukka dates are some of the best in terms of association between the dated material and the events of metalworking. Also in Nigeria, Darling (2013) dated samples of fired slag pit furnaces at the Durham Thermoluminescence Laboratory, producing very early dates of 2400 BC ± 1100 for Fitola (Dur TL57–2AS) and 1400 BC ± 850 (Dur TL57–3AS) for the site of Matanfada in the Hausaland area of Northern Nigeria. The Durham TL dates require some comment because they have unusually very high error terms. According to Darling (2013), the laboratory could not find any sources of error and control samples are currently being dated. Until this dating is properly resolved, the Fitola dates must be viewed with caution.

http://www.springer.com/978-3-319-11640-2

Metals in Past Societies
A Global Perspective on Indigenous African Metallurgy
Chirikure, S.
2015, XXI, 166 p. 65 illus., 44 illus. in color., Softcover
ISBN: 978-3-319-11640-2