

## DID THEY OR DIDN'T THEY INVENT IT? IRON IN SUB-SAHARAN AFRICA

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### I

Judging from a number of recent publications, the long-running debate over the origins of iron smelting in sub-Saharan Africa has been resolved... in favor of those advocating independent invention. For Gérard Quéchon, the French archeologist to whom we owe very early dates for iron metallurgy from the Termit Massif in Niger, “indisputably, in the present state of knowledge, the hypothesis of an autochthonous invention is convincing.”<sup>1</sup> According to Eric Huysecom, a Belgian-born archeologist, “[o]ur present knowledge allows us . . . to envisage one or several independent centres of metal innovation in sub-Saharan Africa.”<sup>2</sup>

Hamady Bocoum, a Senegalese archeologist, asserts that “more and more numerous datings are pushing back the beginning of iron production

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<sup>1</sup>Gérard Quéchon, “Les datations de la métallurgie du fer à Termit (Niger): leur fiabilité, leur signification” in Hamady Bocoum, ed., *Aux origines de la métallurgie du fer en Afrique: une ancienneté méconnue* (Paris, 2002), 114. The same statement is found in an almost identical chapter with the same title by Quéchon in *Mediterranean Archaeology* 14 (2001) (hereafter *Meditarch*), 253. That issue is titled “The Origins of Iron Metallurgy: Proceedings of the First International Colloquium on the Archaeology of Africa and the Mediterranean Basin Held at the Museum of Natural History in Geneva, 4-7 June, 1999.” UNESCO published an English translation of Bocoum’s book in 2004 under the title *The Origins of Iron Metallurgy in Africa: New Light on Its Antiquity—West and Central Africa.*

<sup>2</sup>Eric Huysecom, “The Beginning of Iron Metallurgy: From Sporadic Inventions to Irreversible Generalizations,” *Meditarch*, 3.

in Africa to at least the middle of the second millennium BC, which would make it one of the world's oldest metallurgies." He thinks that "in the present state of knowledge, the debate [over diffusion vs. independent invention] is closed for want of conclusive proof accrediting any of the proposed transmission channels [from the north]."<sup>3</sup> The American archeologist Peter R. Schmidt tells us "the hypothesis for independent invention is currently the most viable among the multitude of diffusionist hypotheses."<sup>4</sup>

Africanists other than archeologists are in agreement. For Basil Davidson, the foremost popularizer of African history, "African metallurgical skills [were] locally invented and locally developed."<sup>5</sup> The American linguist Christopher Ehret says

Africa south of the Sahara, it now seems, was home to a separate and independent invention of iron metallurgy . . . To sum up the available evidence, iron technology across much of sub-Saharan Africa has an African origin dating to before 1000 BCE.<sup>6</sup>

The eminent British historian Roland Oliver thinks that the discovery of iron smelting "could have occurred many times over" in the world and that African ironworking probably originated in the northern one-third of the continent.<sup>7</sup> The equally eminent Belgian-American historian Jan Vansina took the rather extreme position that "[i]ron smelting began in several places at about the same time," naming the western Great Lakes

<sup>3</sup>Hamady Bocoum, "La métallurgie du fer en Afrique: un patrimoine et une ressource au service du développement" in Bocoum, *Origines*, 94, 97.

<sup>4</sup>Peter R. Schmidt, "Cultural Representations of African Iron Production" in Schmidt, ed., *The Culture and Technology of African Iron Production* (Gainesville, 1996), 8. See also Pierre de Maret, "L'Afrique centrale: Le `savoir-fer'" in Bocoum, *Origines*, 125; François Paris, Alain Person, Gérard Quéchon, and Jean-François Sal- iège, "Les débuts de la métallurgie au Niger septentrional: Aïr, Azawagh, Ighazer, Termit," *Journal des Africanistes* 72(1992), 58; Schmidt and D.H. Avery, "More Evidence for an Advanced Prehistoric Iron Technology in Africa," *Journal of Field Archaeology* 10(1983), 428, 432-34; Candice L. Goucher, "Iron Is Iron 'Til It Is Rust: Trade and Ecology in the Decline of West African Iron-Smelting," *JAH* 22(1981), 180; John A. Rustad, "The Emergence of Iron Technology in West Africa, with Special Emphasis on the Nok Culture of Nigeria" in B.K. Swartz and R. Dumett, eds., *West African Culture Dynamics: Archaeological and Historical Perspectives* (The Hague, 1980), 237.

<sup>5</sup>Basil Davidson, *West Africa Before the Colonial Era: A History to 1850* (London, 1998), 8.

<sup>6</sup>Christopher Ehret, *The Civilizations of Africa: a History to 1800* (Charlottesville, 2002), 161. Curiously, he suggests African iron metallurgy was developed in two places, northern Nigeria/Cameroon and the Great Lakes region, while ignoring Niger, source of the earliest available dates.

<sup>7</sup>Roland Oliver, *The African Experience* (New York, 1991), 65.

area, Gabon, the Termit Massif, the Taruga site in central Nigeria and the Igbo region in southeastern Nigeria. He maintained that “[a] simple dispersal even from Taruga to the Igbo sites not far away is excluded because different types of furnaces were used.”<sup>8</sup>

In the concluding chapter of UNESCO’s recent book on the subject, the Senegalese-born scholar Louise-Marie Maes-Diop surveys the beginnings of iron metallurgy worldwide and finds “the earliest vestiges of reduced ore” in eastern Niger, followed by Egypt.<sup>9</sup> But even allowing for some overexuberance on the part of independent inventionists, the case is closed. Or is it?

## II

The idea that sub-Saharan Africans independently invented iron is more than a century old. It goes back at least to a German scholar, Ludwig Beck, who published a five-volume history of iron between 1884 and 1903. In the first volume he wrote: “. . . [w]e see everywhere an original art of producing iron among the numerous native tribes of Africa, which is in its entire essence not imported but original and . . . must be very old.”<sup>10</sup> Around the same time some Egyptologists, notably the Frenchman Gaston Maspéro, concluded that ancient Egypt had learned its ironworking from black Africans to the south.<sup>11</sup> The German Felix von Luschan, better known among Africanists for his writings on the art of old Benin, also thought sub-Saharan Africans originated iron technology, as did the British metallurgist William Gowland.<sup>12</sup>

<sup>8</sup>Jan Vansina, “Historians, Are Archeologists Your Siblings?” *HA* 22(1995), 395. See also John Thornton, *Africa and Africans in the Making of the Atlantic World, 1400-1800* (2d ed.: Cambridge, 1998), 46; P.T. Craddock and J. Picton, “Medieval Copper Alloy Production and West African Bronze Analyses—Part II,” *Archaeometry* 28(1986), 6; Ralph A. Austen and Daniel Headrick, “The Role of Technology in the African Past,” *African Studies Review* 26(1983), 165-68.

<sup>9</sup>Louise-Marie Maes-Diop, “Bilan des datations des vestiges anciens de la sidérurgie en Afrique: l’enseignement qui s’en dégage” in Bocoum, *Origines*, 189. Thirty-four years earlier Maes-Diop had written that “in all probability, iron metallurgy on the African continent is autochthonous and was not introduced through external influences,” but hers was a lonely voice then. L.-M. Diop, “Métallurgie traditionnelle et âge du fer en Afrique,” *BIFAN* 30B(1968), 36.

<sup>10</sup>Ludwig Beck, *Die Geschichte des Eisens in technischer und kulturgeschichtlicher Beziehung* (5 vols.: Braunschweig, 1884-1903), 1:335. I am grateful to Adam Jones for the quotation.

<sup>11</sup>Gaston Maspéro, “Les forgerons d’Horus,” *Anthropologie* 2(1891), 405-07.

<sup>12</sup>Felix von Luschan, “Eisentechnik in Afrika,” *Zeitschrift für Ethnologie* 41(1909), 22ff.; William Gowland, “The Metals in Antiquity,” *Journal of the Royal Anthropological Institute* 42(1912), 285.

This theory has been explained in two opposite ways. Bocoum says it was based mainly on the originality of African ore reduction processes and furnace and bellows forms.<sup>13</sup> Canadian archeologist François J. Kense suggests, instead, that eighteenth- and nineteenth-century European visitors found African iron metallurgy seemingly so primitive they reasoned it must have preceded the more advanced technology of Eurasia.<sup>14</sup>

Other Egyptologists, assuming that the great stone works of antiquity could not have been built without iron tools, thought the Egyptians themselves invented the technology.<sup>15</sup> This idea was carried to an extreme in the early decades of the twentieth century by Grafton Elliot Smith, who contended that *all* "higher" culture originated in Egypt. Later in the century, the Senegalese savant Cheikh Anta Diop agreed that Egypt was *the* cradle of civilization. He was sure that iron metallurgy originated in Egypt's Old Kingdom *ca.* 2600 or 2700 BCE.<sup>16</sup> But, whereas Smith was scornful of black Africans, Diop insisted that the ancient Egyptians themselves were black, and this would become an article of the Afrocentric creed.

As late as mid-century the idea that ironworking had begun somewhere in Africa was still being propagated, but by then the tide had turned.<sup>17</sup> Decades of research had revived and reinforced the classical belief that iron smelting originated in Anatolia, possibly among a people called the Chalybes, and that it was developed further in the same region by the Hittites. It was accepted that meteoritic iron was shaped into small objects in Egypt as early as predynastic times, and that some crude items, contrasting with sophisticated imports from Anatolia or Syria, were made locally of native iron in the second half of the second millennium BCE.

However, Egyptologists and metallurgists reached general agreement that Egypt was not the first, and may even have been the last, country of

<sup>13</sup>Hamady Bocoum, "Aux origines de la métallurgie du fer en Afrique de l'Ouest," *Meditarch*, 235.

<sup>14</sup>François J. Kense, *Traditional African Iron Working* (Calgary, 1983), 5. See also A.L. Kroeber, *Anthropology: Race, Language, Culture, Psychology, Prehistory* (rev. ed.: New York, 1948), 767.

<sup>15</sup>As far back as 1837 British Egyptologist John Gardner Wilkinson suggested that iron, or even steel, was used for stoneworking in early Pharaonic times but that the tools had rusted away. J.G. Wilkinson, *Manners and Customs of the Ancient Egyptians* (3 vols.: London, 1837), 3:246-47, 249-50.

<sup>16</sup>Cheikh Anta Diop, "La métallurgie du fer sous l'ancien Empire égyptien," *BIFAN* 35B(1973), 532ff.; idem, "L'usage du fer en Afrique," *Notes Africaines* no. 152 (October 1976), 93.

<sup>17</sup>See, for example, Denis-Pierre de Pedrals, *Archéologie de l'Afrique noire* (Paris, 1950), 22-24, 35-36. G.E. Smith's works were being reprinted as late as 1971.

the Near East to shift from bronze to iron for tools and weapons.<sup>18</sup> In other words, the technology moved from north to south, not vice versa. Assyrian invasions in the seventh century BCE are thought to have hastened the adoption of iron. Herodotus found the metal in common use in the fifth century BCE, but there is little written evidence of the smelting of local ores before the Ptolemaic period.

In addition, there was no archeological evidence as yet of very early ironworking in sub-Saharan Africa. At this point the French Africanist Raymond Mauny stepped in with what seemed like a plausible scenario for the transmission of iron technology to, at least, western Africa below the desert.

### III

Mauny started from the solid premise that by *ca.* 1100 BCE the Phoenicians had common knowledge of ironworking. At about the same time they began exploring, then colonizing, the western Mediterranean. According to classical tradition, the port of Utica in modern Tunisia was founded in 1101 BCE and the nearby port of Carthage in 814 BCE. While it is likely the Phoenicians brought their ironworking expertise with them, Mauny noted that iron had not yet been found in Carthaginian tombs before the sixth century BCE, and that iron did not seem to replace bronze for common objects in Carthage until the third century BCE.

From then on, Mauny's theory became almost entirely speculative. He assumed that Carthage passed along its knowledge of iron to the Berber natives of the region around the sixth century BCE, and that they in turn transmitted it to their fellow Berbers in the Sahara. As inveterate warriors,

<sup>18</sup>W.M. Flinders Petrie, *The Arts and Crafts of Ancient Egypt* (Edinburgh, 1909), 104-06; G.A. Wainwright, "The Coming of Iron," *Antiquity* 10(1936), 23; Jean Leclant, "Le fer dans l'Égypte ancienne, le Soudan et l'Afrique," *Annales de l'Est. Actes du colloque international 'Le fer à travers les âges: Hommes et techniques'* (Nancy, 3-6 octobre 1955), 83, 86 ; A. Lucas and J.R. Harris, *Ancient Egyptian Materials and Industries* (4th ed.: London, 1962), 235-43; Paul Huard, "Introduction et diffusion du fer au Tchad," *JAH* 7(1966), 388; Bruce G. Trigger, "The Myth of Meroe and the African Iron Age," *African Historical Studies* 2(1969), 34-36; R.F. Tylecote, *A History of Metallurgy* (London, 1976), 46; H.H. Coghlan, *Notes on Pre-historic and Early Iron in the Old World* (2d ed.: Oxford, 1977), 43; Nikolaas J. van der Merwe, "The Advent of Iron in Africa" in Theodore A. Wertime and James D. Muhly, *The Coming of the Age of Iron* (New Haven, 1980), 465; Kense, *Traditional*, 152-53; Michel Valloggia, "La maîtrise du fer en Égypte: Entre traditions indigènes et importations," *Meditarch*, 195, 197, 204; Michel Wuttmann, "La métallurgie du fer dans l'Égypte ancienne: les données de l'archéologie," *Meditarch*, 207.

these Saharan nomads would have been especially eager to acquire improved weapons made of the new metal. Mauny presumed that the southern Berbers already had black slaves to do their arduous labor and would therefore have employed them to work iron. The technology could then have been taken south to savanna country by slaves fleeing their masters, or deliberately transmitted to the lands of black farmers where both iron ore, especially laterite, and the wood to fuel smelting furnaces were relatively abundant. The blacks could then supply the Berbers with raw metal for ironworking. He tentatively dated this development to 300 BCE.<sup>19</sup>

Mauny offered some linguistic evidence for his model. Derivatives of the Phoenician word for iron, *barzel*, are found in Berber vocabularies throughout the Sahara and also in the Teda (Tubu) language of Tibesti and the Fezzan.<sup>20</sup> Mauny also saw affiliations with the terms for iron among several savanna-dwelling black peoples, including the Bariba, Jukun, and Kanuri.<sup>21</sup> He might have added that Carthaginian influence on the Berbers may be attested to this day by the Tifinagh alphabet of the Tuareg, which is thought by some scholars to derive ultimately from a Punic script.

Mauny's compatriot Henri Lhote, known for his pioneering work on Saharan rock art, took sharp issue with Mauny's reconstruction, unwittingly setting off a debate that has lasted half a century. Saharan Berbers, he wrote, are not metallurgists, and he doubted they *ever* were capable of teaching ironworking to the blacks. Words for iron derived from the Punic root *brzl* generally stop short at the land of the blacks. The high smelting furnaces common in West Africa are not found north of that linguistic/racial divide, and the goatskin bellows of northern Africa are not generally found south of it. Sub-Saharan blacks, he said, have so many different local words for iron that they must have learned about the metal otherwise than through the Saharan Berbers or the Egyptians. "[E]thnographic, linguistic, historical and archeological facts," he concluded, "join in affirming the strictly 'African' character of the iron industry in the black world."<sup>22</sup> And yet Lhote had no more solid information to go on than Mauny.

<sup>19</sup>Raymond Mauny, "Essai sur l'histoire des métaux en Afrique occidentale," *BIFAN* 14B(1952), 577-8. Mauny drew his information about Carthage mainly from Stéphane Gsell, *Histoire ancienne de l'Afrique du Nord* (8 vols.: Paris, 1913-30), 4:74-75; 5:80; 6:77-79.

<sup>20</sup>*Barzel* is still the word for iron in Hebrew.

<sup>21</sup>Mauny, "Essai," 581-82.

<sup>22</sup>Henri Lhote, "La connaissance du fer en Afrique occidentale," *Encyclopédie Mensuelle d'Outre-Mer*, I, fascicule 25 (September 1952), 272. L.-M. Diop later ("Métallurgie traditionnelle," 22) made the interesting point in support of Lhote that usually nomads are educated by their sedentary neighbors and not vice versa.

In rebuttal, Mauny said the lack of iron-smelting evidence in the Sahara was not surprising. Both iron ore and especially wood for charcoal fuel are scarce until the southern limit of the desert is reached around 16° N. Whatever timber was available would have been quickly exhausted, leaving few traces of ironworking. Moreover, as nomads, Saharan Berbers would need or want much less iron than sedentary black farmers to the south. Bellows types are so numerous and mixed in West Africa that they prove nothing. The multiplicity of words for iron in West Africa, he said, reflected the favorable environment for the metal owing to the abundance of ores, fuel, and markets. He compared it to the proliferation of words for camels in the Sahara. Less common metals in West Africa, such as copper and gold, he noted, are designated by fewer words.

Citing an observation by Lhote that the Berber Tuareg sometimes procure their artisans by raiding tribes that possess them, Mauny saw in that “one of the most efficient means that must have been employed by their ancestors in transmitting the iron industry from neighbor to neighbor from the Mediterranean shores to the edge of the black world.” He concluded that both he and Lhote would have to wait until “archeology decides who is right” as between diffusion and independent invention.<sup>23</sup>

For the next quarter-century, Mauny stuck to his theory with some modifications and additions.<sup>24</sup> He eventually believed that iron technology might have crossed the Sahara from Phoenician/Carthaginian colonies in Libya and Morocco, as well as from Carthage itself. As mid-first-millennium-BCE dates for iron metallurgy began coming in from the “Nok Culture” area in Nigeria, he suggested it had crossed the desert earlier and more quickly than previously thought. He linked this technology transfer to introduction of the horse and chariot to the Sahara by Libyco-Berbers beginning around 1000 BCE, and to Saharan rock art showing those nomadic warriors carrying lances that appeared to be of iron. He thought black farmers south of the desert would have sought to arm themselves with the same weapons to resist the invaders. But in the end Mauny admitted that “until there is further archaeological evidence, no positive conclusion is really possible” about the origins of ironworking in West Africa.<sup>25</sup>

<sup>23</sup>Raymond Mauny, “Autour de l’historique de l’introduction du fer en Afrique occidentale,” *Encyclopédie Mensuelle d’Outre-Mer*, III, fascicule 32 (April 1953), 109-10.

<sup>24</sup>Mauny died in 1994 but appears to have stopped writing by 1978.

<sup>25</sup>Raymond Mauny, *Les siècles obscurs de l’Afrique noire* (Paris, 1970), 69, 73; idem, “The Western Sudan” in P.L. Shinnie, ed., *The African Iron Age* (Oxford, 1971), 66-70, 83-84; idem, “Trans-Saharan Contacts and the Iron Age in West Africa,” *Cambridge History of Africa, Volume 2, from c. 500 BC to AD 1050* (Cambridge, 1978), 278-80, 319, 322, 333-35. The quote is from 334-35.

Mauny's theory was widely accepted by fellow Africanists, often with the reservation that, though reasonable, it was unproven.<sup>26</sup> Not only was there no real evidence that Berbers transmitted iron technology across the Sahara, but there was no evidence for early iron metallurgy in Carthage itself, or indeed anywhere in North Africa.

#### IV

Before we go further in quest of the grail of sub-Saharan iron origins, we might usefully pause for a look at the current state of radiocarbon dating because the technique is so vital to this paper. The fabulous carbon-14 breakthrough by Willard Libby in the 1940s opened a new era for archeology. C<sup>14</sup> is found in all organisms and begins decaying at a steady rate when the organism dies. Organic substances thousands of years old could now be scientifically dated by measuring the amount of C<sup>14</sup> remaining in them since death. But by 1968 it was realized that radiocarbon dates were not true calendar dates because the amount of C<sup>14</sup> in the atmosphere, and hence in organisms, fluctuates over time owing to variations in solar cosmic rays. This problem was solved by radiocarbon-dating tree rings whose exact age was determined independently by dendrochronology, the science of tree-ring dating. Radiocarbon dates can currently be corrected into ranges of calendar years by calibration against tree rings for the past 8400 years.

Conventionally, radiocarbon dates are expressed as a year before the present, i.e., BP (or bp), with the "present" fixed at 1950, and there is always a  $\pm$  number representing the statistical uncertainty of measurement at one sigma or standard deviation. Radiocarbon dates can also be expressed as bce or ce simply by subtracting 1950 from the BP date if the latter is more (bce) or subtracting the BP date from 1950 if the former is

<sup>26</sup>See, for example, H. Alimen, *Préhistoire de l'Afrique* (Paris, 1955), 279; Huard, "Introduction," 378-82; Thurstan Shaw, "On Radiocarbon Chronology of the Iron Age in Sub-Saharan Africa," *Current Anthropology* 10(1969), 229; Roland Oliver and Brian M. Fagan, *Africa in the Iron Age c. 500 B.C. to A.D. 1400* (Cambridge, 1975), 9, 48-49, 60-63 (as we have seen, Oliver later changed his mind); R.F. Tylecote, "The Origin of Iron Smelting in Africa," *West African Journal of Archaeology* 5(1975), 4-7; Van der Merwe, "Advent," 476-78; Susan Keech McIntosh and Roderick J. McIntosh, "West African Prehistory," *American Scientist* 69(November-December 1981), 609; François J. Kense, "The Initial Diffusion of Iron to Africa" in Randi Haaland and Peter Shinnie, eds., *African Iron Working: Ancient and Traditional* (Oslo, 1985), 22-24; Kevin Shillington, *History of Africa* (New York, 1989), 45-47; James L. Newman, *The Peopling of Africa: a Geographic Interpretation* (New Haven, 1995), 108; J.D. Fage, with William Tordoff, *A History of Africa* (4th ed.: London, 2002), 18-19.



less (ce). Dendrochronologists and radiocarbon scientists worked out tables to convert radiocarbon dates to what are known as calibrated dates based on C<sup>14</sup> fluctuations. Unlike radiocarbon dates, calibration is always expressed as a range of dates, not a single one, with the earliest no more valid than the latest. A full calibration at one sigma means there is a 68.2% chance that the true calendar date lies somewhere within the range. A full two-sigma calibration raises the certainty to 95.4% and is obligatory if serious misinterpretations are to be avoided. The conventional shorthand for a calibration range is earliest date–latest date cal BCE or cal CE, and ideally the calibration program used is identified along with the number assigned to the sample tested.

A major problem for archeologists worldwide is that the slope of the calibration curve flattens out in some parts, producing abnormally long ranges of calibrated ages. One such part is between 2300 and 2600 BP; radiocarbon dates in this range have calibrated age ranges of up to four centuries. This problem can be mitigated in places with historically dated artifacts to rely on, but sub-Saharan Africa seldom has that convenience. Unfortunately, the recent literature of African iron metallurgy suggests, as we shall see, that the basics of calibrated dating have not been completely understood by everyone. In particular, claims of early iron metallurgy are sometimes based unjustifiably on single radiocarbon dates rather than on a range of calibrated dates, or on the older end of such a range. There is also a tendency to assume improperly a chronological association between dated organic objects and proximate inorganic objects in unstratified contexts.<sup>27</sup>

## V

J.E.G. Sutton once lamented “the unfortunate intellectual gulf which exists between sub-Saharan and Mediterranean archaeology.”<sup>28</sup> The same may be said of the field of history. Compounding the problem, Anglophone scholars don’t always keep up with French-language publications, and vice versa. When evidence for Punic ironworking at Carthage finally did begin to appear in the late 1970s, few Africanists paid any attention, even among those well disposed toward Mauny’s theory. Some recent works still ignore it.

In 1975 a team of French archeologists under Serge Lancel began finding evidence of metallurgical activity at Punic Carthage on the slopes of Byrsa Hill, the city’s ancient core. The next year an ironworking atelier,

<sup>27</sup>A useful handbook is Sheridan Bowman’s *Radiocarbon Dating* (Berkeley, 1990).

<sup>28</sup>J.E.G. Sutton, “West African Metals and the Ancient Mediterranean,” *Oxford Journal of Archaeology* 2(1983), 181.

indicated by slag, charcoal, tuyère fragments and furnace parts, was uncovered, dated by Lancel to the third century BCE.<sup>29</sup> Further excavations found several such workshops on land that, according to Lancel, had been leveled for that purpose at the end of the fifth century BCE or the beginning of the fourth.<sup>30</sup> He thought iron smelting was involved.

In the 1980s German archeologists, notably Friedrich Rakob and Hans Georg Niemeyer, found much more, and much older, proof of ironworking in an area between Byrsa Hill and the nearby Mediterranean shore. The finds were announced at an international colloquy in Strasbourg in 1988. A whole "artisanal quarter" dating to the eighth century BCE had come to light. The evidence included iron slag "in great quantity," furnaces, tuyères and burned earth. Crucially, sherds of Greek cups imported from the Aegean island of Euboea and dating to the third quarter of the eighth century or even earlier were found in the same soil.<sup>31</sup> Both Rakob and Niemeyer, like Lancel, thought iron smelting was indicated. By 1995 Francophone scholars were reporting that the artisanal quarter went back to the first half of the eighth century BCE and that this in fact ended a century-old debate over whether the classical date of 814 BCE for the founding of Carthage was far-fetched: it wasn't.<sup>32</sup>

Despite the above reports and others (some in German), Anglophone Africanists and metallurgists continued to tell us that no early evidence had been found of ironworking at Carthage.<sup>33</sup> Twelve years after the

<sup>29</sup>Serge Lancel, Jean Deneauve, and Jean-Michel Carrié, "Fouilles françaises à Carthage (1974-1975)," *Antiquités Africaines* 11(1977), 39-40, 46-47; Lancel, "Fouilles de Carthage 1976-77: La colline de Byrsa et l'occupation punique," *Comptes rendus de l'Académie des Inscriptions et Belles-Lettres* (1978), 316-23, 329; idem, *Mission archéologique française à Carthage: Byrsa I. Rapports préliminaires des fouilles (1974-1976)*, (Rome, 1979), 81, 241-47, 269.

<sup>30</sup>Serge Lancel, *Mission archéologique française à Carthage: Byrsa II: Rapports préliminaires sur les fouilles 1977-1978: Niveaux et vestiges puniques* (Rome, 1982), 217-40, 246; idem, *Introduction à la connaissance de Carthage: La colline de Byrsa à l'époque punique* (Paris, 1983), 16-19.

<sup>31</sup>Friedrich Rakob, "La Carthage archaïque" in *Carthage et son territoire dans l'Antiquité, Actes du IV<sup>e</sup> colloque international sur l'histoire et l'archéologie de l'Afrique du Nord réuni dans le cadre du 113<sup>e</sup> Congrès national des Sociétés savantes (Strasbourg, 5-9 avril 1988)*, (Paris, 1990), 36; Hans Georg Niemeyer, "A la recherche de la Carthage archaïque: premiers résultats des fouilles de l'Université de Hambourg en 1986 et 1987" in *ibid.*, 51; Serge Lancel, *Carthage* (Paris, 1992), 57. Euboea is the largest island of the Aegean Sea.

<sup>32</sup>M. Gras, P. Rouillard, and J. Teixidor, *L'univers phénicien* (rev. ed.: Paris, 1995), 268; Leila Ladjimi Sebaï, "Didon et Enée, la fondation de Carthage" in *Carthage: L'histoire, sa trace et son écho* (Paris, 1995), 54-55.

<sup>33</sup>See, for example, van der Merwe, "Advent," 477; Kense, *Traditional*, 154; idem, "Initial Diffusion," 24; S. Terry Childs and David Killick, "Indigenous African Metallurgy: Nature and Culture," *Annual Review of Anthropology* 22(1993), 322;

Strasbourg colloquy an archeologist at home in both English and French asserted that no “mark of iron production” older than 700 BCE had been discovered.<sup>34</sup> Inexcusably, a chapter in UNESCO’s 2002 volume on the origins of iron metallurgy in Africa simply repeats what Mauny knew about iron at Carthage half a century earlier.<sup>35</sup>

The archeological finds at Carthage seemed to breathe new life into Mauny’s theory, but an article by a German geochemist named Ingo Keesmann that appeared at the end of 2002 sucked some out again. He analyzed samples of the slag unearthed by his compatriots and reported that all showed evidence of iron smithing, not iron smelting. In other words, the raw metal may have been imported from somewhere else and only shaped into usable objects at Carthage. Keesmann has also concluded that the earlier French evidence proved only smithing. Nevertheless, he is sure the Carthaginians knew how to smelt, that usable ores were probably available in the hinterland, and that for safety’s sake they would have produced their own metal whenever they could.<sup>36</sup> Finding proof of it, he thinks, is only a matter of time. Keesmann’s analysis of Carthage slag has not yet been corroborated by any other expert.<sup>37</sup>

If ironworking (as distinct from smelting) dating to the eighth century BCE has been proven at Carthage, there is still little material support for

James Woodhouse, “Iron in Africa,” in Graham Connah, ed., *Transformations in Africa: Essays on Africa’s Later Past* (London, 1998), 166; S. Terry Childs and Eugenia W. Herbert, “Metallurgy and Its Consequences” in Ann Brower Stahl, ed., *African Archaeology* (Malden, MA, 2005), 280.

<sup>34</sup>Augustin F.C. Holl, “Metals and Precolonial African Society” in Joseph O. Vogel, ed., *Ancient African Metallurgy: the Sociocultural Context* (Walnut Creek, CA, 2000), 8.

<sup>35</sup>Joseph Fazing Jemkur, “Les débuts de la métallurgie du fer en Afrique de l’Ouest” in Bocum, *Origines*, 26. The article was apparently translated from English.

<sup>36</sup>Ingo Keesmann, “Untersuchungen zur Metallurgie im archaischen und punischen Karthago,” *Meditarch*, 99, 102, 108 (I am grateful to Hans Friedrich Tomaschek for translating this article). (*Meditarch*, 14, is dated 2001 but came out in December 2002.) Keesmann clarified certain points in a personal communication, 3 April 2003. British archeologists working in the old harbor area of Punic Carthage in the late 1970s found evidence of ironworking in what seemed to have been an industrial area. R.F. Tylecote examined the finds, said smithing was involved, and dated the objects to ca. 350-250 BCE. Hans Georg Niemeyer, “Archaeological Evidence of Early Iron Technology at Carthage and Other Phoenician Settlements,” *Meditarch*, 86, 91. Lancel speculated that magnetite iron ore was brought to Carthage by sea from the Annaba (ex-Bône) area in present-day Algeria, a distance of about 150 nautical miles. Lancel, *Byrsa II*, 233-34; idem, *Colline de Byrsa*, 18-19.

<sup>37</sup>In a personal communication of 8 February 2004, archeometallurgist David Killick questioned Keesmann’s interpretation, saying he has found “no unambiguous mineralogical distinction between smelting and smithing slags” in Africa.

Mauny's view that the technology was transmitted across the Sahara in the first millennium BCE. "Hard evidence," as Augustin Holl wrote in 2000, "has yet to document trans-Saharan trade at this time."<sup>38</sup> But available soft evidence, circumstantial evidence, does not seem negligible.

It is quite possible that iron was introduced into what is now Tunisia even before the Phoenicians got there. There is archeological evidence that Cypriot sea traders were taking iron goods to Sardinia by the thirteenth century BCE. The passage from the eastern Mediterranean to Sardinia, between Sicily and Tunisia, is less than 90 statute miles wide. One can easily imagine the Cypriots' becoming aware of the North African mainland early on and putting in there to replenish their food and water by exchanging their wares with the locals.<sup>39</sup>

## VI

The Phoenicians, and their Carthaginian and presumably other far-flung, offspring, were known to the ancients as the quintessential merchants of the Mediterranean world. The primary motive for the Phoenician thrust into the western Mediterranean is said to have been "the search for sources of metal, in particular gold, silver, copper and tin."<sup>40</sup> Iron, by far the most common metal on earth, was abundant in the Near East. Copper, on the other hand, is an estimated 700 times scarcer than iron in the earth's continental crust, and tin, essential for making bronze, in turn an estimated 35 times scarcer than copper.<sup>41</sup> There were sources of copper in

<sup>38</sup>Holl, "Metals," 9.

<sup>39</sup>Fulvia Lo Schiavo, "Sardinian Metallurgy: the Archaeological Background," in Miriam S. Balmuth, ed., *Studies in Sardinian Archaeology* (Ann Arbor, 1986), 2:237, 240, 242, 245-46; idem, "Early Metallurgy in Sardinia" in Robert Maddin, ed., *The Beginning of the Use of Metals and Alloys* (Cambridge, 1988), 102; Lucia Vagnetti and Fulvia Lo Schiavo, "Late Bronze Age Long Distance Trade in the Mediterranean and the Role of the Cypriots" in E. Peltenburg, ed., *Early Society in Cyprus* (Edinburgh, 1989), 227. Alternatively, Cypriot sailors, if willing to brave Scylla and Charybdis, could have gone to Sardinia via the Strait of Messina and missed Tunisia altogether. It is possible that those sailors from Cyprus were themselves Phoenicians. See Miriam S. Balmuth and Robert J. Rowland, Jr., eds., *Studies in Sardinian Archaeology* (Ann Arbor, 1984), 1:42-43.

<sup>40</sup>B.H. Warmington, "The Carthaginian Period" in UNESCO's *General History of Africa 2: Ancient Civilizations of Africa* (Berkeley, 1981), 442. See also Warmington, *Carthage, a History* (rev. ed.: New York, 1969), 23; Niemeyer, "Archaeological Evidence," 83.

<sup>41</sup>David Killick, "Science, Speculation and the Origins of Extractive Metallurgy" in D.R. Brothwell and A.M. Pollard, eds., *Handbook of Archaeological Sciences* (London, 2001), 484. For optimum strength, bronze requires about 10% tin. Tamara S. Wheeler and Robert Maddin, "Metallurgy and Ancient Man" in Wertime/Muhly, *Age of Iron*, 110.

what are now Mauritania and Niger (about which more later) that the Phoenicians might have coveted had they learned of them. And there was a source of tin in Niger's Air Mountains that was much closer to Carthage than the tin of Cornwall that is believed to have figured in Carthaginian trade.

French archeologist Danilo Grébénart has drawn attention to the abundance in Air sands of nodules or nuggets of cassiterite, the main tin ore, that need only be collected there, not mined. Admittedly without proof, he speculates that cassiterite may have been exported to a presumably tin-hungry Carthage.<sup>42</sup> El Meki, a southern Air village where the nodules are assembled nowadays for export, is about 1300 miles from Carthage as the crow flies, whereas Cornwall is about 2200 statute miles away by sea.

In the 1930s and 1940s, growing numbers of paintings and engravings of horse-drawn chariots, oxcarts, and wagons were being found amid Saharan rock art—at last count they total more than 700.<sup>43</sup> Mauny, Lhote, and others connected the dots and theorized the existence of prehistoric trans-Saharan “routes des chars,” or “chariot roads.” Remarkably, as indicated above, Mauny did not mention them in his 1952 article, although they might have bolstered his case for the transmission of iron technology to West Africa. But by 1970 he had incorporated the horses and chariots in his argument.<sup>44</sup> Meanwhile, however, the “chariot road” theory faded when it was shown that the chariots are depicted almost wherever suitable rock surfaces are to be found in the Sahara. Moreover, the fragility of the chariots and the roughness of the terrain would have ruled out any long journeys.

Mauny never quite abandoned the theory, although he did refine it. In the *Cambridge History of Africa* (2/1978), “routes des chars” was translated as “chariot tracks” instead of “roads.” Mauny insisted that the

<sup>42</sup>Danilo Grébénart, “Les métallurgies du cuivre et du fer autour d’Agadez (Niger), des origines au début de la période médiévale” in Nicole Echard, ed., *Métallurgies africaines: Nouvelles contributions* (Paris, 1983), 115-16; idem, “Characteristics of the Final Neolithic and Metal Ages in the Region of Agadez (Niger)” in Angela E. Close, ed., *Prehistory of Arid North Africa: Essays in Honor of Fred Wendorf* (Dallas, 1987), 313; idem, *Les premiers métallurgistes en Afrique occidentale* (Paris, 1988), 253; idem, “Les premiers métaux en Afrique de l’Ouest” in Jean-Pierre Leroy, ed., *La préhistoire de l’Afrique de l’Ouest: nouvelles données sur la période récente* (Saint-Maur, 1996), 82.

<sup>43</sup>Baouba ould Mohamed Naffé, Robert Vernet, and Mohamed ould Khattar, “Archéologie de la Mauritanie” in Robert Vernet, ed., *Archéologie en Afrique de l’Ouest: Sahara et Sahel* (Saint-Maur, 2000), 162.

<sup>44</sup>Mauny, *Siècles obscurs*, 69; idem, “Western Sudan,” 83-84.

drawings “are not distributed indiscriminately . . . but, with a few exceptions, . . . are grouped along two relatively narrow bands across the desert.” One ran basically from the Fezzan in Libya toward Gao on the Niger river, the other from Morocco toward the Timbuktu area farther up the Niger. “Obviously,” he wrote,

these are not roads in any modern sense . . . They are more or less parallel tracks running from one well or water-hole to the next . . . through those lands which afforded the best going for wheeled vehicles and which were furnished with the best pastures. Nor is it necessary to suppose that the same chariots served for a whole trans-Saharan journey . . . [They] were clearly too fragile to last for more than a few hundred kilometers of driving over difficult terrain.<sup>45</sup>

Lhote admitted frankly that he and Mauny had erred in plotting chariot designs as “routes” since the vehicles were incapable of transporting anything very far and “must have been of essentially local use.” But he continued to recognize “axes of penetration running northeast/southwest across the central Sahara that would constitute, in a way, the bone structure of the Berber-speaking domain.”<sup>46</sup>

The horse-and-chariot designs, and the figures of men that accompany them, are important to the question of sub-Saharan metallurgical origins because it is likely the chariots contained metal parts, and because javelins, lances, and daggers are represented that almost certainly had metal heads or blades, and possibly metal shafts too.

It was demonstrated in the mid-1960s by hippologist Jean Spruytte that very light chariots could be made entirely from wood and skins using only stone tools.<sup>47</sup> His experimental chariot, weighing only 30 kilograms, was ridiculed by some old Saharan hands. Lhote rated its “practical utility almost nil” on Saharan terrain.<sup>48</sup> Henri-Jean Hugot thought Spruytte’s

<sup>45</sup>Mauny, “Trans-Saharan Contacts,” 280-81. Mauny’s hesitancy over using the “routes des chars” in his iron technology-transmission theory and his continuous use of quotes when referring to them suggests he was never fully satisfied with the concept of “roads.”

<sup>46</sup>Henri Lhote, *Les chars rupestres sahariens des Syrtes au Niger, par le pays des Garamantes et des Atlantes* (Paris, 1982), 48, 62. See also Lhote, “Les chars rupestres du Sahara et leurs rapports avec le peuplement dans les temps protohistoriques” in Gabriel Camps and Marceau Gast, eds., *Les chars préhistoriques du Sahara: Archéologie et techniques d’attelage* (Aix-en-Provence, 1982), 23, 25.

<sup>47</sup>J. Spruytte, “Un essai d’attelage préhistorique,” *Plaisirs Equestres* 34(July 1967), 279-81. See also Spruytte, *Etudes expérimentales sur l’attelage, contribution à l’histoire du cheval* (Paris, 1977).

<sup>48</sup>Lhote, *Chars rupestres*, 72-75; See also idem, “Chars rupestres,” 23.

model “would not last five kilometers before falling apart completely.”<sup>49</sup> Gabriel Camps reasoned that if the javelins shown installed upright on many chariot representations were metallic, the tires [and other parts] could just as well have been of metal too, and this would appear to be a generally accepted view.<sup>50</sup>

Specialists agree that the horse is not indigenous to Africa, and most think that it and the chariot virtually simultaneously reached North Africa and the Sahara overland from Egypt.<sup>51</sup> Traditionally they entered Egypt in the late eighteenth century BCE with the Semitic Hyksos invaders, but the earliest hieroglyphic mention of horses and chariots dates to the sixteenth century BCE, when the Hyksos were driven out.<sup>52</sup> Not long thereafter, by about 1500 BCE according to some Francophone students of the Sahara, the horse and chariot reached the great desert via Libya.<sup>53</sup> This seems early in the light of Egyptian evidence, but it dovetails with findings of Saharan paleoclimatology.

During the second millennium BCE, the Sahara experienced a final humid phase before descending into the hyper-arid conditions we know today. The timing apparently varied from place to place. Lake Chad expanded for the last time between 1550 and 950 BCE.<sup>54</sup> In the Azawagh region to the west of Aïr, a humid episode is recorded between 3900 and

<sup>49</sup>H.-J. Hugot, *Le Sahara avant le désert* (Paris, 1974), 281.

<sup>50</sup>Gabriel Camps, “Les chars sahariens: Images d’une société aristocratique,” *Antiquités Africaines* 25(1989), 20-21. See also Karl Heinz Striedter and Michel Tauveron, “Un char peint de Wan Tabarakat (Tadrart, Algérie)” in Leroy, “Préhistoire,” 64-65.

<sup>51</sup>A notable exception is the French archeologist Alfred Muzzolini, who has argued that horse and chariot could equally have come by ship from the Levant or the northern shores of the Mediterranean. Muzzolini, “La période des chars’ au Sahara. L’hypothèse de l’origine égyptienne du cheval et du char,” in Camps/Gast, *Chars préhistoriques*, 49-55.

<sup>52</sup>Ahmoese, first pharaoh of the XVIII Dynasty, who took power ca. 1580-70 BCE, is given credit. Nevertheless, the ancient Egyptian word for horse, *susim*, indicates that the animal arrived from Semitic-speaking parts: *susim* is the Hebrew word for horses.

<sup>53</sup>Camps, “Chars sahariens,” 33; Michel Tauveron, “Art rupestre du Sahara central” in Leroy, *Préhistoire*, 46; Pierre Colombel, “Art préhistorique du Tassili n’Ajjér” in Leroy, *Préhistoire*, 55. Earlier, Lhote (*Chars rupestres*, 118), put the date at 1200 BCE. Quite exceptionally, Muzzolini suggested that the chariot period did not start until shortly after the Greeks founded Cyrene in eastern Libya in the seventh century BCE. Alfred Muzzolini, *Art rupestre préhistorique des massifs centraux sahariens* (Oxford, 1986), 274.

<sup>54</sup>Marianne Cornevin, “New Data Concerning the Aïr Massif (Niger) and Its Surroundings” in UNESCO, *Libya Antiqua* (Paris, 1986), 109.

3300 BP.<sup>55</sup> In the Ténéré region east of Aïr, lakes made their last appearance between 3500 and 3000 BP.<sup>56</sup> Where water was accessible, savanna fauna—elephants, lions, rhinoceroses, giraffes, antelopes, ostriches—could and did roam.<sup>57</sup> And North Africans with horses and cattle pulling wheeled vehicles could navigate the Sahara.

Those North Africans who entered the central Sahara and touched down in its various massifs are designated most often in the literature as Libyco-Berbers.<sup>58</sup> Rock art shows the men as warriors with javelins or lances, and sometimes with a dagger attached to the left arm. They also carry a small shield, usually round but sometimes rectangular. Featureless heads sport feathers, probably ostrich plumes. The body, most often seen frontally and static, resembles two triangles meeting at a narrow waist, with sticklike arms extended and bent. The figure is clothed in a cinched tunic, possibly of leather, broad in the shoulder and flaring at the legs.<sup>59</sup>

We know from chariot designs that Libyco-Berbers reached almost as far as the Niger river. Some crude sketches have been found on rocks at Es Souk in the Adrar des Iforas Massif, 170 miles from the river.<sup>60</sup> For Lhote, “it would be extraordinary if [the charioteers] had not reached the

<sup>55</sup>François Paris, “Le bassin de l’Azawagh: peuplements et civilisations, du néolithique à l’arrivée de l’Islam” in Alain Marliac, ed., *Milieus, sociétés et archéologues* (Paris, 1995), 231.

<sup>56</sup>Jean-Pierre Roset, “L’occupation humaine de l’Aïr et du Ténéré, au Niger, depuis 10 000 ans” in Marliac, *Milieus*, 173. Muzzolini (“Période des chars,” 46) speaks of “a last, small, humid pulsation” reported around 1000-1500 BC in several parts of the Sahara.

<sup>57</sup>Cornevin, “New Data,” 110; François Paris, Alain Person, and Jean-François Salvière, “Peuplements et environnements holocènes du bassin de l’Azawagh oriental (Niger)” in Jean Devisse, ed., *Vallées du Niger* (Paris, 1993), 390; Robert Vernet, *Climats anciens du nord de l’Afrique* (Paris, 1995), 149.

<sup>58</sup>They are also called Libyo-Berbers, Libyan Berbers, paleo-Berbers, proto-Berbers, or simply Berbers or Libyans. “Libyco-Berbers” has been used as well for people who moved into the western Sahara.

<sup>59</sup>See, for example, Huard, “Introduction,” 378, 380; Hugot, *Sahara*, 292-93; Olivier/Fagan, *Africa in Iron Age*, 61-62; Henri Lhote, *Vers d’autres Tassilis: Nouvelles découvertes au Sahara* (Paris, 1976), 179; Ginette Aumassip, “Entre Adrar des Ifoghas, Tassili et Aïr: Les contacts du bassin avec le Nord-Est” in Devisse, *Vallées du Niger*, 101-02.

<sup>60</sup>Lhote, *Chars rupestres*, 186-88. In 1947 Mauny (“Une route préhistorique à travers le Sahara occidental,” *BIFAN* 9B, 344) reported a chariot engraving near Goundam, some 20 miles from the Niger northwest of its great bend, but other specialists do not seem to have accepted his evidence. See Lhote, *Chars rupestres*, 8-9, and Camps, “Chars sahariens,” 29, for maps plotting finds of chariot drawings. In the western Sahara an oxcart is depicted near the ruins of Tegdaoust, about 250 miles from the Senegal river. Naffé/Vernet/Khattar, “Archéologie de la Mauritanie,” 164-65.



great river, where black farmers could have supplied them with cereals in quantity, as they do today [for the Tuareg].”<sup>61</sup> But if and when this happened is unknown.

## VII

Two French researchers have, however, finally found good evidence linking the Libyco-Berbers and their horses and chariots with the use of metal and within a specific time frame. In 1979 archeologist Jean-Pierre Roset discovered an ancient occupation site along a wadi called Iwelen in northern Air, nearly 200 miles north of Agadez. The wadi still receives some water from Mt. Gréboun (altitude 6,376 feet), 15 miles to the northeast, during the July-September rainy season. Roset and a colleague, anthropologist François Paris, visited Iwelen repeatedly in the 1980s and, in Marianne Cornevin’s words, “made a major contribution to knowledge of the Sahara during the so-called Chariot period.”<sup>62</sup>

The Iwelen find consists of the remains of two small settlements, the larger covering about seven and a half acres, within a few hundred yards of each other on either side of the wadi. From them the ground slopes up to granite rocks covered with hundreds of engravings, and just below the rocks are some 60 burial mounds. Many of the engravings show a variation of the Libyco-Berber warrior described above. His stance is always frontal and stiff. His head is enlarged and tulip-shaped, projecting three points, two of which seem to be feathers. His legs as well as his arms are sticklike, and his feet are turned outward. He always brandishes a long spear or lance, usually with a leaf-shaped head, and sometimes carries a shield. Two of the engravings show chariots, one being pulled by what seem to be horses. Many other engravings show cattle and a variety of wild savanna animals.

The settlement sites yielded an abundance of ceramics of a form and decoration completely different from that of the Neolithic pottery that preceded them in the region.<sup>63</sup> But most importantly for our purpose, three leaf-shaped spearheads made of very thinly beaten copper were found. The points and edges had been sharpened. They were identical to the weapons depicted on the rock engravings. And significantly, no trace of stone weapons came to light, though quartz objects abounded, and the bows and arrows depicted in earlier Saharan rock art were absent from the Iwelen engravings.

<sup>61</sup>Lhote, *Chars rupestres*, 188.

<sup>62</sup>Marianne Cornevin, *Archéologie africaine* (Paris, 1993), 124.

<sup>63</sup>Iwelen means potsherds in the Tuareg language.

Charcoal from hearths found in the settlement areas was carbon-dated. The oldest date was  $2680 \pm 40$  BP, or a two-sigma range of 910-790 cal BCE. But datings of bone and leather from the most common type of burial mound, called crater tumuli for the circular hollow on top, were up to nearly a thousand years older. The earliest date was  $3595 \pm 100$  BP, or 2300-1600 cal BCE, which persuaded Roset and Paris that Iwelen's post-Neolithic occupants began arriving in the mid-second millennium BCE. For both, the new ceramics, the copper, the new type of tomb, the engravings of human figures, and the chariots all added up to a new culture. Roset calls it "paleo-Berber," Paris "a new civilization of Mediterranean origin."<sup>64</sup>

It is not clear, however, from the Iwelen evidence, when or even whether metalworking reached Aïr with the new immigrants. The three spearheads and other copper objects—small blades, awls, axes, clamps—were found in the habitation zone, not the tombs, so Roset dates them no earlier than the eighth century BCE. He also thinks metallurgy arrived at the same time, but no furnace remains have been uncovered. On the other hand, Paris believes the rock art with its spear-armed warriors appeared at the very outset, and Roset is sure that any chariots needed metal reinforcements to function in the area, which suggests that copper reached Iwelen with the first settlers. (Paris also thinks the site was occupied only seasonally, not permanently, by nomadic herders, and that the tombs suggest it had a primarily religious significance.) Roset says iron followed copper to Iwelen but does not hazard a guess as to when.<sup>65</sup>

One would think that over the centuries the people of Iwelen would have learned to make their own copper weapons and tools, at least from imported raw material, and, if they kept in touch with their northern relatives, one can imagine that iron technology was eventually transmitted to them from that direction, but there is no evidence for either hypothesis.<sup>66</sup>

<sup>64</sup>Roset, "Occupation humaine," 173-74; François Paris, "Les sépultures monumentales d'Iwelen (Niger)," *Journal des Africanistes* 60(1990), 74.

<sup>65</sup>For the full story of post-Neolithic Iwelen see Jean-Pierre Roset, "Iwelen: an Archaeological Site of the Chariot Period in Northern Aïr," in UNESCO, *Libya Antiqua*, 113-46; idem, "Néolithisation, néolithique et post-néolithique au Niger nord-oriental," *Bulletin de l'Association française pour l'étude du Quaternaire* 4 (1987), 204, 208-12; idem, "Occupation humaine," 161-95; Paris, "Sépultures monumentales," 47-75; Paris et al., "Débuts de la métallurgie," 57-58; Cornevin, *Archéologie africaine*, 122-27; Boubé Gado, Abdoulaye Maga, and Oumarou Amadou Ide, "Archéologie du Niger" in Vernet, *Archéologie*, 221, 223, 224, 226, 230.

<sup>66</sup>It has been suggested that the copper came from the Agadez area, specifically the basin of a one-time stream called the Eghazer, where both copper ore and native copper are found on the surface, but that it was fashioned locally and then taken to Iwelen. Danilo Grébénart, "Relations inter-ethniques sahara-sahéliennes dans

“The Saharan Berbers are not metallurgists,” wrote Lhote in 1952, “and one may doubt they ever were.”<sup>67</sup> But he acknowledged the presence of blacksmiths among the Tuareg. They are members of a caste of craftsmen called the Inaden; those of the Hoggar (Ahaggar) highlands in the central Sahara have been particularly described.<sup>68</sup> Ironworkers are also to be found among the Arabized Berbers of the western Sahara and the black Teda of the eastern Sahara.<sup>69</sup>

## VIII

There does seem to be evidence for Berber transfer of metallurgy across the Sahara, but it comes not from Niger but from Mauritania in the far west. Ancient copper artifacts began to be noticed in that region in the early twentieth century. By 1951 enough had been found for Mauny to wonder, in print, whether Mauritania had experienced a Copper Age.<sup>70</sup> An answer came in 1968, when French archeologist Nicole Lambert began excavating what was known as the Grotte aux Chauves-souris (Bat Cave) on a hill called the Guelb Moghreïn near Akjoujt in western Mauritania. It was not a cave at all, but an ancient mining gallery dug by humans following a rich vein of malachite ore. The ore was not only extracted, but locally smelted, as furnace remains and slag attest. Four other ancient exploitation sites were found later on the Guelb Moghreïn. Ra-

l'Ouest africain durant la préhistoire finale et la protohistoire,” *Préhistoire Anthropologie Méditerranéennes* 4(1995), 129. See also Grébénart, “Afrique occidentale: les débuts de la métallurgie,” *Archéologia* no. 198 (January 1985), 50.

<sup>67</sup>Lhote, “Connaissance,” 271.

<sup>68</sup>Lloyd Cabot Briggs, *Tribes of the Sahara* (Cambridge, 1960), 70-71, 149, 158-60; D. Jemma, “Les artisans de l’Ahaggar,” *Libyca*, 20 (1972), 269-70, 288; Jeremy Keenan, *The Tuareg: People of Ahaggar* (2d. ed.: London, 2002), 93-95, 101-03. See also H.T. Norris, *The Tuaregs: Their Islamic Legacy and Its Diffusion in the Sahel* (Warminster, 1975), 4, 222; Nicole Echard, “A propos de la métallurgie: Système technique, organisation sociale et histoire” in E. Bernus and N. Echard, *La région d’In Gall-Tegidda n Tesemt (Niger): Programme archéologique d’urgence 1977-1981, V: Les populations actuelles* (Niamey, 1992), 37. Lhote thought the caste was of Jewish origin. He said that the Inaden now mainly repair metal objects, but used to smelt iron from local ore. Henri Lhote, *Les Touaregs du Hoggar* (Paris, 1984), 56-58, 165, 169-73, 200. Inaden is also spelled Inadan, Ineden and Enaden in the literature.

<sup>69</sup>Briggs, *Tribes*, 233-34; Walter Cline, *The Teda of Tibesti, Borku, and Kawar in the Eastern Sahara* (Menasha, 1950), 39, 42; Pierre Beck and Paul Huard, *Tibesti: Carrefour de la préhistoire saharienne* (Paris, 1969), 227-34; Françoise Treinen-Claustre, *Sahara et Sahel à l’Age du Fer: Borkou, Tchad* (Paris, 1982), 150-68.

<sup>70</sup>Raymond Mauny, “Un âge du cuivre au Sahara occidental?,” *BIFAN* 13B(1951), 168-80.

diocarbon datings, eventually calibrated, are nearly all in the range 800 to 200 cal BCE. Subsequently at least three other metallurgical centers from the same period were discovered in the Akjoujt region.

The number of ancient copper objects found in the western Sahara and attributed to the Akjoujt industry exceeded 160 at last count. The great majority are weapons: arrowheads, lance points, and daggers. Tools include hatchets, pins, awls, burins, and hooks. There are the inevitable personal ornaments—rings, earrings, pendants—and some ingots. All the items are very small and very light; when the number reached about 140, the total weight barely topped two kilograms. They were produced in a Neolithic context in which stone tools vastly outnumbered the metal ones, so one can hardly speak of a Copper Age on the basis of present evidence.

How did copper mining and working get started at Akjoujt? It is possible the industry was indigenous, but no one yet seems to have made a real case for that. Lambert saw a resemblance between the Akjoujt products and those of the El Argar culture in southeastern Spain, where copper was being manufactured by at least 1700 BCE and bronze some 200 years later. She thought the few ancient brass and bronze artifacts also found in Mauritania might have been imported from the western Maghreb. She noted that chariot engravings had been found on rocks in three places near Akjoujt and thought they might be “road signs” indicating an early traffic between Morocco and Mauritania.<sup>71</sup>

Mauny discerned Phoenician or Carthaginian initiatives behind the Akjoujt industry, with Berbers actually importing the technology, but Lambert’s idea of an Iberian connection might have some merit.<sup>72</sup> In the

<sup>71</sup>Nicole Lambert, “Medinet Sbat et la protohistoire de Mauritanie occidentale,” *Antiquités Africaines* 4 (1970), 55-56 ; idem, “Les industries sur cuivre dans l’ouest saharien,” *West African Journal of Archaeology* 1(1971), 11-13; idem, “Nouvelle contribution à l’étude du Chalcolithique de Mauritanie,” in Echard, *Métallurgies africaines*, 73. For details of the Akjoujt discoveries, besides Lambert’s articles, see Mauny, *Siècles obscurs*, 65-66; idem, “Trans-Saharan Contacts,” 319-22; Oliver/Fagan, “Africa in Iron Age,” 60-61; Grébénart, “Afrique occidentale,” 48-49, 52; idem, “Premiers métallurgistes,” 250-52; Susan Keech McIntosh and Roderick J. McIntosh, “Recent Archaeological Research and Dates from West Africa,” *JAH* 27(1986), 426-27; idem, “From Stone to Metal: New Perspectives on the Later Prehistory of West Africa,” *Journal of World Prehistory* 2(1988), 104-06; Woodhouse, “Iron in Africa,” 166, 173; Naffé/Vernet/Khattar, “Archéologie de la Mauritanie,” 166-70.

<sup>72</sup>Mauny, “Trans-Saharan Contacts,” 319-22. Mauny was aware of the El Argar culture, but thought it too early to have played a role in Mauritania. See also David Killick, Nikolaas J. van der Merwe, Robert B. Gordon, and Danilo Grébénart, “Re-assessment of the Evidence for Early Metallurgy in Niger, West Africa,” *Journal of Archaeological Science* 15(1988), 369; McIntosh/McIntosh, “Stone to Metal,” 105.

late 1960s and early 1970s, British archeologist Colin Renfrew, in a sweeping challenge to the then-reigning diffusionist orthodoxy, suggested that copper metallurgy was independently invented on the Iberian Peninsula long before Phoenicians or Greeks reached the western Mediterranean.<sup>73</sup> Since then much evidence has accumulated that he was right, and that Iberian copper metallurgy dates back at least to 3000 BCE.<sup>74</sup>

It also seems that the technology crossed from Spain to Morocco before the Phoenicians set foot on the Moroccan coast. Until the mid-twentieth century, it was thought the western Maghreb had not experienced a Copper or Bronze Age. Finds of metal objects, ancient mines, and, especially, rock engravings have undercut that notion: copper in Morocco may date all the way back to the third millennium BCE, according to some leading researchers.<sup>75</sup> Rock art in the High Atlas shows weapons typical of the El Argar culture, especially daggers, halberds, and axes.<sup>76</sup> Conceivably, cuprous objects reached Morocco in exchange for two North African products, ivory and ostrich eggshells, that have been found in third- and second- millennium-BCE graves in southeast Spain.<sup>77</sup> But no certain proof of early copper smelting has yet turned up in the Maghreb.

Did the Akjoujt copper industry, whatever its origins, lead to an independent invention of iron metallurgy? The malachite of Bat Cave occurred in a matrix of hematite and magnetite that was discarded in the smelting process. There is no evidence that the coppersmiths ever produced iron, although the raw material was at hand. However, proof of

<sup>73</sup>See, for example, Colin Renfrew, *Before Civilization: The Radiocarbon Revolution and Prehistoric Europe* (Harmondsworth, 1976), 74-75, 101, 115.

<sup>74</sup>Tylecote, *History*, 10; Robert Chapman, *Emerging Complexity: the Later Prehistory of South-East Spain, Iberia, and the West Mediterranean* (Cambridge, 1990), 30-32, 46; Almudena Hernando Gonzalo, "The Development of Cultural Complexity in the Western Mediterranean: A New Approach" in Miriam S. Balmuth, Antonio Gilman, and Lourdes Prados-Torreira, *Encounters and Transformations: the Archaeology of Iberia in Transition* (Sheffield, 1997), 52; Killick, "Science," 485-86.

<sup>75</sup>G. Camps and P. Cadenat, "Nouvelles données sur le début de l'Age des Métaux en Afrique du Nord," *Bulletin de la Société d'Etudes et de Recherches Préhistoriques* no. 30(1980), 48; Georges Souville, "Témoignages sur l'âge du bronze au Maghreb occidental," *Comptes rendus de l'Académie des Inscriptions et Belles-Lettres* (1986), 105.

<sup>76</sup>Camps/Cadenat, "Nouvelles données," 44-45, 49-50; Souville, "Témoignages," 105, 107, 109-13. See also Richard J. Harrison and Antonio Gilman, "Trade in the Second and Third Millennia B.C. Between the Maghreb and Iberia" in Vladimir Markotic, ed., *Ancient Europe and the Mediterranean* (Warminster, 1977), 91, 95, 97, 101n5.

<sup>77</sup>*Ibid.*, 90-91, 93, 97, 99; Chapman, *Emerging Complexity*, 72, 167, 189, 193, 210, 248, 250. Elephants survived in the Maghreb until Roman times.

ironworking from the same period has recently been found some 250 miles south of Akjoujt in the middle Senegal river valley. At a site called Walalde, iron artifacts dating to somewhere between 800 and 550 cal BCE have been found, and in a second phase of occupation, from *ca.* 550 to 200 cal BCE, clear evidence of iron smelting has been excavated. The latter phase also yielded three copper artifacts with a telltale chemical signature of the Akjoujt ores—more than 1% of arsenic and a smaller amount of nickel. Further excavation and study are required to evaluate the find, but it is clearly an important contribution to the history of metallurgy in sub-Saharan Africa.<sup>78</sup>

## IX

Akjoujt shares honors with another area, in central Niger, for the earliest copper metallurgy found thus far in Black Africa. The case for independent invention of iron smelting in sub-Saharan Africa may stand or fall on the metallurgical findings in Niger, so they merit the closest scrutiny. Grébénart, the principal investigator in central Niger, sees such close parallels between what he calls “Cuivre II” in Niger and the Mauritanian industry that he is almost certain of a common origin though 1500 miles separate the two. The industries are contemporary. The low furnaces used seem identical. The coppermiths of both areas made very small objects and very few of them, apparently amounting to only a few kilograms a year in Niger. The objects themselves were of similar kinds, though stylistically different. They were produced in a Neolithic context featuring stone tools and typical Saharan ceramics. Grébénart thinks the metallurgy was taken to both areas by Berber artisans from Morocco’s Atlas Mountains.<sup>79</sup>

In 1353 Ibn Battuta visited a Saharan town named Takadda and found copper from a nearby “mine” being smelted by slaves in local homes. The metal was fashioned into bars and used as currency.<sup>80</sup> More than six cen-

<sup>78</sup>Alioune Deme and Susan Keech McIntosh, “Excavations at Walalde: New Light on the Settlement of the Middle Senegal Valley by Iron-Using Peoples,” in preparation; McIntosh, personal communication, 12 November 2004; Thomas Fenn, personal communication, 2 February 2005. Fenn analyzed the copper objects.

<sup>79</sup>Grébénart, “Métallurgies du cuivre,” 117; idem, “Le néolithique final et les débuts de la métallurgie,” in Bernus/Echard, *Région d’In Gall-Tegidda II* (Niamey, 1985), 411; idem, “Afrique occidentale,” 52; idem, “Characteristics,” 314; idem, “Premiers métallurgistes,” 252; idem, “Relations inter-ethniques,” 129.

<sup>80</sup>N. Levtzion and J.F.P. Hopkins, eds., *Corpus of Early Arabic Sources for West African History* (Princeton, 2000), 302.

turies later French archeologists identified a cluster of ruins called Azelik wan Birni, some 85 miles northwest of Agadez, as Ibn Battuta's Takadda. From 1977 to 1981 Grébénart excavated at this and other sites in the Agadez region and found evidence of both copper and iron metallurgy. Radiocarbon dates obtained from his finds led him to divide them into four periods that he named Cuivre I and II and Fer I and II, with Cuivre II and Fer I partly overlapping.

The earliest calibrated dates, grouped in Cuivre I, took copper technology back to the beginning of the third millennium BCE, far earlier than any previous evidence of metal in sub-Saharan Africa. The charcoal used for the testing came from 14 irregularly shaped, often elongated, baked-clay structures that Grébénart originally took to be furnaces in which native copper was melted (not smelted). Such copper is still found on the surface in the Agadez region. Grébénart described the Cuivre I technology as "pre-metallurgical" in that treatment of native copper involved no chemical changes.

Traces of copper were found in slag-like materials that Grébénart collected, but no slag heaps or tuyères were associated with the "furnaces," and no copper artifacts were found in the vicinity. Nor were there any habitation sites around. Ceramics linked to the structures were identified by Grébénart as Saharan Neolithic.<sup>81</sup>

The main Cuivre I site, and the one that produced the earliest dates, is called Afunfun 175. It is located about 25 miles south-southeast of Agadez. Grébénart's evidence was re-examined by other specialists who, in a much-talked-about article co-authored by Grébénart himself, deflated the initial claims for Cuivre I. Some of the Afunfun 175 structures, it was suggested, "may be baked linings formed when partially buried dead tree trunks or stumps were ignited by grass fires." Slag-like material extracted was found to be "partially vitrified soil."

Of 18 structures excavated, only four were judged "definitely furnaces of some kind," but only one of them, called furnace 8, showed any "positive evidence for metallurgy." The one charcoal sample from this furnace was radiocarbon-dated to 1710±110 BCE and calibrated to 2400-1750 BCE. But the authors noted that the age of the charcoal was not necessarily close to the age of the structure. They drew attention to what is known as the "old-wood" (or "old-charcoal") problem.<sup>82</sup>

<sup>81</sup>Grébénart, "Métallurgies du cuivre," 112; idem, "Afrique occidentale," 50, 52; idem, "Characteristics," 287, 296, 302; idem, "Premiers métallurgistes," 259.

<sup>82</sup>Killick et al., "Reassessment," 367-71, 379-81, 390. See also Suzanne Bernus, "Découvertes, hypothèses, reconstitution et preuves: le cuivre médiéval d'Azelik-Takedda (Niger)" in Echard, *Métallurgies africaines*, 162, 168-69.

In arid regions, dead trees of termite-resistant species may persist for centuries. Or charcoal produced by forest fires, being inedible both for termites and fungi, can last indefinitely. If the climate improves, people may move into the area and use the deadwood or charcoal for fuel. If the fuel is charcoal for a metallurgical (or pre-metallurgical) furnace, its radiocarbon date may be far older than the furnace itself.<sup>83</sup> The article in question strongly recommended that the radiocarbon dating for furnace 8 be cross-checked by another technique, such as thermoluminescence, a radiometric method of dating pottery that could have been used on the fired lining of the furnace. Unfortunately, this was never done, and in fact the recommendation may have come too late, because thermoluminescence signals are degraded by exposure to sunlight. To avoid this, archeologists wrap the sample in light-proof plastic immediately after excavation.

British archeometallurgist David Killick, principal author of this re-assessment of Cuivre I, speculates that a grove of trees once stood at Afunfun 175 and was killed by desiccation of the region. Fire destroyed the last stumps, roots, or fallen trunks at some unknown time after the trees died, leaving cavities containing charcoal and lined with fired clay. If a tree had a long life span, there is no way of telling whether the charcoal dates from the beginning, middle, or end of that life. Four of the 18 structures excavated at Afunfun 175 showed clear evidence of use as furnaces or fire pits. Killick thinks this occurred at various times later, when metal-using groups visited the site and worked copper and iron. Iron slag found in one of the structures (furnace 1) has been two-sigma dated to 400-600 cal CE.<sup>84</sup>

Despite Grébénart's backtracking, he has not given up on Cuivre I, although he concedes it is "an archeological enigma." He believes that local people independently learned how to work (but not smelt) native copper. He was a bit encouraged by the announcement by other French archeologists of a find at a site called In Tékébrin, about 200 miles west of Agadez. Among potsherds, charcoal, and burned cattle bones on a fossil dune were two small, thin copper sheets or plates (lamellae) and some nodules of native copper. The sherds, charcoal, and bones yielded radiocarbon datings that were calibrated to between 2625 and 1675 BCE.

The archeologists thought it probable that the lamellae were made locally by hot-hammering of native copper, although no furnaces or cru-

<sup>83</sup>For discussion of the "old-wood" problem, see David Killick, "On the Dating of African Metallurgical Sites," *Nyame Akuma* no. 28 (1987), 29-30; Killick et al., "Reassessment," 390-91; McIntosh/McIntosh, "Stone to Metal," 103-04.

<sup>84</sup>David Killick, "What Do We Know About African Iron Working?" *Journal of African Archaeology* 2(2004), 105; personal communication, 1 May 2004.



cibles were found. Grébénart wanted to see the two sheets as “a beginning of a proof that could justify the initially recognized technological stage of Cuivre I” but noted that only the context had been dated and that the copper objects could very well derive from a later human occupation than the potsherds, charcoal, and bones.<sup>85</sup>

If Cuivre I is not on solid ground, Grébénart’s Cuivre II certainly is. As mentioned above, he sees close similarities with Akjoujt coppersmithing and, in contrast to his position on Cuivre I, posits common Berber origins. But Cuivre II would appear to have started before the Mauritanian industry; its smelting furnaces are said to “represent the earliest securely dated copper working in West Africa.”<sup>86</sup> Dates from 15 Cuivre II furnaces, when calibrated at two sigmas, fall within the range from 1258 BCE to 130 CE, indicating that copper ore was being smelted in the region for the greater part of the first millennium BCE.<sup>87</sup> Unlike Cuivre I, as Grébénart himself emphasizes, this was “a true metallurgy.”<sup>88</sup>

The major excavation sites are at Afunfun (no. 162), Azelik (ex-Takadda), and Ikawaten, more than 100 miles northwest of Agadez. At these places and others, hundreds of small clay furnaces were built, usually in the shape of a truncated cone but sometimes cylindrical. The base, between 50 centimeters and a meter in diameter, was more or less buried in the soil. The shaft probably rose no more than a meter aboveground. Tuyères sloped downward into the furnace. Combustion was presumably activated by bellows. To extract the metal mass, the shaft had to be broken, so a furnace could be used only once. Remaining in the bowl-like base were slag, fragments of furnace walls and of tuyères, and sometimes residual charcoal usable for dating.<sup>89</sup>

The copper makers appear to have smelted easy-to-work copper oxide and copper carbonate ores found on the surface or just under it, possibly mixed with native copper. Unlike most prehistoric copper-smelting slags, those of Cuivre II contain very little iron oxide, which might have led to the by-production of iron. Experts infer furnace-operating temperatures of 1350-1450° C.<sup>90</sup>

<sup>85</sup>Grébénart, “Relations inter-ethniques,” 125, 130n1. For details of the In Tékébrin find see Paris et al., “Débuts,” 62-63; Paris/Person/Saliège, “Peuplements et environnements,” 388; Paris, “Bassin de l’Azawagh,” 245-46, 248.

<sup>86</sup>Michael S. Bisson, “Copper Metallurgy: Copper in African Prehistory,” in Joseph O. Vogel, ed., *Encyclopedia of Precolonial Africa* (Walnut Creek, 1997), 126.

<sup>87</sup>Killick et al., “Reassessment,” 370. A sixteenth century dating, 640-890 CE, is clearly aberrant.

<sup>88</sup>Grébénart, “Premiers métallurgistes,” 250.

<sup>89</sup>Grébénart, “Métallurgies du cuivre,” 112; idem, “Afrique occidentale,” 50; idem, “Characteristics,” 302-03; Killick et al., “Reassessment,” 381.

<sup>90</sup>Ibid., 381, 388-89, 391.

The copper workers were apparently itinerant artisans. Their furnaces were remote from permanent settlements. The sites seem to have been occupied only during the smelting operations, which were apparently ephemeral, perhaps seasonal, but not necessarily annual. Copper artifacts, found in the vicinity of the furnaces, were all made by hammering of the heated metal—lost-wax casting was not yet known. The objects were tiny and simple: very flat, spatula-shaped arrowheads, pins, awls, burins, perforated plaques, strips, rods, open rings, ingots (the biggest weighing 160 grams). Grébénart estimated the annual output at Afunfun 162 at between 1.5 and 5 kilograms, and overall average annual Cuivre II production at 8.5 to 17 kilograms.<sup>91</sup>

At some time during the Cuivre II period the nomadic metalsmiths began hot-hammering objects of bronze and brass as well as copper; Grébénart guesses ca. 650 BCE for the bronze.<sup>92</sup> It might have been the first appearance of copper alloys in sub-Saharan Africa outside the Nile valley. As we know, tin for bronze was abundantly available nearby in the Air Mountains and easy to exploit. Zinc for brass, though much scarcer, was also found there. There is no hard evidence, however, that either alloy was made locally. The bronze and brass were apparently used only for jewelry, specifically bracelets, finger rings, and ankle rings.<sup>93</sup>

All the while, stone continued to be the material of choice for utensils in the region, and ceramics characteristic of the pre-metallic Sahara remained unchanged. "It seems as if the use of metal," says Grébénart, "was simply added to that of stone, bone and wood to round out the small tools and weapons of everyday life."<sup>94</sup> As with the Akjoujt period in Mauritania, Niger's Cuivre II could hardly be called a Copper Age.

## X

The region in which Cuivre I and II overlapped was bordered on the south by a 150-mile-long, southward-curving escarpment known as the Tigidit Cliff. The cliff faces north, and the land behind it slopes gently downward from the crest. The scarp is nowhere very high, and easily crossed. In the area south of the cliff, Grébénart and his colleagues discovered an ancient iron-making culture that he dubbed Fer I.

<sup>91</sup>Grébénart, "Métallurgies du cuivre," 112, 114; idem, "Afrique occidentale," 50-51; idem, "Characteristics," 303, 306-07; idem, "Premiers métallurgistes," 253; idem, "Relations inter-ethniques," 125-26.

<sup>92</sup>Grébénart, "Premiers métallurgistes," 251.

<sup>93</sup>Grébénart, "Afrique occidentale," 51; idem, "Characteristics," 303, 313; idem, "Premiers métallurgistes," 252-53; "Premiers métaux," 81-82.

<sup>94</sup>Grébénart, "Characteristics," 312-13.

Fer I differed considerably from Cuivre II. Iron was smelted and forged in, or on the fringes of, permanent settlements. The habitation sites ranged from 20 or 30 meters in diameter to more than a hectare, indicating that some were real villages. Thirty-one such sites were found in a stretch of about 125 miles. The metallurgical furnaces of Fer I, unlike those of Cuivre II, were built on the ground, not in it, so when the oven was smashed to recover the iron bloom, the slag, fired-clay wall fragments and residual charcoal scattered, making accurate dating impossible.

However, refuse dumps containing potsherds, iron artifacts, slag, and charcoal were found on many sites, and the charcoal from such closed environments can be used to date the other wastes. Four calibrated datings ranged from 810 BCE to 194 CE. On the basis of a single dating, 810 to 380 BCE, Grébénart claimed for a while that Fer I “made its appearance toward the start of the eighth century BCE,” but he could just as well have said it began as late as 400 BCE because such is the nature of calibrated datings.<sup>95</sup> The other three datings suggest that Fer I should be assigned to the second half of the first millennium BCE and the first century or two CE.

As with Cuivre II, Fer I produced very small objects, overall output was quite limited, and stone tools continued to predominate. The metal artifacts were comparable to those of Cuivre II—arrowheads, pins, rings, bracelets, and perforated plaques—but also included barbed and unbarbed harpoon heads, blades, and nails. Grébénart said they gave the impression of being more used in everyday life than those of Cuivre II. The objects were fashioned from iron rods by hammering—only elementary forging techniques were employed. The volume of slag hardly exceeds a cubic meter where it is most abundant, indicating that production was slight.

For several centuries Fer I people were in contact with the copper workers of Cuivre II to the north of the Tigidit Cliff. We know that because many of their iron tools have been found around Cuivre II furnaces, and Cuivre II bronze and brass ornaments have been found on many Fer I sites, including on human remains in tombs. Some products were not exchanged; each group held on to its distinctive pottery, and Cuivre II *copper* artifacts are not found in Fer I settlements.

While both Cuivre I and Cuivre II pottery were identified by Grébénart as “Saharan Neolithic,” Fer I pottery was described as “Sahelian Neolithic.” This and other cultural differences, most notably the separate metalworking specialities, plus the spatial relationship, led Grébénart to postulate the presence of two distinct ethnic groups, one oriented toward the Sahara, the other toward the Sahel. In other words, copper technolo-

<sup>95</sup>Grébénart, “Afrique occidentale,” 52.

gy may have come from the north and iron technology from the south. If true, this would of course strengthen the case for the independent invention of iron smelting. In any event, there is no evidence that Fer I evolved from Cuivre II as some Africanists have suggested.

Grébénart extended Fer I to cover early ironworking in the Termit Massif of eastern Niger and the Jos Plateau region of Nigeria, but stopped short of endorsing independent invention. "As with the copper metallurgy," he wrote,

external influences are possible: Carthaginian to the north, Nubian to the east, without any need for intermediary landmarks. One man or a group of individuals knowing how to manufacture iron can cover great distances from their place of origin and put their know-how into practice when they find the necessary ore and fuel in one place. That the Agadez-Termit-Jos triangle was an autonomous center for the manufacture of iron should not be excluded, but this hypothesis can only become a certainty when supported by datings clearly older than those of the eastern Mediterranean basin.<sup>96</sup>

Grébénart's fourth metalworking phase, Fer II, need not detain us. It is confined to the ancient community of Marandet, about 55 miles southwest of Agadez at the foot of the Tigidit Cliff. Both iron and copper were worked there during the second half of the first millennium CE. It is not known whether the blacksmiths and coppersmiths were the same people or separate groups. The site is remarkable for its multitude of small, ancient metallurgical crucibles, estimated by Grébénart to number close to 200,000.<sup>97</sup>

## XI

Grébénart's effort to assimilate Termit ironworking to his Fer I ill-fits the very early radiocarbon datings obtained in the massif. Those datings make the best case yet for independent invention. Termit is a small patch

<sup>96</sup>Grébénart, "Premiers métallurgistes," 260. The material on Fer I comes from Grébénart's writings: "Métallurgies du cuivre," 114-18; "Afrique occidentale," 51-53; "Characteristics," 308-12; "Premiers métallurgistes," 142-43, 253-54, 260; "Relations inter-ethniques," 126-28. See also Killick et al., "Reassessment," 370.

<sup>97</sup>Grébénart, "Métallurgies du cuivre," 116; idem, "Afrique occidentale," 52; idem, "Marandet" in Devisse, *Vallées du Niger*, 375-77. Analysis of material from the crucibles indicates they were used to melt local native copper and apparently imported brass and copper-lead alloys. David Killick, personal communication, 1 February 2005.

of now-uninhabited highlands rising to 2300 feet on the edge of the Sahara some 200 miles east of the Tigidit Cliff. It lies about 1400 miles almost due south of Carthage. In 1972 Gérard Quéchon and Jean-Pierre Roset reconnoitered the area archeologically and found iron or copper objects on 12 surface sites. Awl-like tools appeared to have been forged from small iron bars by hammering. One of the archeological sites, called Do Dimmi, contained the vestigial bases of 11 small shaft furnaces—eventually 22 were found—in which iron had apparently been smelted. Charcoal found near one of them was subsequently radiocarbon-dated to  $2628 \pm 120$  BP, or  $678 \pm 120$  bce, uncalibrated.

The dating caused a stir among Africanists because it was the earliest yet obtained for sub-Saharan iron metallurgy. The find was remarked twice in the *Journal of African History's* periodic surveys of new archeological datings.<sup>98</sup> The second article calibrated the dating to 1126-606 BCE at the two-sigma level, judged “its association with iron smelting . . . unquestionable,” but cautioned that “the wood might have been already old when used as charcoal. This is not unlikely in the Sahara.”<sup>99</sup> The calibrated range was later corrected to 1030-580 BCE.<sup>100</sup> In an article reporting the results of their reconnaissance, Quéchon and Roset acknowledged that the dating was unexpectedly early and would have to be checked by further prospecting in Termit.<sup>101</sup>

Quéchon returned to the area three times in the 1980s, then announced at an international conference in 1989 that a dozen new radiocarbon datings of Termit charcoal showed that iron and copper objects appeared there “before 1350 BCE.”<sup>102</sup> The new dates were published in the *Journal des Africanistes* in 1992, accompanied by the same assertion.<sup>103</sup> Quéchon's three co-authors on that occasion went a step further the following year, crediting him with revealing “a culture that, between 3500 and 3000 BP, succeeded in mastering iron metallurgy.”<sup>104</sup> By 1996 Quéchon was claiming that the first metal objects appeared at Termit

<sup>98</sup>Merrick Posnansky and Roderick McIntosh, “New Radiocarbon Dates for Northern and Western Africa,” *JAH* 17(1976), 183-84, 193; D. Calvocoressi and Nicholas David, “A New Survey of Radiocarbon and Thermoluminescence Dates for West Africa,” *JAH* 20(1979), 10, 25.

<sup>99</sup>*Ibid.*, 10.

<sup>100</sup>Grébénart, *Premiers métallurgistes*, 143; Paris et al., “Débuts de la métallurgie,” 58.

<sup>101</sup>Gérard Quéchon and Jean-Pierre Roset, “Prospection archéologique du massif de Termit (Niger),” *Cahiers ORSTOM. Série Sciences Humaines* 11(1974), 97.

<sup>102</sup>Cornevin, *Archéologie africaine*, 122.

<sup>103</sup>Paris et al., “Débuts de la métallurgie,” 58.

<sup>104</sup>Paris/Person/Saliège, “Peuplements,” 388.

“around 1500 BCE.” And on the strength of five new datings from the Do Dimmi furnace sites reported in 1989, he said iron ore was being smelted in the area between 1000 and 500 BCE.<sup>105</sup> More recently, Quéchon narrowed the timing of the oldest metallurgical furnaces to “around 800 BCE.”<sup>106</sup>

The 700-year gap between the appearance of metal objects and the appearance of furnaces called for an explanation. Quéchon thinks it “very unlikely” that two stages were implied, the first with imported metals, the second with local reduction of ores. Even for the period when metal tools were becoming more common, furnace remains are very scarce, so it is no wonder, in his view, that earlier traces have not yet been found.<sup>107</sup>

As we have seen, datings on charcoal from Saharan sites may be skewed by the “old-wood” problem. To get around that, Quéchon submitted samples of Termit potsherds, as well as charcoal, for radiocarbon-testing. The pots were made with a vegetable temper composed of annual plant remains, either grain husks, grass, or seeds, that can be accurately dated. Some of the datings published in 1992 were on ceramic temper rather than charcoal although that was not indicated at the time. The full set of Termit dates, with identification of the tested substances, was published in 2002.<sup>108</sup>

Six of those dates are important for this paper because they concern potsherds found on the same sites as metal objects. They range, in two-sigma calibration, from 1673-1421 to 1257-901 BCE.<sup>109</sup> In addition, Quéchon was able to compare datings of potsherds and charcoal found in proximity on five Termit sites, and judged the concurrence “very convincing.”<sup>110</sup> His overall conclusion is that the early dates from Termit “obviously exclude a Mediterranean or Meroitic [Nubian] origin for iron met-

<sup>105</sup>Gérard Quéchon, “Archéologie préhistorique de la région de Termit” in Leroy, *Préhistoire*, 23.

<sup>106</sup>Quéchon, “Datations” in Bocoum, *Origines*, 109; idem, “Datations,” *Meditarch*, 251.

<sup>107</sup>Quéchon, “Datations” in Bocoum, *Origines*, 109-10; idem, “Datations,” *Meditarch*, 251.

<sup>108</sup>Quéchon, “Datations” in Bocoum, *Origines*, 109-10; idem, “Datations,” *Meditarch*, 250-51; Alain Person and Gérard Quéchon, “Données chronométriques et chronologiques de la métallurgie à Termit” in Bocoum, *Origines*, 118-19; idem, the same article, *Meditarch*, 260-61.

<sup>109</sup>The measurements were all done in a Paris laboratory and are numbered, in order of age, Pa 810, Pa 811, Pa 510, Pa 481, Pa 669 and Pa 688 (Pa 668 in the 1992 article). A seventh dating (Pa 519) on a potsherd associated with metal, 777-391 BCE, was deemed “archeologically illogical” by Quéchon (109 in *Origines*, 250 in *Meditarch*).

<sup>110</sup>Quéchon, “Datation” in Bocoum, *Origines*, 108, 110; idem, “Datations,” *Meditarch*, 250-51.

allurgy south of the Sahara” and argue strongly for independent invention.<sup>111</sup>

A place named Egaro some 40 miles west of the Termit Massif has yielded even earlier dates. Two potsherds found near iron objects on surface sites were dated by calibration to 2900-2300 and 2520-1675 BCE. This has been seen as confirmation that iron metallurgy in Niger goes back deep into the second millennium BCE.<sup>112</sup> However, Quéchon himself cautioned that the finding “lacks the critical apparatus that would allow it to be totally affirmative.”<sup>113</sup>

Quéchon’s data and conclusions on Termit have been widely accepted, but a few specialists contend that his case is seriously flawed. The principal criticism is that there is no real proof that the (reliably-)dated potsherds found in association with metal objects or charcoal are contemporaneous with them. Pottery making at Termit may indeed go back 7000 years. The sherds found with metal and fuel were apparently all recovered from what archeologists call deflation surfaces. These are formed by winds blowing away soil or sand and thereby mixing artifacts from different periods. Normally archeologists rely on stratigraphy to determine whether associated materials are contemporaneous, but in very arid regions like Termit this is usually impossible, and Quéchon has produced no stratigraphic evidence.

Quéchon is well aware of the deflation problem and admits that it is crucial, but he believes the Termit datings and what he describes as the consistent composition of the surface assemblages demonstrate that certain dated potsherds are from the same epoch as the metal objects and charcoal. The use of metal at Termit coincided with what he calls “the final Neolithic,” and he says “documents” for that period “proved that the sites . . . were almost always totally exempt from disturbances and mixtures.”<sup>114</sup> He would call them “open-air sites rather than surface sites in the customary sense of the term,” presumably meaning that deflation is not involved.<sup>115</sup>

Critics charge that such assertions are insufficiently documented. Quéchon’s claim that iron objects were always found with the same range of

<sup>111</sup>Gérard Quéchon, “La fin du néolithique et les débuts de la métallurgie dans le massif de Termit (Niger): éléments de méthodologie” in Marliac, *Milieux*, 311; idem, “Archéologie préhistorique,” 23; idem, “Datations” in Bocoum, *Origines*, 111, 114; idem, “Datations,” *Meditarch*, 252-53.

<sup>112</sup>Paris et al., “Débuts,” 58-59, 62.

<sup>113</sup>Quéchon, “Datations” in Bocoum, *Origines*, 111; idem, “Datations,” *Meditarch*, 252.

<sup>114</sup>Quéchon, “Datations” in Bocoum, *Origines*, 113.

<sup>115</sup>Quéchon, “Datations” *Meditarch*, 253.

pottery types has to be taken on faith, they say, because he has not published an adequate number of illustrations. Detailed drawings of the surface material have not been forthcoming. David Killick challenges Quéchon's claim that potsherd and charcoal dates from the same surface scatters agree in convincing fashion. He says that "this is not at all obvious" from the table presented, and instead finds some of the coupled datings rather far apart.<sup>116</sup>

No archeometallurgist has ever accompanied Quéchon to Termit, and Killick deplores the absence of any metallographic or chemical study of the iron artifacts, which, he suggests, might have been made of meteoritic iron rather than smelted metal.<sup>117</sup> The recently developed technique that can date iron directly, known as accelerator mass spectrometry (AMS), seems not to have been tried.<sup>118</sup>

Killick notes that the only Termit evidence of smelting or forging is the cluster of 22 furnace bottoms at Do Dimmi dated to the first half of the first millennium BCE, and which Quéchon believes go back to around 800 BCE. He thinks it unfortunate that fired furnace ceramics from the site were not dated by thermoluminescence, which might have corrected for any old-wood problem with the charcoal tested. Killick's reading of the site is that the furnace bases, geometrically arranged in a sinuous line, were "the product of a single group of metalworkers and were produced in a short span of time, perhaps a single year." He points out that Quéchon has offered no explanation of how iron smelting could have developed in Niger in a completely Neolithic environment. And he wonders why, if Termit ironworking really goes back well into the second millennium BCE, as Quéchon affirms, it took so many centuries to appear in neighboring areas.<sup>119</sup>

American archeologist Susan Keech McIntosh faults Quéchon and his colleagues for not establishing "detailed, well-dated sequences of pottery" for Termit to make up for the lack of stratified deposits. Potsherds have been sorted into four very broad groups, but the situation, she says, calls for "methods that systematically describe, count, and compare the styles and types of pottery present on the surface of many sites to make an argu-

<sup>116</sup>Killick, "What Do We Know," 102-03, 104.

<sup>117</sup>Quéchon, "Datations" in Bocoum, *Origines*, 106; idem, "Datations," *Meditarch*, 248.

<sup>118</sup>Killick, "What Do We know," 103, 104. See also Susan Keech McIntosh, "Archaeology and the Reconstruction of the African Past" in John Edward Philips, ed., *Writing African History* (Rochester, NY, 2005), 73-78. See Richard G. Cresswell, "Radiocarbon Dating of Iron Artifacts," *Radiocarbon* 34(1992), 898-905, for a description of AMS.

<sup>119</sup>Killick, "What Do We Know," 103-04.



ment for chronology based on changing popularity of various categories," techniques archeologists call "seriation."<sup>120</sup>

McIntosh also criticizes Quéchon's interpretation of calibrated radiocarbon dates. As we know, calibration always produces a range of dates, not a single one, with the earliest no more valid than the latest, yet Quéchon invariably favors the earlier dates. He arbitrarily asserts that metal objects began appearing by about 1500 BCE, and that the Do Dimmi furnaces date to about 800 BCE. McIntosh observes that the latter dating could be off by four centuries, so Quéchon's chronological claim for Do Dimmi fails to use calibration correctly.<sup>121</sup>

A decade before Killick and McIntosh, Grébénart also expressed skepticism over Quéchon's claims. "Just the presence of iron objects associated with potsherds," he wrote,

*on the surface of an occupation site in a hyper-sandy desert region [his italics], does not suffice to date iron metallurgy and the appearance of iron. Either the objects dated must come from an enclosed assemblage, such as a refuse pit, guaranteeing the almost certain contemporaneity of the contents, or the ovens used to make the metal must be dated.*

While he accepted the first-millennium-BCE Do Dimmi furnace dates, which mesh with his Fer I, he argued that the earlier Termit (and Egaro) results "can only be retained when accompanied by datings made on materials incontestably contemporaneous with the industry and the techniques they are supposed to date."<sup>122</sup>

For another French archeologist specializing in Niger, Anne C. Haour,

[n]o definitive statement can be made on the occurrence of metal implements on surface settlements . . . other than to wish that these had been recovered in stratigraphically secure contexts. Skepticism . . . is the wisest approach.<sup>123</sup>

## XII

Believers in the independent invention of iron smelting on the basis of the Niger data point to early datings reported elsewhere in sub-Saharan

<sup>120</sup>McIntosh, "Archaeology and Reconstruction," 76-77.

<sup>121</sup>Ibid., 74. See also Killick, "What Do We Know," 110.

<sup>122</sup>Grébénart, "Relations inter-ethniques," 126, 129.

<sup>123</sup>Anne C. Haour, "One Hundred Years of Archaeology in Niger," *Journal of World Prehistory* 17(2003), 217-18.

Africa as support for the theory. Often cited is Taruga in central Nigeria, some 560 miles south-southwest of the Termit Massif. There it has been shown that the so-called “Nok Culture,” famous for its terracotta figurines, also produced iron in the first millennium BCE.<sup>124</sup> The sculptures may date back to the very beginning of that millennium, but iron smelting may not have begun before the fifth or sixth century BCE.<sup>125</sup>

The Taruga site consists of a three-acre flat terrace in a well-watered, wooded valley about 55 miles southwest of the village that gave the Nok Culture its name. Bernard Fagg, the British archeologist who identified the culture in the 1940s, excavated 13 iron-smelting furnaces there in the 1960s. The furnaces were all thin-walled, freestanding clay shafts over foot-deep slag pits cut into decomposed granite. Surviving furnace walls rose about eight inches (20 centimeters) above the ancient ground level, and had probably been a meter or two high when functional. Shaft diameters ranged from 14 to 41 inches. Tuyère fragments, slag, charcoal, and iron objects were also found on the site, and abundant pottery suggested a settled community. Unlike other Nok Culture sites, Taruga yielded no polished stone axes, hinting at a full iron-using society.<sup>126</sup>

Terracotta figures found at Taruga made clear the connection of the furnaces to the broader Nok complex. Fagg suggested that the sculptures might have been objects of worship to insure the success of iron smelting and blacksmithing.<sup>127</sup> His daughter, Angela Fagg, excavated a Nok Valley occupation site named Samun Dukiya in 1969-70 and found fragments of many iron objects—knife blades, arrowheads, spearheads, hooks, and bracelet—but no furnaces. Stone artifacts were also common.<sup>128</sup>

While mid-first-millennium-BCE radiocarbon datings are especially chancy, as mentioned above, a consensus seems to have emerged for just that period for the beginning of iron metallurgy at Taruga.<sup>129</sup> An earlier

<sup>124</sup>Africanists have debated whether Nok artistic traditions constitute a culture.

<sup>125</sup>Yashim Isa Bitiyong, “Culture Nok, Nigeria” in Devise, *Vallées du Niger*, 397, 413; Bernard de Grunne, *The Birth of Art in Black Africa: Nok Statuary in Nigeria* (Paris, 1998), 19, 114.

<sup>126</sup>Tylecote, “Origin,” 5-6; Rustad, “Emergence,” 230-31; Thurstan Shaw, “The Nok Sculptures of Nigeria,” *Scientific American* 244/2 (February 1981), 121; J.F. Jemkur, *Aspects of the Nok Culture* (Zaria, 1992), 54-55.

<sup>127</sup>Bernard Fagg, *Nok Terracottas* (2d. ed.: London, 1990), 39, first published in 1977.

<sup>128</sup>Shaw, “Nok Sculptures,” 119; Jemkur, *Aspects*, 58-59.

<sup>129</sup>*Ibid.*, 67-70; idem, “Débuts,” 23; Bitiyong, “Culture Nok,” 397-98; David W. Phillipson, *African Archaeology* (2d. ed.: Cambridge, 1993), 175-76; Duncan E. Miller and Nikolaas J. van der Merwe, “Early Metal Working in Sub-Saharan Africa: a Review of Recent Research,” *JAH* 35(1994), 9; Elizabeth Isichei, *A History of African Societies to 1870* (Cambridge, 1997), 70; Scott MacEachern, “Western

start, however, should not be ruled out. Nigerian archeologist J.F. Jemkur notes two eighth-century-BCE C<sup>14</sup> datings, but thinks they “may represent old charcoal lying on the land surface on which the furnaces were constructed.”<sup>130</sup> Two other datings, calibrated only to the one-sigma level, are 810-520 and 805-535 BCE, which make an early-first-millennium-BCE beginning possible, if not probable.<sup>131</sup>

When the first Taruga datings came out, they were the oldest ever reported for iron technology in sub-Saharan Africa. British metallurgist Ronald F. Tylecote saw a resemblance between the Nigerian furnaces and those used in northern Germany and Denmark during the first few centuries CE, and postulated a common origin.<sup>132</sup> Other scholars thought that “the early Nigerian smelting process did not differ substantially from that of the Mediterranean.”<sup>133</sup> Carthage was invoked by several as the source of the technology.<sup>134</sup> Grébénart has linked Taruga to Tigidit and Termit.<sup>135</sup> But no real evidence for any of these hypotheses has yet been produced.

Nigerian archeologist Edwin Eme Okafor has excavated metallurgical furnaces in Nsukka Division, some 150 miles south of Taruga, and concluded that “bloomery iron-smelting probably began [there] around the fifth century B.C., much the same time as at Taruga.” He based this mainly on a two-sigma calibrated dating of 765-120 BCE.<sup>136</sup> More recently Okafor, on the basis of the same range of dates, has asserted that iron-ore reduction in Nsukka Division began around the time of the earliest one, even though the calibration means, as noted above, that there is a 95.4% chance the true date falls between 765 and 120 BCE.<sup>137</sup>

African Iron Age” in Vogel, *Encyclopedia*, 425; Woodhouse, “Iron in Africa,” 167; David A. Aremu, “Les routes du fer en Afrique: une contribution du Nigéria” in Bocoum, *Origines*, 147.

<sup>130</sup>Jemkur, *Aspects*, 67.

<sup>131</sup>Bitiyong, “Culture Nok,” 397.

<sup>132</sup>Tylecote, “Origin,” 6-7; idem, *History*, 47.

<sup>133</sup>Nikolaas J. van der Merwe and Donald H. Avery, “Pathways to Steel,” *American Scientist* 70/2(March-April 1982), 151.

<sup>134</sup>Shaw, “Radiocarbon Chronology,” 229; idem, “Nok Sculptures,” 121-22; Tylecote, “Origin,” 5, 7; Mauny, “Trans-Saharan Contacts,” 333.

<sup>135</sup>Grébénart, “Métallurgies,” 118; idem, “Débuts,” 53; idem, *Premiers métallurgistes*, 254. He placed Taruga on the Jos Plateau, but the Nok Culture heartland lies west of the plateau, and Taruga itself is more than 70 miles away.

<sup>136</sup>Edwin E. Okafor, “New Evidence on Early Iron-Smelting from Southeastern Nigeria” in Thurstan Shaw, Paul Sinclair, Basseyy Andah, and Alex Okpoko, eds., *The Archaeology of Africa: Food, Metals and Towns* (London, 1993), 437-39. See also Okafor and Patricia Phillips, “New 14C Ages from Nsukka, Nigeria, and the Origins of African Metallurgy,” *Antiquity* 66(1992), 686, 688.

<sup>137</sup>Edwin E. Okafor, “La réduction du fer dans les bas fourneaux: Une industrie vieille de 2500 ans au Nigéria” in Bocoum, *Origines*, 36, 37, 45, 47; idem, “Early Bloomery Iron Smelting in Igboland,” *Meditarch*, 299.

## XIII

Other early dates have come from just north of the Mandara Mountains that straddle the border between northeastern Nigeria and northern Cameroon. Canadian archeologist Scott MacEachern has reported on extensive stratigraphic excavations conducted in the area in the early 1990s that have dated local ironworking to the first millennium BCE. A piece of cow bone associated with iron artifacts and slag at Ghwa Kiva in Nigeria has produced a two-sigma spread of 1250-350 cal BCE. Charcoal from Doulo Igzawa 1 in Cameroon, also associated with iron tools and slag, ranged from 800 to 400 cal BCE. MacEachern conservatively puts the start of ironworking at "before 500 BCE." He suggests that metallurgical knowledge may have reached the area via an ancient trans-Saharan route from Tripoli to Borno, south of Lake Chad, but he also acknowledges the possibility of independent invention.<sup>138</sup>

Nearly 600 miles south-southwest of the Mandara area sites, what appeared to be an ancient iron-smelting furnace was excavated in 1989-90 at Oliga, just north of Cameroon's capital of Yaoundé. The Cameroonian excavator, Joseph-Marie Essomba, submitted 12 charcoal samples from different strata of the structure to radiocarbon laboratories. The tests produced a wide range of datings that were calibrated to the two-sigma level. Two samples worked out to 1300-800 cal BCE, one to 1256-500 cal BCE, one to 773-212 cal BCE, and the rest clustered in the second half of the first millennium BCE.<sup>139</sup> Essomba cautioned that the three oldest datings "might appear for the moment excessive and should be taken with circumspection." He acknowledged that dates spanning well over a millennium for a single furnace "pose a problem." But he claimed, nonetheless, that the oldest ones "pushed back the beginnings of the Iron Age in the region" to the eighth or ninth century BCE.<sup>140</sup>

French archeologist Bernard Clist, who has studied the Oliga data and visited the place, doubts very much that the excavated site represents an iron-smelting furnace. He notes the vast spread of dates, some coming from charcoal in strata just a few centimeters apart, and knows of no other archeological dig where so many samples found so close together

<sup>138</sup>Scott MacEachern, "Iron Age Beginnings North of the Mandara Mountains, Cameroon and Nigeria" in Gilbert Pwiti and Robert Soper, *Aspects of African Archaeology* (Harare, 1996), 489-95; idem, personal communication, 21 September 2004.

<sup>139</sup>Joseph-Marie Essomba, "Dix ans de recherches archéologiques au Cameroun méridional (1979-1989)," *Nsi* no. 6(1989), 44-48, 53; idem, "Bilan de l'archéologie de l'âge du fer au Cameroun méridional" in Bocoum, *Origines*, 137-38. One dating, 831 BCE-CE 567, was discounted as seemingly aberrant.

<sup>140</sup>*Ibid.*, 138-39.

have been dated so far apart. Clist also points out that there is no objective way to single out any date in the gamut of Oliga dates as more accurate than any other. He believes the data come from what archeologists deem a “secondary deposit,” a natural pit at the base of a hillside down which rain has washed remains of an iron-smelting furnace, including slag and tuyères, along with charcoal from various periods besides that of the furnace.<sup>141</sup> Killick, who has also assessed the Oliga evidence, concurs with Clist’s interpretation.<sup>142</sup>

In neighboring Gabon, ironworking seems to date from roughly the same period as in Cameroon, but archeologists working in the region have postulated a north/south movement of the technology carried by Bantu metalworkers. Clist and Richard Oslisly separately reported finding, in the mid-1980s, an ancient iron-smelting furnace in the middle Ogooué river region just below the equator at a site named Otoumbi 2. Two samples from the site yielded radiocarbon dates of 2640±70 bp and 2400±50 bp that were two-sigma calibrated to 961-559 BCE and 752-401 BCE respectively.<sup>143</sup> Subsequently, however, Clist re-evaluated the evidence and eventually decided that what he had thought was a furnace was instead “the remains of a termite mound altered by a brush fire and erosion.”<sup>144</sup> Although Clist expressed reservations about the site as early as 1988, some Africanists still talk about the Otoumbi 2 datings as if they were valid.<sup>145</sup> Clist now believes the earliest evidence for iron smelting in Gabon dates to around 400 BCE and comes from the upper Ogooué re-

<sup>141</sup>Bernard Clist, personal communication, 10 October 2004; idem, “Des premiers villages aux premiers Européens: Quatre millénaires d’interactions entre l’homme et son milieu autour de l’estuaire du Gabon” (Doctorat, Université Libre de Bruxelles, 2005), 769, 771-72, 781.

<sup>142</sup>David Killick, personal communication, 10 October 2004.

<sup>143</sup>B. Peyrot and R. Oslisly, “Paléoenvironnement et archéologie au Gabon (1985-1986),” *Nsi* no. 1(1987), 14; Bernard Clist, “Archaeology in Gabon 1886-1988,” *African Archaeological Review* (hereafter AAR) 7(1989), 71, 83; Richard Oslisly and Bernard Peyrot, “L’arrivée des premiers métallurgistes sur l’Ogooué, Gabon,” AAR 10(1992), 134.

<sup>144</sup>Bernard Clist, “Un nouvel ensemble néolithique en Afrique centrale: le groupe d’Okala au Gabon,” *Nsi* no. 3(1988), 49; M.-P. Jézégou and Bernard Clist, “L’âge du Fer Ancien: Gabon” in Raymond Lanfranchi and Bernard Clist, eds., *Aux origines de l’Afrique centrale* (Libreville, 1991), 204; Clist, *Gabon: 100 000 ans d’Histoire* (Libreville, 1995), 182; idem, personal communications, 2 October and 26 November 2004; idem, “Premiers villages,” 776-77, 781.

<sup>145</sup>Woodhouse, “Iron in Africa,” 167, 169; Pierre de Maret and G.Thiry, “How Old Is the Iron Age in Central Africa?” in Schmidt, *Culture and Technology*, 31; Richard Oslisly, “Chronologie des ages du fer dans la moyenne vallée de l’Ogooué au Gabon,” *Meditarch*, 264; de Maret, “Afrique centrale,” 125. Woodhouse claimed that the datings were “generally accepted” and cited Clist’s *Gabon* as a source!

gion at adjacent sites called Moanda 1 and 2.<sup>146</sup> He thinks the technology is likely to have derived from Nigeria.<sup>147</sup>

One other nation in the region, the Central African Republic, may have produced the earliest credible date for ironworking in west-central Africa. In the course of inventorying his country's ancient megaliths between 1987 and 1992, C.A.R. archeologist Etienne Zangato discovered an elaborate system of iron production possibly dating to the ninth century BCE. The evidence comes from the Ndio district in the far west of the country, near the Cameroon border. At a place Zangato called Gbabiri 1 site 77, he found the remains of metallurgical ateliers. Charcoal from a forge where iron bloom was refined and iron objects were fashioned was radiocarbon-dated and two-sigma calibrated to 839-782 BCE.

The structure also contained tuyère, bloom, and ingot fragments, and around it were found iron artifacts: a knife blade, a bell, and stems of what may have been arrowheads or assegai points. Charcoal from an iron-smelting furnace on the same site was dated to 513-430 cal BCE.<sup>148</sup> Zangato believed iron metallurgy was introduced to the area by newcomers, but he did not speculate as to where they came from.<sup>149</sup> Augustin Holl has hailed Zangato's find as "exciting evidence of early African iron working," but more than one ninth-century-BCE dating is needed to establish its antiquity, particularly since furnaces found on seven other sites in the region yielded much later dates.<sup>150</sup>

#### XIV

The Great Lakes region of East Africa is widely thought to have produced further evidence that sub-Saharan Africans may have independently invented iron smelting. In the introduction to the important 2001 issue of *Mediterranean Archaeology* cited in this paper's first note and many subsequent ones, Huyssecom states that

[t]he research of . . . Van Grunderbeek and . . . Schmidt has shown that the region . . . could . . . have benefited from an early independent metallurgy starting at the beginning of the 1st millennium B.C., or according to some radiocarbon datings even earlier, i.e. from the 15th century B.C.

<sup>146</sup>Jézégou/Clist, "Age du Fer," 206; Clist, *Gabon*, 183; idem, "Premiers villages," 769, 774.

<sup>147</sup>Clist, "Archaeology in Gabon," 85; Jézégou/Clist, "Age du Fer," 203, 207; Clist, personal communication, 5 November 2004.

<sup>148</sup>Etienne Zangato, *Sociétés préhistoriques et mégalithes dans le nord-ouest de la République centrafricaine* (Oxford, 1999), 46-47, 95, 101, 103, 106-09, 142-43.

<sup>149</sup>Ibid., 46, 144.

<sup>150</sup>Holl, "Metals," 14; Zangato, *Sociétés préhistoriques*, 47.

He adds, however, that “here, contrary to the position in Niger, the dates of the beginning of metallurgy have not been established.”<sup>151</sup>

Starting in 1969, Schmidt elicited and unearthed a great deal of information—ethnographic and oral-historical as well as archeological—about the Haya people, who live in the northwest corner of Tanzania, between Lake Victoria and the borders of Rwanda and Burundi, in a district known as Buhaya. Haya traditions about iron production led him to prospect an ancient shrine at a site called Rugomora Mahe. The remains of a forge and other features linked to iron metallurgy there were dated to the mid-first-millennium BCE.<sup>152</sup> Schmidt thinks that earlier dates obtained in the area derive from the charcoal of forest fires that long predated ironworking.<sup>153</sup> He is inclined to believe that iron smelting was independently invented in Africa, but says the hypothesis “awaits substantiation.” and has conceded that “[k]nowledge of iron production may ultimately derive from Europe or Asia.”<sup>154</sup> Meanwhile, he has credited African smelters with inventing certain iron-making techniques, about which more later.

The oldest dates for ironworking in the Great Lakes region come from Rwanda and Burundi. Belgian archeologists led by Marie-Claude Van Grunderbeek worked in both countries between 1978 and 1986 and found equally ancient iron-smelting remains on the Central Plateau that the two share. The Burundi finds consisted only of fragments of furnace shafts and scattered slag, but in Rwanda, near the town of Butare (meaning “iron” in the local language), a wealth of evidence turned up—charcoal and tuyères as well as shaft fragments and slag—and 20 iron smelting furnaces were excavated. All the discoveries were associated with ceramics characterizing a culture known to specialists as Urewe.<sup>155</sup>

<sup>151</sup>Huysecom., “Beginning of Iron Metallurgy,” *Meditarch*, 3.

<sup>152</sup>Peter R. Schmidt, “A New Look at Interpretations of the Early Iron Age in East Africa,” *HA* 2(1975), 128, 132-33; idem, *Historical Archaeology: a Structural Approach in an African Culture* (Westport, 1978), 190-91, 195, 198, 272, 277, 292; Schmidt/Avery, “More Evidence,” 434; idem, “Complex Iron Smelting and Prehistoric Culture in Tanzania” in Schmidt, *Culture and Technology*, 174; Schmidt, *Iron Technology in East Africa: Symbolism, Science, and Archaeology* (Bloomington, 1997), 14-15. The dates he used range from around 400 to 600 BCE.

<sup>153</sup>Ibid., 14.

<sup>154</sup>Schmidt, *Culture and Technology*, 8; Schmidt and S.Terry Childs, “Innovation and Industry During the Early Iron Age in East Africa: The KM2 and KM3 Sites of Northwest Tanzania,” *AAR* 3(1985), 54.

<sup>155</sup>Marie-Claude Van Grunderbeek, Emile Roche, and Hugues Doutrelepon, “L’âge du fer ancien au Rwanda et au Burundi: archéologie et environnement,” *Journal des Africanistes* 52(1982), 5-58; Van Grunderbeek, “Essai de délimitation chronologique de l’âge du fer ancien au Burundi, au Rwanda et dans la région des Grands Lacs,” *Azania* 27(1992), 53-80; Van Grunderbeek, Roche, and Doutrelepon, “Un type de

The Rwanda furnaces consisted of bowl-shaped excavations up to 2.4 feet (75 centimeters) deep and 4.5 feet (140 centimeters) in diameter, topped by conic shafts roughly equal in height to the bowl diameter. The shafts were made of superimposed rolls of clay. Several clay tuyères were inserted under the superstructure, barely penetrating the bowl. The Belgian team found one 10-inch-long (25-centimeter) tuyère in place, its burned end protruding just a couple of inches into the furnace. The tuyères were probably discarded after one smelt. In the bigger furnaces the bottom of the bowl was anciently lined with fresh leafy branches, grasses, and papyrus, then the charcoal and ore were arranged above them. After the smelt the shaft was destroyed to get at the bloom, which was hammered to extract impurities. None of the manufactured objects have yet been found.<sup>156</sup>

Some of the charcoal was radiocarbon-dated to the second millennium BCE, but the oldest date, 3615±205 BP, was later found to be some 1600 years too early, and a note of caution was attached by the excavators to two late-second-millennium dates. Another date on charcoal from a Rwanda furnace, 2635±95 BP, was two-sigma calibrated to 1000-400 BCE. Surprisingly in view of what we know about calibration, van Grunderbeek and her colleagues have taken this to mean that iron smelting in the area goes back to the ninth century BCE. They believe this judgment is supported by a dating of charcoal extracted from slag that calibrated to 1450-500 BCE.<sup>157</sup>

Despite the ninth-century claim, and recognition that iron smelting could have been invented in the Great Lakes region, van Grunderbeek thinks the basic technology entered the region from the northeast as part of an Old World-wide diffusion of ironworking knowledge from the Middle East. She suggests transmission from Arabia via the Horn of Africa, and cites an early trace in Rwanda of zebu cattle that are thought to have originated in India.<sup>158</sup> In this she differs from Schmidt, who notes linguistic evidence that early Bantu populations acquired ironworking from Central Sudanic speakers. Central Sudanic peoples are scattered today

fourneau de fonte de fer associé à la culture urewe (âge du fer ancien) au Rwanda et au Burundi," *Meditarch*, 271-97.

<sup>156</sup>Van Grunderbeek/Roche/Doutrelepon, "Age du fer ancien," 19, 21, 23; idem, "Type de fourneau," 288-89.

<sup>157</sup>Ibid., 276-77. In 1982, after 14 of the 20 furnaces had been excavated, they said smelting activity had started by at least the seventh century BCE ("Age du fer ancien," 17, 19, 57).

<sup>158</sup>Van Grunderbeek, "Essai," 72-73, 76; Van Grunderbeek/Roche/Doutrelepon, "Type de fourneau," 273-76, 295.



from Chad to the northwestern fringe of Uganda, and are known to have inhabited the western Great Lakes region in the first millennium BCE.<sup>159</sup>

The Arabian hypothesis evoked by van Grunderbeek is, like that of Carthage, plausible but based purely on circumstantial evidence. The first contacts between South Arabia and the Ethiopian highlands may go back at least to the late second millennium BCE.<sup>160</sup> Evidence of ironworking at Hajar bin Humeid in Yemen, some 50 miles from Ma'rib, the ancient capital of Saba', has been attributed to the tenth century BCE and may be a century older.<sup>161</sup> The oldest datable iron artifacts in Ethiopia were found about 30 miles northeast of Aksum, at Yeha, where Semitic-speaking colonists from Saba settled by the fifth century BCE and possibly as early as the eighth century.<sup>162</sup> Words used for iron on the Ethiopian Plateau seem to derive from the Semitic roots *bir* or *bar*, even in Cushitic languages.<sup>163</sup> But Great Lakes iron technology still has not been tracked to the Horn.

## XV

Nevertheless, the overall impression that independent invention has carried the day, noted at the beginning of this paper, has faded with a closer look at the record. In some cases, the very people responsible for many of the earliest radiocarbon datings in sub-Saharan Africa—Lambert in Mauritania, Grébénart and Roset in Niger, MacEachern in Nigeria and

<sup>159</sup>Schmidt, *Iron Technology*, 15.

<sup>160</sup>J.A. Todd and J.A. Charles, "Metallurgy as a Contribution to Archaeology in Ethiopia," *Abbay* 9(1978), 33; Stuart Munro-Hay, *Aksum* (Edinburgh, 1991), 63; idem, "State Development and Urbanism in Northern Ethiopia" in Shaw et al., *Archaeology*, 611; Donald N. Levine, *Greater Ethiopia: the Evolution of a Multiethnic Society* (2d. ed.: Chicago, 2000), 28, 31-32.

<sup>161</sup>Gus W. Van Beek, ed., *Hajar Bin Humeid: Investigations at a Pre-Islamic Site in South Arabia* (Baltimore, 1969), 361, 364-65, 367; Trigger, "Myth of Meroe," 50; Bertram B.B. Mapunda, "Patching Up Evidence for Ironworking in the Horn," *AAR* 14(1997), 116.

<sup>162</sup>Todd/Charles, "Metallurgy," 32-33, figure 5; Jean-Pierre Mohen, *Métallurgie préhistorique: introduction à la paléoméallurgie* (Paris, 1990), 195; Munro-Hay, *Aksum*, 61-62, 66; idem, "State Development," 612-13; David W. Phillipson, *Ancient Ethiopia: Aksum: Its Antecedents and Successors* (London, 1998), 42-45, 149n61; Jean-François Breton, *Arabia Felix from the Time of the Queen of Sheba: Eighth Century B.C. to First Century A.D.*, tr., Albert LaFarge (Notre Dame, 1999), 39, 43.

<sup>163</sup>Leclant, "Fer," 89; Charles P. Blakney, "On 'Banana' and 'Iron,' Linguistic Footprints in African History" (M.A., Hartford Seminary Foundation, 1963), 94-97; Trigger, "Myth of Meroe," 50; Mohen, *Métallurgie préhistorique*, 195.

Cameroon, van Grunderbeek in Rwanda and Burundi—have expressed the belief that metallurgy came, or may have come, from the Middle East or the Mediterranean basin. Others, like Schmidt in Tanzania and Clist in Gabon (and Grébénart and van Grunderbeek as well), have discarded their earliest dates. In other cases, enthusiasm for the idea of autonomous development seems to have colored interpretation of radiocarbon datings. And in still others, archeological rigor in prospecting and publishing appears to have been wanting.

The main argument against independent invention has always involved the complexity of iron metallurgy. Alone among the metals worked in antiquity, iron is smelted below its melting point of 1540° C. The ideal temperatures for smelting iron range between 1100° and 1400° C. Smelting occurs when the iron in the ore fuses chemically with carbon from the charcoal fuel. The more carbon dissolved in the iron, the lower its melting point. The proportion of fuel to ore, and the supply of combustion air from bellows and tuyères or natural draft, determine whether cast iron, steel, wrought iron, or a useless lump of mixed matter will result. The percentage of iron in the ore and the density of the charcoal are other relevant variables. Smelting produces a bloom, a spongy or pasty mass composed of iron, slag, and leftover fuel that bears little resemblance to the final metal product. To consolidate the separate bits of iron and get rid of unwanted matter, the bloom must be reheated and hammered more than once to produce a useful substance.

In sum, the reduction of iron ore requires much more sophisticated expertise than does the smelting of other metal ores. Copper, for instance, melts at 1083° C., does not fuse with carbon, and can be readily cast. As Canadian metallurgist J.E. Rehder puts it,

[t]he working out of...relationships [between iron and carbon] that occur invisibly within the smelting furnace seems sufficient to account for the long time taken for experienced copper smelters to learn how to smelt iron from iron ore.<sup>164</sup>

That period has been estimated at a millennium or two in Anatolia. Killick has pointed out that “iron working can succeed only within a very narrow window of temperature and gas composition.”<sup>165</sup>

<sup>164</sup>J.E. Rehder, *The Mastery and Uses of Fire in Antiquity* (Montreal, 2000), 123. The consensus is that the use of iron-oxide ore as a flux in copper smelting eventually led to the invention of iron metallurgy.

<sup>165</sup>Killick, “What Do We know,” 109. See also Childs/Killick, “Indigenous African Metallurgy,” 320. In a personal communication, 4 December 2004, Killick explained: “All the oxygen blown into the furnace is consumed by reaction with char-

No wonder, then, that Africanists and metallurgists tended initially—and still generally do in the latter case—to be wary of claims that iron making had been independently invented in sub-Saharan Africa without previous metallurgical experience. “This complicated technology,” Mauny opined in 1967, “could not have arisen in a milieu totally ignorant of metallurgy.”<sup>166</sup> American metallurgist Theodore A. Wertime contended in 1973 that “[o]nly peoples with the very long metallurgical tradition possessed by the tribal peoples of Anatolia would have had the know-how and patience to experiment with iron.”<sup>167</sup>

The discoveries in and around the 1970s of ancient copper production in Mauritania and Niger appeared at first to meet the criterion of metallurgical experience prior to iron, but, as we have seen, no direct link has yet been established between the two technologies in those countries. There is little doubt that elsewhere in sub-Saharan Africa, iron making was not preceded by the making of any other metal.

The question was implicitly posed by the skeptics: how could sub-Saharan Africans have hit upon iron metallurgy when masters of copper and bronze metallurgy in the Andes, Iberia, Italy, the Balkans, the Indian sub-continent, and southeast Asia apparently never managed to do so? Even the hyper-inventive Chinese did not begin producing iron until at least half a millennium after the Middle East, which makes their independent discovery of the technology debatable.

One of the arguments advanced for independent invention is that, if Africans did not have copper/bronze technology to build upon, they did have pyrotechnological experience making pottery. Indeed, potsherds found in the Sahara are as old as, if not older than, any yet found in the Middle East, and the case for independent African invention of ceramics

coal to produce a mixture of carbon monoxide and carbon dioxide. What matters for metallurgy is the ratio of CO to CO<sub>2</sub>. Copper can be reduced from copper oxide at a ratio of around 2:5, but iron smelting requires ratios of around 100:1. This is a crucial difference. The temperatures required are about the same in both cases, but the air supply for iron smelting must be regulated very carefully to ensure that there is enough heat produced to attain the needed temperatures, but not too much CO<sub>2</sub>.”

<sup>166</sup>Raymond Mauny, “Datation au C-14 de sites ouest africains de l’âge du fer” in Henri J. Hugot, ed., *Actes du VI<sup>e</sup> Congrès Panafricain de Préhistoire et d’Etudes du Quaternaire* (Dakar, 1967), (Chambéry, 1972), 533. See also McIntosh/McIntosh, “West African Prehistory,” 609; idem, “Stone to Metal,” 103; Phillipson, *African Archaeology*, 159.

<sup>167</sup>Theodore A. Wertime, “The Beginnings of Metallurgy: a New Look,” *Science*, 182 (30 November 1973), 885. See also Tylecote, “Origin,” 4; van der Merwe/Avery, “Pathways to Steel,” 150-51; Childs/Killick, “Indigenous African Metallurgy,” 320.

is very strong.<sup>168</sup> Metallurgists generally agree that kiln-firing of ceramics could have paved the way for metallurgy.<sup>169</sup> But in fact, with the exception of Egyptian-influenced Nubia, Saharan and sub-Saharan potters lacked kilns (and still do, for the most part).

However, in some places pottery is fired in pits. According to Nigerian archeologist Bassey W. Andah, pit-firing raises temperatures high enough to smelt iron from laterite blocks used to prop up the pottery being fired.<sup>170</sup> But in 1981 American archeologist Merrick Posnansky noted that West Africa had produced no positive evidence of pit-fired pottery before the Christian era, and pit-firing does not seem to have been employed anciently anywhere else in sub-Saharan Africa.<sup>171</sup> Andah himself has remarked that in Nigeria, pottery “was always open fired at a very low temperature.”<sup>172</sup> African potters have never been known to use the charcoal fuel essential for iron making. A pot-making-to-metal-making sequence would therefore seem highly dubious for sub-Saharan Africa.

<sup>168</sup>See, for example, McIntosh/McIntosh, “Recent Archaeological Research,” 419-21; Andrew B. Smith, *Pastoralism in Africa* (London, 1992), 51, 65, 67; Barbara E. Barich, “Holocene Communities of Western and Central Sahara: a Reappraisal” in Frank Klees and Rudolph Kuper, eds., *New Light on the Northeast African Past: Current Prehistoric Research* (Cologne, 1992), 188; idem, “Saharan Neolithic” in Vogel, *Encyclopedia*, 390; Christopher Ehret, “Nilo-Saharan and the Sahara-Sudanese Neolithic” in Shaw et al., *Archaeology*, 110; A. Muzzolini, “The Emergence of a Food-Producing Economy in the Sahara” in idem, 229; Phillipson, *African Archaeology*, 112-13; Angela E. Close, “Few and Far Between: Early Ceramics in North Africa” in William K. Barnett and John W. Hoopes, *The Emergence of Technology and Innovation in Ancient Societies* (Washington, 1995), 23-25; Jean-Pierre Roset, “Les céramiques anciennes du Niger” in Leroy, *Préhistoire*, 28-29; Kevin MacDonald, “The Late Stone Age and Neolithic Cultures of West Africa and the Sahara” in Vogel, *Encyclopedia*, 394.

<sup>169</sup>H.H. Coghlan, “Some Fresh Aspects of the Prehistoric Metallurgy of Copper,” *Antiquaries Journal* 22(1942), 31; Theodore A. Wertime, “Man’s First Encounters with Metallurgy,” *Science*, 146(4 December 1964), 1258, 1264-66; idem, “The Pyrotechnic Background” in Wertime/Muhly, *Age of Iron*, 8; Cyril Stanley Smith, *A Search for Structure: Selected Essays on Science, Art, and History* (Cambridge, 1981), 127; Rehder, *Mastery and Uses*, 35, 42, 107-08. Tylecote supposed that metallurgy owed something to pottery making though, in his view, they did not have much in common and it would have been hard to reduce metal ore in a pottery kiln. Ronald F. Tylecote, “Furnaces, Crucibles, and Slags” in Wertime/Muhly, *Age of Iron*, 183.

<sup>170</sup>Bassey W. Andah, “Iron Age Beginnings in West Africa: Reflections and Suggestions,” *West African Journal of Archaeology* 9(1979), 146-48. See also Rustad, “Emergence,” 231; Jemkur, “Débuts de la métallurgie du fer,” 29.

<sup>171</sup>Merrick Posnansky, “Introduction to the Later Prehistory of Sub-Saharan Africa” in *General History of Africa* 2, 546.

<sup>172</sup>Bassey W. Andah, *Nigeria’s Indigenous Technology* (Ibadan, 1992), 76. See also Alison Hodge, *Nigeria’s Traditional Crafts* (London, 1982), 57-58, 63.

It has been suggested that the absence of previous pyrotechnological experience could have been an asset as well as a handicap in that it “led to the development of modes of experimentation that are distinctive to Africa.”<sup>173</sup> Or, as Andah has put it in reference to West Africa,

people not used to working a metal by first melting it stood a good chance of inventing some form of smelting process not necessarily dependent on large, high temperature furnaces borrowed from the copper melting process.<sup>174</sup>

The wide distribution of iron ores on the African continent, made manifest by its laterite soils, has been cited as another support for the independent-invention hypothesis.<sup>175</sup> Iron ore, as indicated above, is almost ubiquitous in the world, yet much rarer metals such as copper, tin, lead, gold, and silver were exploited earlier because it was easier to do so. Silica is also abundant in Africa, but that seldom led to glass. Streams were not harnessed by waterwheels, nor winds by windmills. However, the pervasiveness of iron ore underlies perhaps the best argument for independent invention, apart from very early datings: the great variety of equipment, techniques, and ores used to make iron in sub-Saharan Africa.

No one disputes the fact that Africa has been the scene, as Holl put it, of “an extraordinary diversity of . . . iron-producing traditions.”<sup>176</sup> South African metallurgist Nikolaas J. van der Merwe has observed that “every conceivable method of iron production seems to have been employed in Africa, some of it quite unbelievable.”<sup>177</sup> Schmidt reckons that by the end of the nineteenth century CE “there were hundreds if not thousands of different iron-production systems active on the continent.”<sup>178</sup>

According to Killick, “students of African metallurgy have documented an amazing variety of processes, many with no known counterparts on other continents,” or again, “African ironworkers adapted the bloomery process to a wider variety of ores and invented a greater range of furnace designs than did bloomery ironworkers elsewhere in the Old World.”<sup>179</sup>

<sup>173</sup>Schmidt/Childs, “Ancient African Iron,” 524.

<sup>174</sup>Andah, “Iron Age Beginnings,” 148.

<sup>175</sup>Holl, “Metals,” 9.

<sup>176</sup>Ibid.

<sup>177</sup>Van der Merwe, “Advent,” 486.

<sup>178</sup>Schmidt, *Culture and Technology*, 9.

<sup>179</sup>Killick, “What Do We Know,” 109; idem, “On Claims for ‘Advanced’ Ironworking Technology in Precolonial Africa” in Schmidt, *Culture and Technology*, 261. See also J.E.G. Sutton, “Temporal and Spatial Variability in African Iron Furnaces” in Haaland/Shinnie, *African Iron Working*, 164-96.

The diversity extended to smelting procedures and products, methods of slag disposal, furnace construction materials, types of bellows, the positioning of tuyères. The implication is that African smelters and smiths experimented with iron technology and invented new ways of making the metal as they went along, in response to varying local natural resources and social circumstances.

For anyone familiar with the precolonial history of sub-Saharan Africa—in this writer's case that of what was once called Lower Guinea (Ivory Coast to Nigeria)—the bewildering multifariousness of iron technology should come as no surprise. In what were ostensibly traditional societies, an atypically large place was left to individualism. The literature is studded with evidence that Lower Guineans were nonconformists in many ways. Richard F. Burton discerned an “inordinate hankering after change, novelty, and originality” among arguably the most disciplined people of all, the Fon of Dahomey.<sup>180</sup>

Everywhere men and women sought to make personal statements within the communal framework. European visitors remarked that seemingly no two persons wore the same clothes or ornaments or amulets, dressed their hair or decorated their faces and bodies in the same way, went off to war in the same getup and with the same equipment, or worshiped their gods in the same manner. Improvisation in song, dance, and music was admired everywhere. So was the ability to orate, to tell stories, and to spice one's conversation with suitable proverbs.

Farmers were quick to test and adopt new crops, medicine men found curative properties in each new imported plant. Each chief wanted his own special stool, umbrella, and staff, and craftsmen obliged with new designs. Great art was not the work of faceless copyists but of great artists, probably as quirky as their counterparts in Europe or America. Private enterprise was highly competitive, and the successful trader was esteemed. Igbo titles rewarded the energetic man. In such an atmosphere, smelters and blacksmiths were unlikely to resist tinkering with their technology.

Schmidt describes such tinkerers as “scientific bricoleurs” and imagines grassroots creativity as “local flashes of technological brilliance and experiment.”<sup>181</sup> Susan and Roderick McIntosh have envisaged the possi-

<sup>180</sup>Richard Burton, *A Mission to Gelele, King of Dahome*, ed. C.W. Newbury (New York, 1966[1864]), 187.

<sup>181</sup>Peter R. Schmidt, “Resisting Homogenization and Recovering Variation and Innovation in African Iron Smelting,” *Meditarch*, 222, 227.

bility of “intense innovative impulses at the local level,” and van der Merwe has inferred “highly observational and inventive” behavior.<sup>182</sup>

Cyril Stanley Smith, a founding father of archeometallurgy, may have given us a clue as to motivation. He thought “aesthetic curiosity” was the original driving force of technological development everywhere, and that the human desire for pretty things like jewelry and sculpture, rather than for “useful” objects such as tools and weapons, first led enterprising individuals to discover new materials, processes, and structures.<sup>183</sup> The undoubted ingenuity of African tinkerers is thought by some Africanists to have inspired entirely new departures in iron metallurgy. Three of these claims have generated some discussion: natural-draft (or induced-draft) furnaces, a “direct steel process,” and “preheating.”

Natural-draft smelting furnaces are distinguished by tall shafts, from 6.5 to as much as 23 feet (2 to 7 meters) high. They operate with longish tuyères, but without bellows, the air for combustion flowing naturally into the furnace. While the natural-draft furnace could well have been independently invented in Africa, Killick notes that “it [is] usually impossible to deduce from archaeological remains alone that a given furnace was operated by natural draft.”<sup>184</sup> And Rehder tells us that such furnaces were also used in Poland and Burma, and might have been more widespread.<sup>185</sup>

In 1980 van der Merwe claimed that ancient African metallurgists had “devised a smelting technology which is apparently unique, producing high carbon steel directly from the furnace” rather than by subsequent smithing.<sup>186</sup> Two years later he and American engineer Donald H. Avery explained that the innovation involved increasing the carbon content of the bloom, i.e., carburizing it, in various types of African furnaces.<sup>187</sup> Steel is iron alloyed with between 0.2% and 2% carbon, and there is no doubt it was widely manufactured in Africa from early times. Killick agrees that “many African iron smelters were able to produce high-carbon steel directly in the bloomery furnace,” but convincingly refutes the

<sup>182</sup>S.K. McIntosh and R.J. McIntosh, “Current Directions in West African Prehistory,” *Annual Review of Anthropology* 12(1983), 249; van der Merwe, “Advent,” 486.

<sup>183</sup>Cyril Stanley Smith, *A Search for Structure: Selected Essays on Science, Art, and History* (Cambridge, 1981), 325, 327-31, 347-48, 351. Killick (“Science, Speculation,” 482) says that subsequent research “has largely confirmed” Smith’s theory.

<sup>184</sup>See, for example, van der Merwe, “Advent,” 486, 500; van der Merwe/Avery, “Pathways to Steel,” 153; Andah, *Nigeria’s Indigenous Technology*, 81; Killick, “On Claims,” 249.

<sup>185</sup>Rehder, *Mastery and Uses*, 128.

<sup>186</sup>Van der Merwe, “Advent,” 500.

<sup>187</sup>Van der Merwe/Avery, “Pathways to Steel,” 153-54.

claim that it was a unique achievement. He points out that “[s]teel blooms similar to those from Africa were produced in some areas of Europe at least as early as . . . 500-100 B.C.,” and concludes that Africans made steel “within the normal range of variation of bloomery processes.”<sup>188</sup> Nevertheless, this does not rule out the possibility that the direct process was independently invented in Africa.

The third claim, summed up, a bit misleadingly for the layman, as “preheating,” has stirred hammer-and-tongs debate. It refers to the use of extra-long clay tuyères inserted deeply into the smelting furnace so that the blast of bellows-driven air is heated within the furnace just before it reaches its fuel-and-ore target, achieving very high temperatures. In a series of publications beginning in 1978, Schmidt and Avery contended that Haya smelters in Tanzania invented the process nearly two millennia before it was patented in England.<sup>189</sup> They were disputed on a number of points by other scholars.<sup>190</sup> For non-specialists the argumentation in this controversy is recondite. According to Killick, “the case for preheated blast in the Haya furnace is . . . not proven,” but neither, it would seem, is it disproven.<sup>191</sup>

Kense has accounted for the versatility of African ironworkers with a diffusionist rationale:

From the premise that the knowledge of iron metallurgy diffused largely [from the north] through the spread of ideas [rather than the movement

<sup>188</sup>Killick, “On Claims,” 258-60. See also Woodhouse, “Iron in Africa,” 170-71.

<sup>189</sup>P.R. Schmidt/D.H.Avery, “Complex Iron Smelting and Prehistoric Culture in Tanzania,” *Science*, 201(22 September 1978), 1085-89 (reprinted in Schmidt, *Culture and Technology*, 172-85); Avery and Schmidt, “A Metallurgical Study of the Iron Bloomery, Particularly as Practiced in Buhaya,” *Journal of Metals* 31 (October 1979), 14-20; Schmidt and Avery, “More Evidence for an Advanced Prehistoric Iron Technology in Africa,” *Journal of Field Archaeology* 10(1983), 421-34; Schmidt/Childs, “Innovation and Industry,” 55-56, 88-91; Childs and Schmidt, “Experimental Iron Smelting: The Genesis of a Hypothesis with Implications for African Prehistory and History” in Haaland and Shinnie, *African Iron Working*, 121-41; Avery and Schmidt, “The Use of Preheated Air in Ancient and Recent African Iron Smelting Furnaces: a Reply to Rehder,” *Journal of Field Archaeology* 13(1986), 354-47 (reprinted in Schmidt, *Culture and Technology*, 240-46); Avery and Schmidt, “Preheating: Practice or Illusion?” in Schmidt, *Culture and Technology*, 267-76.

<sup>190</sup>J.E. Rehder, “Use of Preheated Air in Primitive Furnaces: Comment on Views of Avery and Schmidt,” *Journal of Field Archaeology* 13(1986), 351-53 (reprinted in Schmidt, *Culture and Technology*, 234-39); Manfred K.H. Eggert, “On the Alleged Complexity of Early and Recent Iron Smelting in Africa: Further Comments on the Preheating Hypothesis,” *Journal of Field Archaeology* 14(1987), 377-82; Killick, “On Claims,” 250-56.

<sup>191</sup>*Ibid.*, 256.



of people or things], it is understandable why such a wide range of metallurgical traditions has arisen.<sup>192</sup>

From the same profusion, Holl infers “that such diversity . . . is a product of a set of local experiments, causing a discontinuous distribution of traditional methods.”<sup>193</sup> Hardly anyone seems to have allowed that, if iron smelting was indeed invented, against heavy odds, in one or more places in sub-Saharan Africa, unsung black Edisons, tinkerers of genius, might have been at work there.

## XVI

The merits of both sides in the diffusion-vs-independent-invention debate have sometimes been obscured by personal non-scientific agendas. As the American historian Eugenia Herbert observes, the debate “has often been politically charged, its oscillations influenced by ideological concerns.”<sup>194</sup> Even scholars quite sympathetic to the idea of independent invention acknowledge that some early claims verged on “wishful thinking” or involved “unsubstantiated assertions.”<sup>195</sup>

Doubt that sub-Saharanans invented iron smelting has at times almost been equated with racism. Back in 1968 Maes-Diop taxed Mauny with assuming that ancient black Africans were incapable of such technical progress, hence his search for Mediterranean origins.<sup>196</sup> More recently Quéchon wrote of his critics: “to deny a priori, under cover of science, Africa’s capacity for innovation carries implications as odious as they are gratuitous.” And he charged that “the question of the origins of African metallurgy has often been inscribed . . . in a logic incorporating the North-South, colonizers-colonized power relationships.”<sup>197</sup>

Bocoum complained that the notion of “Darkest Africa, a cul-de-sac in good evolutionist tradition, [owing] everything to the rest of the world,” continues to sustain “that avatar diffusionism” against the evidence.<sup>198</sup>

<sup>192</sup>Kense, *Traditional*, 169.

<sup>193</sup>Holl, “Metals,” 9.

<sup>194</sup>Eugenia W. Herbert, “African Metallurgy: The Historian’s Dilemma,” *Meditarch*, 42.

<sup>195</sup>Holl, “Metals,” 9; Schmidt, “Culture and Technology,” 8.

<sup>196</sup>Diop, “Métallurgie traditionnelle,” 25.

<sup>197</sup>Quéchon, “Datations,” *Meditarch*, 253; idem, “Datations” in Bocoum, *Origines*, 114. These quotes come from the last sentence of what were otherwise almost identical articles. It would appear the change was made to cater to a UNESCO audience.

<sup>198</sup>Hamady Bocoum, “Introduction générale” in Bocoum, *Origines*, 11.

For Belgian archeologist/anthropologist Pierre de Maret, “the very great antiquity of [African] pyrotechnology” should be recognized because “it is important to establish a certain cultural reciprocity among peoples.”<sup>199</sup>

Schmidt makes no bones about his non-scientific motivation. He claims that the “paradigm of African inferiority in technological life is widely taught throughout the West and Africa,” that “entrenched historiography . . . underwrites continued Western technical domination of Africa,” that “historical representation that portrays African inferiority . . . has been instrumental in the economic and psychological subjugation” of the continent. Therefore, one of his “primary concerns,” he says, “is to deconstruct Western representations about African iron technology.” He states frankly that he is involved in an ideological and political “project” to “depreciate” what he considers to be the “myth of African technological inferiority.”<sup>200</sup> Schmidt’s purpose is not unworthy, to be sure, but inevitably makes his findings suspect.

British archeologist James Woodhouse wonders whether rejection of dates contradicting diffusionist theories “is based on reasonable evidence, or simply results from an unwillingness to accept new data that contradict long-held ideas.”<sup>201</sup> Jan Vansina’s previously cited discussion of the debate might have drawn the most attention. He maintains that the problems of old-wood use, unproven association of artifacts, uncertain dating, and inadequate sampling are all so many smokescreens masking bias with highly technical arguments. “For instance,” he says,

French scholars systematically accept earlier dates for iron-smelting...than their English-speaking colleagues do . . . Perhaps the French have been more influenced by African nationalism and the English-speakers more by neo-evolutionary theory? Be that as it may, bias is certain. It cannot be an accident that almost every early date proposed by one group is dismissed by the other . . . [T]he reason for accepting or rejecting proposed dating usually is that they fit or do not fit with the chronological bracket that seems ‘reasonable,’ given a belief that there was—or was not—diffusion involved. Precisely because debates about chronology are both reasonable and frequent, they should attract attention as a litmus test for bias.<sup>202</sup>

In fact, as we have seen, there are Anglophones and Francophones on both sides of the debate, not national groups set one against the other.

<sup>199</sup>De Maret, “Afrique centrale,” 131.

<sup>200</sup>Schmidt, *Iron Technology*, 4, 5, 8.

<sup>201</sup>Woodhouse, “Iron in Africa,” 170. See also Holl, “Metals,” 16.

<sup>202</sup>Vansina, “Historians,” 383-84.

Andah, Avery, Craddock, Davidson, Ehret, Goucher, Oliver, Picton, Rustad, Schmidt, Thornton and Trigger are among Anglophone Africanists who have been inclined to accept very early dates. Edmond Bernus, Clist, Doutrelepon, Grébénart, Haour, Lambert, Roche, Roset and van Grun-derbeek are among Francophones who have not embraced independent invention.<sup>203</sup> There also seems to be a good number of Africanists, speaking either language, who have reserved judgment in the absence of iron-clad proof, so to speak, of either hypothesis.

Vansina's contention that standards of evidence are invoked merely to disguise bias is, according to Susan McIntosh,

simply at odds with the way archaeology proceeds everywhere else in the world to resolve dating ambiguities. Disputes about the dating of early metallurgy are not unique to Africa . . . [A]rchaeology has usually demanded extraordinary proof of extraordinary claims. If iron was in fact being produced in Niger in 1500 B.C. as a result of independent invention, then we shall need to rethink substantially the existing account of the history of metallurgy. . . [D]oes the current evidence warrant such a tectonic shift? The chemical rules that make iron production such a complex, difficult, and unpredictable process are not suspended for Africa . . . How were Africans, apparently alone among the peoples of the world, able to leapfrog over multiple technological thresholds?<sup>204</sup>

## XVII

Fear of offending putative African sensitivities may have influenced the debate in part. Some obvious questions are not even being asked. Can it be mere coincidence, for example, that in the roughly million and a half square miles of West Africa, most of the very early dates for ironworking come from the northern fringe, the area closest to the Mediterranean world?<sup>205</sup> And is not that east-west band among the least propitious venues imaginable for the invention of iron metallurgy, outside of sterile sands and frozen wastes? The technology is (or was, before the advent of

<sup>203</sup>Marianne Cornevin is a well-known French archeologist whose opinion on independent invention shifted from "probable" in 1986 ("New Data," 111) to "possible" in 1993 (*Archéologie africaine*, 122). French prehistorian Robert Vernet, a Niger specialist like Grébénart, Haour and Roset, allows for "an autonomous center of invention" there but says that "there is no doubt proto-Berbers from North Africa . . . introduced metal objects . . . and metallurgical techniques" to the region. Vernet, *Le Sud-ouest du Niger de la Préhistoire au début de l'Histoire* (Niamey, 1996), 360.

<sup>204</sup>McIntosh, "Archaeology," 77-78.

<sup>205</sup>Do Dimmi is at 16°25' N, Afunfun 175 at 16°40' N, Walalde at 16°31' N.

coal) a notorious consumer of charcoal fuel. Even at its greenest, the southern edge of the Sahara was very lightly wooded, and not all kinds of savanna trees are suitable for making charcoal.<sup>206</sup>

Vansina insists that “complex innovations are never single events but processes.”<sup>207</sup> At the same time he seems prone to assume independent invention wherever sub-Saharan Africa has produced very early datings.<sup>208</sup> But processes have to start somewhere. The “absence of cultures demonstrating a transitional state between dependence on stone and then iron” has been remarked.<sup>209</sup> Without high-temperature pyrotechnological experience, without pottery kilns or firing-pits, could the process of African ironworking have begun by spontaneous generation? And does the assumption that iron metallurgy was separately invented in many places not banalize one of mankind’s signal achievements?

If metallurgy reached Mauritania from Morocco, as seems almost beyond dispute, why could it not have reached Niger from there or elsewhere in North Africa? Does the early appearance of iron objects ever imply that ore was smelted even if evidence of metallurgical furnaces that early is lacking? Quéchon has made the telling point that absence of proof does not constitute proof of absence, but should that not hold as true for, say, Carthage or the Sahara as for Termit?<sup>210</sup>

Tylecote once observed that “hardly any remains of early [iron-smelting] furnaces [are] known from Asia Minor,” even though it is generally regarded as the scene of the first iron smelting and archeologists have been digging there for a long time.<sup>211</sup> In contrast, the vast African continent still has hardly been scratched by the archeologist’s trowel. Should this fact not discourage scholars from striding to judgment on iron making in Africa? Moreover, how many historians (and archeologists too) are sufficiently well versed in archeometallurgy, in the shortcomings of radio-carbon dating, and in the dimensions of calibration to assess properly what evidence there is?

<sup>206</sup>Goucher, “Iron Is Iron,” 181-84; Randi Haaland, “Iron Production, Its Socio-Cultural Context and Ecological Implications” in Haaland/Shinnie, *African Iron Working*, 54-56, 61-64, 66-67, 69-70; Edwin Eme Okafor, “Eguru Amube Amalla Orba: Blacksmith Clan Among the Orba,” *Nyame Akuma* no. 32 (December 1989), 26; François J. Kense and John Ako Okoro, “Changing Perspectives on Traditional Iron Production in West Africa” in Shaw et al., *Archaeology*, 455, 457. See also Rehder, *Mastery and Uses*, 149-52, 158-59.

<sup>207</sup>Vansina, “Historians,” 394.

<sup>208</sup>*Ibid.*, 395.

<sup>209</sup>Kense/Okoro, “Changing Perspectives,” 456.

<sup>210</sup>Quéchon, “Datations,” *Meditarch*, 248; idem, “Datations” in Bocoum, *Origines*, 106.

<sup>211</sup>Tylecote, “Furnaces,” 21.

Some Africanists are indeed treading cautiously. Herbert thinks it may “never be possible to write a history of African metallurgy that truly satisfies the historian’s inordinate greed for both generalization and specificity.”<sup>212</sup> “Before a clear picture can be developed,” says Woodhouse, “much more research needs to be undertaken both on the existing data and in the field with excavation.”<sup>213</sup> For Okafor, the “dates associated with iron-working activities are not at present sufficiently precise or reliable to settle the question of origins.”<sup>214</sup>

David Killick considers the quality of evidence assembled up to now as

so poor that we cannot yet establish when iron working began in sub-Saharan Africa. Statistical manipulation of the current corpus of radiocarbon dates for the earliest metallurgy is absolutely useless—as statisticians are fond of saying, garbage in means garbage out. We must accept the limitations of the evidence, and keep searching until we find short-lived carbon samples in undeniable stratigraphic association with certified iron working debris.<sup>215</sup>

## XVIII

In conclusion, here are a few points on which there might be a measure of agreement:

If the basic idea of iron metallurgy came to sub-Saharan Africa from the north, it came not from a single point like Carthage but from a great 2000-mile arc of land stretching from Morocco to Yemen. And it came in various forms because of local adaptations and permutations along the way. Kense’s suggestion that the technology may have been transmitted via ideas rather than things or people evoked for this writer the “whisper relay,” remembered from summer camp, when a statement given the first boy was unrecognizable by the time it reached the last. But more likely, as imagined by Grébénart (and quoted above in section X), the transmission involved the movement of skilled persons into new settings. In any event, if the technology began in Anatolia, it reached Morocco and Yemen transformed, and would metamorphose still further as it spread unevenly through Africa.

<sup>212</sup>Herbert, “African Metallurgy,” 48.

<sup>213</sup>Woodhouse, “Iron in Africa,” 180.

<sup>214</sup>Okafor, “New Evidence,” 434. See also Kense, “Initial Diffusion,” 27; Kense/Okoro, “Changing Perspectives,” 456; Curtin et al., *African History*, 24.

<sup>215</sup>Killick, “What Do We Know,” 110.

The great diversity of iron metallurgy in sub-Saharan Africa is most likely due both to external influences and local innovations in varying combinations. For sure there was “independent invention,” even if it only duplicated structures and procedures that had already been devised somewhere in Eurasia. For example, Africans might well have invented tall natural-draft furnaces and steel manufacture through experimentation and in the absence of models to copy.

If sub-Saharan Africans were smelting iron earlier than the mid-first millennium BCE, as some archeologists have been claiming and some historians echoing, they might have mastered the technology as early as, or even earlier than, the British or the Chinese.<sup>216</sup> But the questions of how and when they managed to do it are still unresolved.

Quite remarkably, nearly seven decades ago, before most archeological exploration and any radiometric dating, an American scholar named Walter Cline assembled evidence of sub-Saharan metalworking and wrote:

The most exhaustive archaeological and metallurgical research will never be able to demonstrate the indigenous discovery of metals or their first importation to Negro Africa. Such research will undoubtedly swing the balance of possibility either toward diffusion or independent invention, but the existing information is not enough to do so.<sup>217</sup>

His prescient judgment might still hold true.

<sup>216</sup>Iron reached the British Isles no later than the seventh century BCE and was being smelted there by the fifth. See Colin Haselgrove et al., *Understanding the British Iron Age: an Agenda for Action* (Salisbury, 2001), 25, and [www.biab.co.uk/chronology.asp](http://www.biab.co.uk/chronology.asp); [www.bbc.co.uk/history/timelines/britain/o\\_iron\\_age.shtml](http://www.bbc.co.uk/history/timelines/britain/o_iron_age.shtml).

Estimates of the starting period for China range from the eighth to the fifth centuries BCE. S.J. Taylor and C.A. Shell, “Social and Historical Implications of Early Chinese Technology” in Maddin, *Beginning*, 208; Donald B. Wagner, “The Earliest Use of Iron in China” in Suzanne M.M. Young et al., *Metals in Antiquity* (Oxford, 1999), 1-9; Rehder, *Mastery and Uses*, 142.

<sup>217</sup>Walter Cline, *Mining and Metallurgy in Negro Africa* (Menasha, 1937), 5.