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Lead Isotopes in West African Copper Alloys

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Abstract

Stable lead isotopes have been measured from copper-alloy castings dating from the late first millennium AD to the 19th Century from Igbo Ukwu, Ife, Jenne, Marandet, Ma'aden Ijâfen, Benin, the Lower Niger sites on the Forcados and Cross Rivers, the Andoni Creek and Apapa, and from Jebba, Tada and Owo. More recent ethnographic specimens from West Africa were also examined as well as a number of African ores. We conclude that the earliest metals (copper, tin, and perhaps lead) came from African sources, but that Northern Europe became the main source of supply early in the second Millennium, initially by trade across the Sahara, but also by the coast from around the middle of the second Millennium.

Résumé

Les premiers isotopes stables ont été mesurés sur des moulages d'alliage de cuivre datant de la fin du premier millénaire AD au dix-neuvième siècle sur les sites d'Igbo Ukwu, Ife, Jenne, Marandet, Ma'aden Ijâfen, Bénin, les sites du bas Niger sur les rivières Forcados et Croix, la Crique d'Andoni, Apapa, Jebba, Tada et Owo. Des spécimens ethnographiques, et donc plus récents, d'Afrique de l'ouest ont également été examinés ainsi que plusieurs minerais africains. Nous concluons de cette étude que les métaux les plus anciens (le cuivre, l'étain, et peut-être le plomb) proviennent de gisements africains, mais que l'Europe septentrionale est devenue la source principale d'approvisionnement tôt durant le deuxième millénaire, d'abord grâce au commerce au travers du Sahara, puis le long des côtes aux alentours de la moitié du second millénaire.

Keywords: West Africa, Ife, Igbo Ukwu, Jenne, Marandet, Ma'aden Ijâfen, Benin, Lower Niger, Forcados River, Cross River, Andoni Creek, Apapa, Tsoede, Jebba, Tada, Owo, Akan, Ashanti

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Introduction

This research was undertaken in the hope of throwing light on the sources of the metals used in the casting of copper-alloy objects in West Africa and hence on patterns of trade. It follows in part from Willett's conclusion that "the lead isotope analyses need to be taken further in order to . . . allow more precise conclusions about the sources of the lead to be drawn than has so far proved possible" (WILLETT 1981: 45). Samples of artefacts were obtained from a wide variety of sources, some of them well documented as to provenance and date, others less so, such as those from Jenne. We are grateful to all those individuals and institutions that made samples available for this project.

In 1995 we published an interim report entitled "Stable Lead Isotope Characterization of Various Copper Alloys used in West Africa" (JOEL *et al.* 1995). Our intention was criticised by at least one of our colleagues on the grounds that there must have been so much re-melting and mixing of the metal over the centuries that it would be impossible to relate artefacts to ore sources. Moreover when the European coastal trade was established metal from the same European source could have been supplied to many different parts of the West African coast. We were well aware of these potential problems so we began by examining the earliest material we had available, leaving younger samples till later. We found the results encouraging so we continued.

A further complication has been the paucity of lead isotope analyses of ore samples from Africa. Databases of isotopic analyses of ores from throughout Africa and from throughout Europe were assembled at the Smithsonian Institution by Emile Joel. Our lead-isotope database now contains over 2000 measurements of European ore specimens from deposits representing most of the major metal-producing areas in Europe, but contains only 304 determinations of ores from various metal-producing areas in Africa[1]. These data have come mainly from the geological literature with particular emphasis placed on those areas suggested as the possible sources of copper metal. Before inclusion in the database, the isotopic data obtained from the literature were evaluated, when possible, to determine their comparability to data produced in our laboratory. Areas of evaluation included measurement methods and standardization procedures, measurement errors and instrumentation biases, and geographical regions and their relevance to the provenance studies of historical artefacts.

Samples for analysis were obtained from the Natural History Museums of London and Washington, the National Museum of Scotland, the Saint Andrews University Geological Museum and the Hunterian Museum of Glasgow University (ore analyses listed in ***Table 1***), but the stage has been reached now where more field collecting is needed[2]. We are grateful to Dr. Terry Childs for allowing us to examine some of the copper objects from her excavations since these enabled us to rule out the Zambian/Zimbabwe/Zairean Copper Belt as a potential source of any of the metal found in our study. The analyses are reported in ***Table 6***.

A small number of pieces in the British Museum had been examined by GOUCHER *et al.* (1976, 1978). We tried to incorporate their results into our own data but found that they formed a separate cluster so we re-sampled the objects. However, the Smithsonian Institution decided to cease supporting research after only a few samples had been measured, and we can only report that we found significant differences between their data and ours in the few duplicates we did run. Because the Smithsonian programme shut down before sufficient additional duplicate analyses could be generated, we could not calculate a correction factor that would bring the data of GOUCHER *et al.* into conformity with ours. As such, we felt our only recourse was to exclude their data from our statistical analysis. Similarly, Dr. Stuart Fleming kindly provided us with 31 analyses of four Ife and 27 Benin and Lower Niger Bronze Industries (LNBI) pieces that had been measured by Drs. R.C. Callahan and B. Keisch but we found that their deviation from our own measurements of eight of the same pieces were too inconsistent to allow us to calculate a correction factor. Consequently we were forced to ignore also the two analyses of Cross River artefacts published by NICKLIN & FLEMING (1980).

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1 Lead isotope analyses compiled by the Smithsonian Institution will be available at the following website: http://www.si.edu/MCI/learning/pb-isotopes.htm

2 Collection and lead isotope analyses of geological and archaeological specimens from Africa currently are being undertaken by Thomas Fenn, University of Arizona.

Methods

We discussed the technique we used to measure lead isotope ratios in JOEL *et al.* (1995) and in the references cited therein. As this paper is already rather long, we will not repeat these details here. We do however need to explain the statistical methods used in forming our groups. First, of course, one simply observes that a number of possibly related artefacts have quite similar sets of ratios. Such artefacts are then combined into a trial group and a calculation is made to determine whether all of the selected artefacts have significant probabilities relative to this group. The level of significance we have used for retaining a specimen within a group is that it must have a five percent or greater probability of conforming to the group when the calculation is made with that specimen included within the group. If, in such a probability calculation of a trial group, one or more specimens with less than five percent probability relative to the group are excluded from the group, a second probability calculation is carried out on the residual group and this process repeated until a stable group is formed from which no specimens are excluded.

In the same calculation, one can search any number of databases of possibly related artefacts to select out all specimens with significantly high probabilities relative to the group to be considered for inclusion within it. These calculations have been carried out by the computer program ADSEARCH, written by Sayre. This process of selection and rejection is repeated as often as is necessary to achieve a group all of whose members have significant probabilities of conforming to the group and, ideally, none of whose members isotopically conform to any other such group.

Of course, occasionally two such groups will be found with isotope fields that are so similar that they overlap and contain some specimens with significant probabilities for inclusion in both groups. Usually in these cases such specimens were assigned to a group, toward which they have the larger probability, knowing that this assignment may not always be correct. However, occasionally such a specimen will have stylistic characteristics that relate it to the group toward which it has the lower probability. In such instances we have entered the specimen in the table listings for both of the groups for which it has significant probabilities. Also, there is always the possibility that two or more groups might so fully overlap each other that they cannot be separated statistically.

Igbo Ukwu

Igbo Ukwu, 24 km south of Awka in south-eastern Nigeria, is a group of three related sites. These are Igbo Isaiah, a shrine where most of the metal objects were found, Igbo Richard, the burial of a dignitary, and Igbo Jonah, a pit in which objects had been buried. All were excavated by Thurstan Shaw (SHAW 1970, 1977), and are dated by radiocarbon assays to 782 to 1018 cal AD when calibrated to two standard deviations[3]. Although most of the Igbo Ukwu objects are cast in bronze, some were smithed from unalloyed copper containing measurable amounts of lead as an impurity. Clearly the smiths recognised the difficulty of casting nearly pure copper in enclosed moulds and did not attempt it, or if they did, they did not long continue the practice. Their castings were highly accomplished and covered with elaborate surface decoration.

Shortly before we started work on this research, lead isotope measurements were obtained from Igbo Ukwu samples by R.M. Farquhar at the University of Toronto, and were published by CHIKWENDU *et al.* (1989). These fit extremely well with our own measurements as do later Farquhar data published in CRADDOCK *et al.* (1997). Those results have been included in our calculations.

Figures 1a and ***1b*** show that the Igbo Ukwu artefacts can be separated, on the basis of their stable lead isotope ratios into two clearly separate groups with three residual specimens that lie in between the two groups in such a way that it can be inferred that they contained an admixture of the metals used in the two groups. ***Figure 1*** also shows what good agreement there is between the analyses carried out by Farquhar and our own. The stable lead isotope ratio measurements include three independent sets of ratios, *i.e.* $^{208}Pb/^{206}Pb$, $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ or the equivalent. In order to demonstrate that the groupings are consistent for all three independent ratios a pair of two-dimensional scatter plots is required. The two Igbo Ukwu artefact groups have approximately the same degree of spread and orientation as do many similar matching groups of ores from a common source. It is probable that the artefacts in each of the groups were made either with metal from a single ore source or from two or more ore sources whose isotope ratio fields are so closely similar that they cannot be separated.

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[3] Calibrated according to STUIVER & BECKER (1993) with averaging according to LONG & RIPPETEAU (1974).

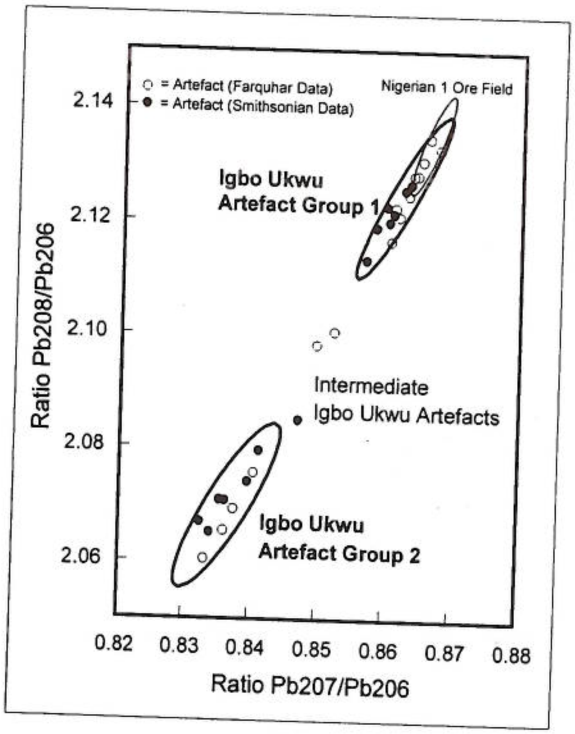

Fig. 1a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot of Igbo Ukwu Artefact Groups 1 and 2 and Intermediate Artefacts (with Farquhar and Smithsonian Data).

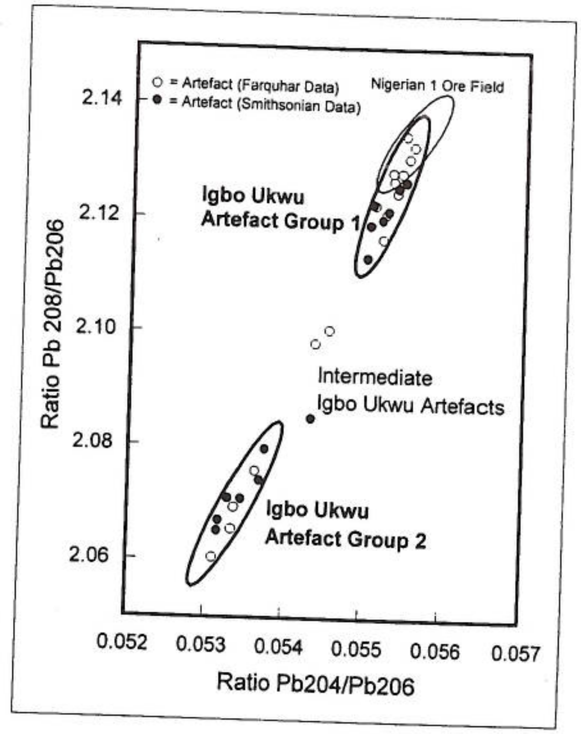

Fig. 1b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot of Igbo Ukwu Artefact Groups 1 and 2 and Intermediate Artefacts (with Farquhar and Smithsonian Data).

Table 2 provides the isotope ratio data and individual descriptions of the Igbo Ukwu Artefact Group 1, Artefact Group 2 and Intermediate objects. It should be noted that ***Table 2*** repeats, with slightly different values, some Farquhar analyses that were listed in the Appendix of Joel *et al.* (1995). The differences occurred because Joel *et al.* (1995) cited data published in Chikwendu *et al.* (1989). These data were revised in Craddock *et al.* (1997). We have assumed that the revised data are more accurate and have changed our database accordingly.

The Igbo Ukwu Artefact Group 1 comprises seventeen objects, six of smithed copper (three of them from Igbo Jonah and three from Igbo Isaiah), and eleven cast copper alloys (two from Igbo Jonah and nine from Igbo Isaiah). Group 2 contains ten objects, three smithed from copper (two from Igbo Isaiah and one from Igbo Jonah) and seven of cast copper alloys (six from Igbo Isaiah and one from Igbo Jonah). There are three objects that do not fit into either group — a twisted manilla of lightly leaded copper and two castings in bronze of a ram's head and of a bird's head. They all come from Igbo Isaiah. These objects lie intermediate between the two groups and therefore seem likely be a mixture of the metals in both groups.

Chikwendu *et al.* (1989) suggested that some of the Igbo Ukwu artefacts contain metal from a polymetallic ore deposit in the area of Abakaliki, 100 km east of Igbo Ukwu in the Benue Rift. Further measurements by Farquhar, published in Craddock *et al.* (1997), confirmed that some of the analysed Igbo Ukwu artefacts and some of the Nigerian ores have overlapping isotope ratios. We have analysed two new Nigerian ore specimens collected from the vicinity of Zurak (9°13'N, 10°32'30"E), about 45 km apart on the north bank of the Benue River. Results from both specimens closely match six of the Farquhar-analysed ores to form a group we have designated as the Nigerian 1 Ore Group (*see **Tab. 1***). The other analysed Nigerian ore specimens, both in the publications cited above and in ***Table 1,*** have isotope ratios that are significantly divergent from this group and from the Igbo Ukwu artefacts. ***Figures 1a, 1b, 2a, 2b,*** and ***2c*** all show that the Nigerian 1 Ore Field either overlaps or is quite close to nine of the Igbo Ukwu Group 1 artefacts. The remaining six Group 1 artefacts all lie significantly outside of this ore field as we now know it. Of course, additional analyses of Benue Rift ores might extend this field to include all of Igbo Ukwu Group 1. However, on the basis of our present knowledge only

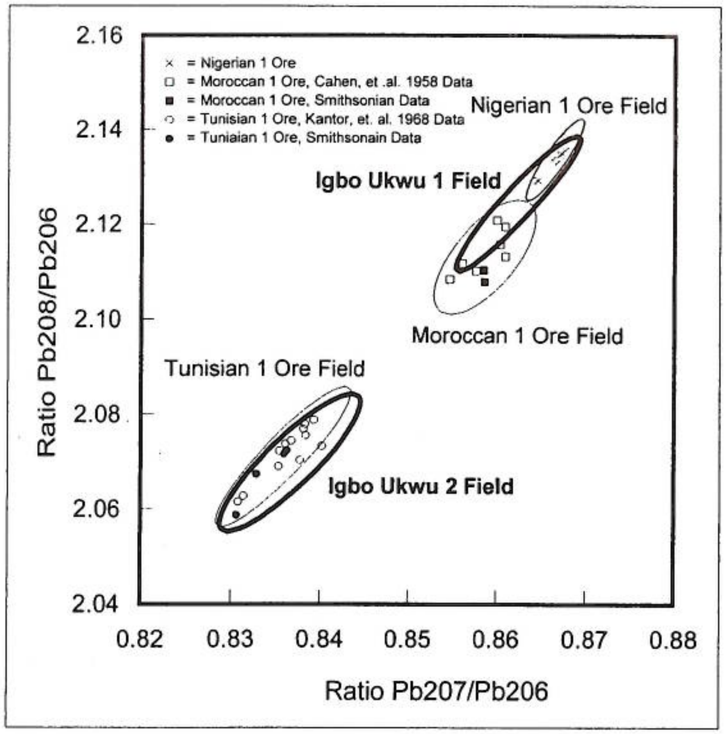

Fig. 2a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing Nigerian, Moroccan and Tunisian Ore Data and Fields (CAHEN *et al.* (1958) and KANTOR *et al.* (1968) unadjusted data), with Igbo Ukwu Artefact Groups 1 and 2 Fields.

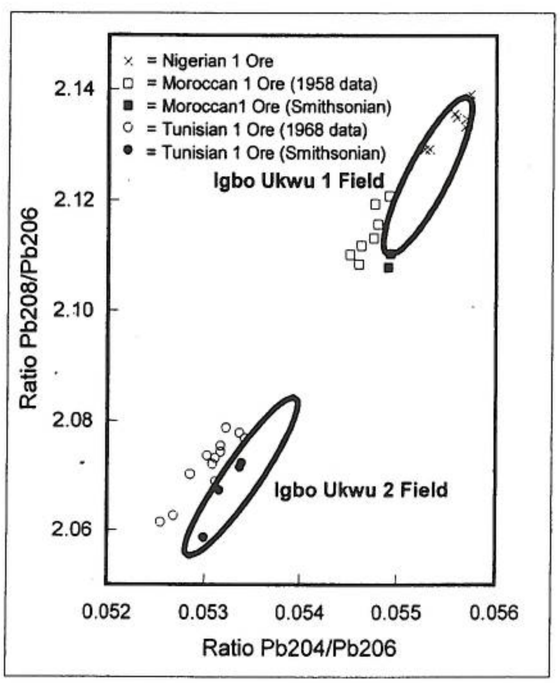

Fig. 2b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing Nigerian, Moroccan and Tunisian Ore Data (CAHEN *et al.* (1958) and KANTOR *et al.* (1968) unadjusted data), with the Igbo Ukwu Artefact Groups 1 and 2 Fields.

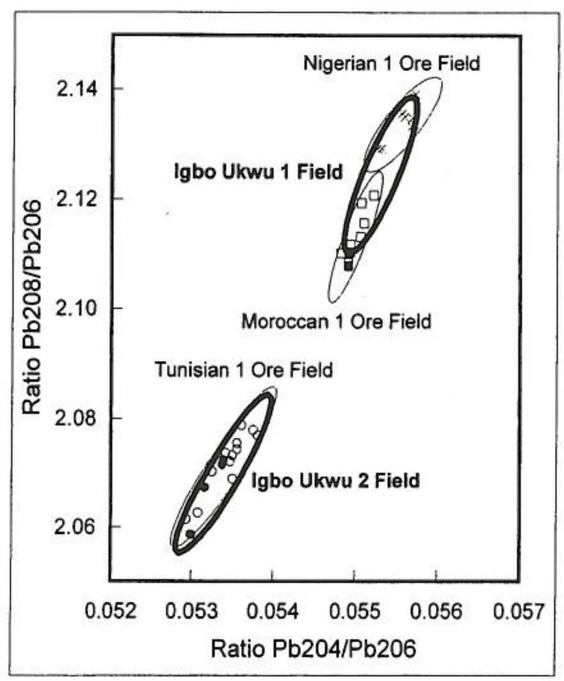

Fig. 2c. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing Nigerian, Moroccan and Tunisian Ore Data and Fields (CAHEN *et al.* (1958) and KANTOR *et al.* (1968) adjusted data), with the Igbo Ukwu Artefact Groups 1 and 2 Fields.

the nine matching or nearly matching artefacts can be regarded as probably having been derived from Benue Rift ores.

The three major stable lead isotopes ^{208}Pb, ^{207}Pb and ^{206}Pb together constitute more than 98 percent of lead in nature; ^{204}Pb is generally present in a concentration of only about 1.4 per cent in nature. Because of its low concentration, ratios involving ^{204}Pb are more difficult to measure and are sometimes less reliable in older measurements. It is important, however, that ^{204}Pb be considered in deciding whether there is indeed a match between a group of artefacts and an ore source.

Figure 2a is a scatter plot involving only the three major lead isotopes in which the Igbo Ukwu 2 Artefact Field is compared to "Tunisian" ore specimens which, in this plot, form an isotope field (Tunisian 1), that is nearly fully coincident with the Igbo Ukwu 2 Field. The "Tunisian" ore specimens include 10 specimens from Tunisia and two from neighbouring Algeria which were analysed in 1968 by KANTOR *et al.*, and an additional four Tunisian ore specimens which have been analysed for this project (*see* ***Tab. 1***). In this plot our data and the Kantor data are in good agreement. Certainly, if one were considering ratios among the three major lead isotopes alone, one would conclude that the agreement between Igbo Ukwu 2 and these ores is exceptionally close.

However, in ***Figure 2b*** it is apparent that the $^{204}Pb/^{206}Pb$ ratios for the Kantor analyses are consistently different from those of our new analyses of Tunisian ores. We have found that we can bring the 1968 data into agreement with our data by simply adding 0.0098 percent to their ^{204}Pb concentrations and dividing all of the concentrations by 1.000098 to restore their sum to exactly 100.0. ***Figure 2c*** shows that our new data combined with the adjusted 1968 data now form a field that overlaps almost perfectly with the Igbo Ukwu 2 Field. Such total overlapping of fields is the strongest possible evidence that an ore group relates to an artefact group. We feel that the adjustment in the 1968 data is quite reasonable. Whether we base our conclusions upon our new data alone or the combination of our data and the adjusted 1968 data, we would conclude that the metal in Igbo Ukwu 2 artefacts very probably was derived from Tunisian or related Algerian ore sources.

Figures 2a, 2b and ***2c*** show a very similar type of overlap between the lower portion of the Igbo Ukwu 1 Field and the Moroccan 1 Ore Field. The ore specimens designated as the Moroccan 1 Ore Field include two that we have analysed and seven published by CAHEN *et al.* (1958). ***Figure 2a*** shows that when only the three major stable lead isotopes are considered the agreement between our data and the 1958 data is good and that their combined field overlaps the lower part of the Igbo Ukwu 1 Field. ***Figure 2b*** shows that the 1958 Moroccan data points are all displaced toward lower values of the ratio $^{204}Pb/^{206}Pb$ when compared to our new Moroccan ore data, as with the 1968 Tunisian data points discussed above. However, when the same correction is made in the early Moroccan data as made in the early Tunisian data and the adjusted data are plotted in ***Figure 2c***, one can see that the adjustment has brought the 1958 data into reasonable agreement with our data. When the adjusted 1958 data are combined with ours, they form a field that covers the lower half of the Igbo Ukwu 1 Field. This is not nearly as neat and convincing a situation as is the Tunisian 1 Ore/Igbo Ukwu 2 overlap. However, it does show that the Igbo Ukwu 1 artefacts that do not overlap with the Nigerian 1 Ore Field possibly could relate to Moroccan ore sources.

Using the Igbo Ukwu 1 and Igbo Ukwu 2 artefact groups as core reference groups we have sought out all of the African and European ore specimens that are compatible with these artefacts. We found no other African lead isotope analyses, other than the ones just described, that overlap these two artefact groups to any great degree. Also we found no European ore sources that coincided with the Igbo Ukwu 1 artefacts. However, three European ore groups, the French Massif Central 4 ores, the German Pfalz ores and the Sardinian 3 ores, do overlap some of the Igbo Ukwu 2 artefacts. ***Figure 3*** shows the nature and extent of these overlaps. A fourth European ore source, the Spanish Rodalquilar ores, has a most unusually tight field that lies totally within the Igbo Ukwu 2 field but does not include any of the Igbo Ukwu 2 artefacts. Since none of our artefacts are compatible with Rodalquilar it is indeed a most unlikely source for them. It is apparent in this figure that none of these ore fields covers more than half of the Igbo Ukwu 2 field. This is in marked contrast to the fact that all of our analyses of the Tunisian 1 ores fall within the Igbo Ukwu 2 field and that when the Kantor 1968 analyses are adjusted to conform to our analyses all of the Tunisian 1 ore analyses lie within the Igbo Ukwu 2 field and collectively nearly coincide with that field (***Fig. 2c***). It is, of course, possible that some of the Igbo Ukwu 2 ar-

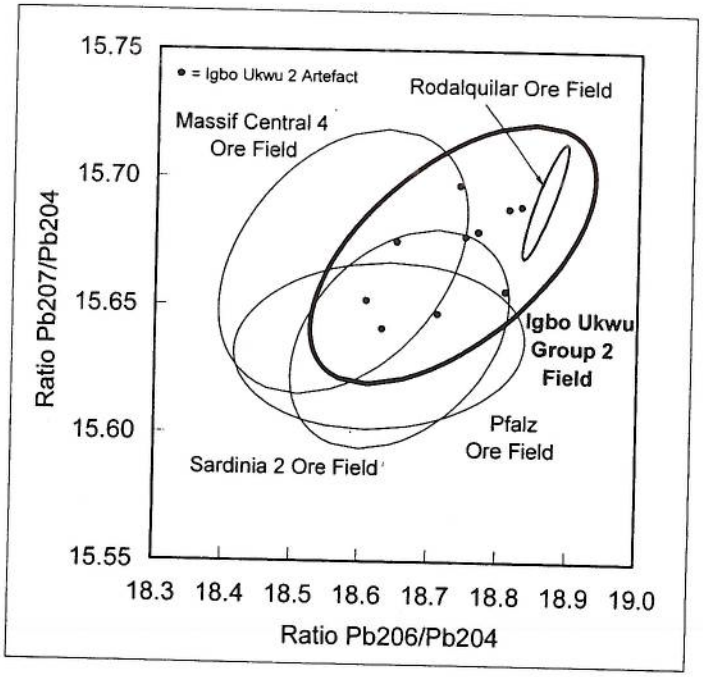

Fig. 3. $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot comparing the French Massif Central 4 Ore Field, the German Pfalz Ore Field, the Sardinia 3 Ore Field and the Spanish Rodalquilar Ore Field to the Igbo Ukwu Artefact Group 2 Field.

tefacts might have come from one or more of these European ore sources, but most unlikely that all of them could have. In general it is more probable that an isotopically consistent group of artefacts of the same age and provenance derive from common ore source/deposition zones, and, from the limited data available at present, the only ores that coincide with Igbo Ukwu 2 are North African.

The most probable conclusion to be drawn from the isotope data is that European metal was not being brought to Nigeria during the Igbo Ukwu period. Instead local Nigerian mines and perhaps NW African mines are indicated as the probable metal sources for Nigeria at that time. There is considerable historical evidence that metal was then being brought south into Africa by caravans from the north. Herbert (1984: 113) reports that the trans-Saharan trade in copper is documented from the 10th century and that could hardly have been the beginning of the trade.

Marandet

Excavations at Marandet, *ca* 85 km SW of Agadez, produced tens of thousands of small crucibles, together with slag and several copper-based ingots (Grébénart 1993). Tin-bronze, leaded tin-bronze, gunmetal (tin-bronze with some zinc), and leaded brass were all in use at the site (Willett 1981). Only limited stratigraphic records were published so it is uncertain whether all these metals were in use at the same time. Radiocarbon dates from the various investigations range from early first millennium cal AD to mid-second millennium cal AD. Mauny (1961: 139) suggests that this site is the "Maranda" referred to by Yakoubi around 872 AD and by Ibn al Faqih in 902 AD on the route from Egypt to the medieval empire of Ghana. It is also mentioned by later Arabic writers in the 10th and 14th centuries AD.

We have conducted lead isotope analysis on four samples from four copper alloy ingots, six samples from four crucibles and a sample taken from a piece of slag (***Tab. 3***). The six samples from crucibles, together with the accompanying slag sample, form a well-defined group, Marandet 1, which is significantly different from the two Igbo Ukwu groups described above and lies well beyond both of them (Joel *et al.* 1995: Fig. 1). Unfortunately our present isotope ratio database of ore analyses provides no indication of an origin for Marandet 1. Using it as a core group for a statistical search of both our African and European ore databases found no African or European ores with significant probabilities relative to it. One would hope that future analyses might indicate some possible sources that one might expect to be African.

The four samples from ingots are inadequate in number and consistency to provide a reliable basis for statistical inference. We have referred to these samples as Marandet Group 2 (***Tab. 3***), but collectively they do not match our definition of a group. The ingot analyses are quite different from analyses of the crucible samples so that one can, at least, infer that metal from more than one source was recovered from Marandet. The ingot analyses are not similar to those of any African ores known to us but are close to those of several European ore sources. Two of these samples have been found to be consistent with our Europe-related Benin/Lower Niger Group 4 and one consistent with another Europe-related Benin/Lower Niger Artefact Group 2, both of which are discussed below. However, the natures and sources of the other artefacts in these two groups are so different from those of the Marandet ingots that these similarities may well be coincidental.

Ife

The city of Ife is on the spot where the Yoruba traditionally believe that the world was created, where kingship began and from where their kings still derive their authority. The earliest credible radiocarbon date for the occupation is in the sixth century cal AD, but there are several from the eighth century cal AD onwards. Sculpture was practiced there in terracotta from at least as early as the eleventh century cal AD until the present. Bronzes were cast from the twelfth to the early fifteenth century cal AD and probably later. The art is particularly distinguished among African art forms by virtue of its portrait-like naturalism, best known from eighteen human heads, mostly of life size, and the life-size Obalufon mask. The bronzes seem to have been used in cults associated with royalty.

We have examined twenty-four samples from nineteen castings from Ife and three from castings from Tada that appear to be from the same geological source as some of the Ife artefacts. The Ife castings include a principal group of fifteen samples taken from ten heads from Wunmonije Compound, the figure of an Ooni, the royal pair, the longer staff and the smaller staff head from Ita Yemoo. We have designated these as Ife 1 Artefact Group. One piece from Benin, an early globular head and a late figure of an Oba, a chain purportedly from Jenne, Mali, and two pieces from the Apapa Hoard also match this group. Interestingly head 16, the so-called "Olokun" head also matches this group, from the formation of which it was excluded as it had been shown by Fagg & Underwood (1949) to be a modern copy made by the sand-casting technique. They suggested that local castings of less significance might have been melted down to make this copy. This appears to be the case, unless the copy was made by chance from other European metal from the same source area. Data for these specimens are listed in ***Table 4***.

The Ife 1 Artefact Group is shown in ***Figures 4a*** and ***4b***. The plot of the Ife 1 Artefact Group has a tight clustering that is suggestive of a single ore source. It lies fully between the two Igbo Ukwu groups (***Fig. 2a***), hence the objects may conceivably have been cast with mixed metal from the Igbo Ukwu sources. However mixing almost always produces a group that is well spread-out between the two source groups being mixed, unless the proportions of mixing remain exactly the same, which is an unlikely restriction. ***Figures 5a*** and ***5b*** show that the Ife 1 artefacts fall within the French Massif Central 4 Ore Field. This again is an instance in which an artefact group field and an ore group field essentially coincide, which is the strongest possible evidence that the two fields relate to each other. A statistical search of our total European Ore Database for samples that were consistent with Ife 1 revealed that also some of the Sardinian 4, Bulgarian 1 and French Alps 2 ore-field specimens lie within the Ife 1 Field. However, ***Figure 6*** shows that each of these ore fields encloses only a fraction of the Ife 1 artefacts. None of these ore-fields could be considered to be the source of all of the Ife 1 specimens.

The Ife 2 Group, listed in ***Table 4***, comprises six samples from four heads from Wunmonije Compound, two of them high zinc-brass heads typical of the Classical Period for which we have only two reasonably acceptable TL-dates *i.e.* that match the ^{14}C dates from excavated sites: 680 ± 100 bp and 625 ± 110 bp (Willett & Fleming 1976). Each of these TL-dates is an average of ten measurements, so each of the errors reported here are averaged standard deviations. Two other heads are of pure copper which Willett (2004) suggests were probably of later date because of the technical difficulty in casting pure copper, and because they show a similar pattern of sprues (although they were not necessary if the crucible was luted onto the mould to exclude the air). Other members of Group 2 include a figure of an Ooni (in a late style from a group of pieces recently discovered), a bracelet found in Ife, the warrior figure from Tada, and the larger ostrich figure from Tada.

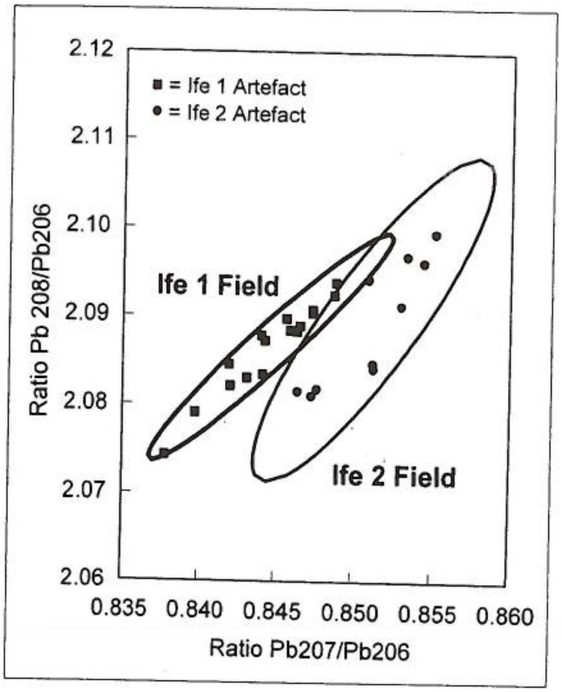

Fig. 4a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot of the Ife Artefact Groups 1 and 2 Data and Fields.

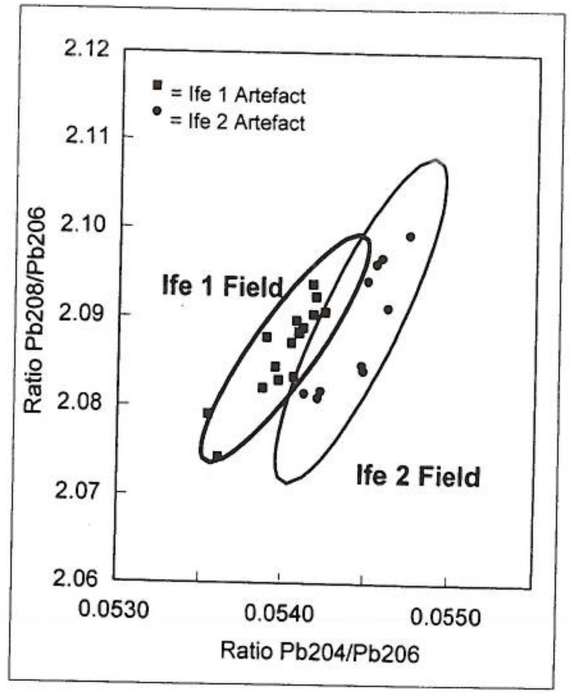

Fig. 4b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot of the Ife Artefact Groups 1 and 2 Data and Fields.

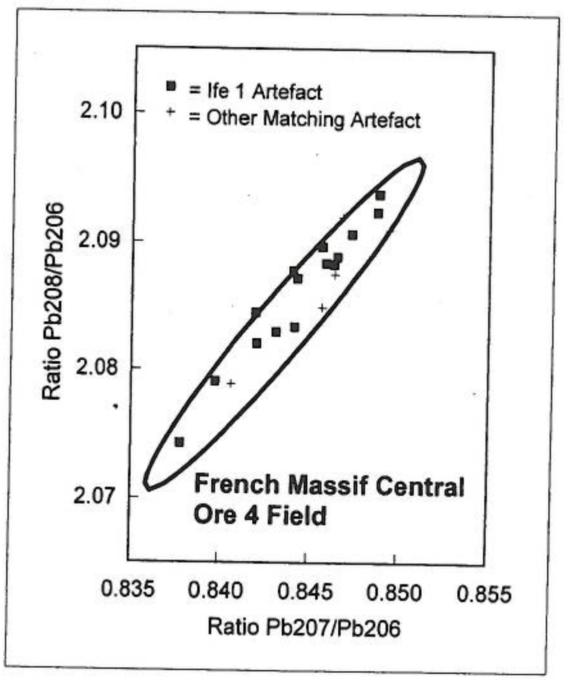

Fig. 5a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing the Ife Artefact Group 1 Data and Other Matching Artefact Data to the French Massif Central Group 4 Ore Field.

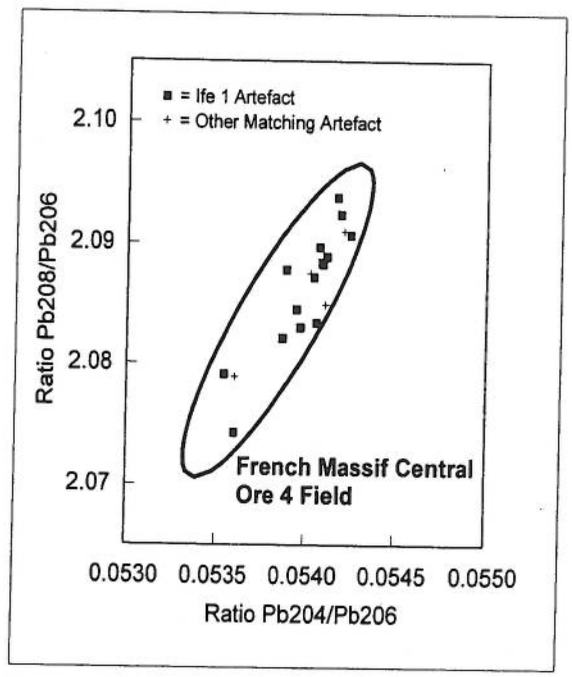

Fig. 5b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the Ife Artefact Group 1 Data and Other Matching Artefact Data to the French Massif Central Group 4 Ore Field.

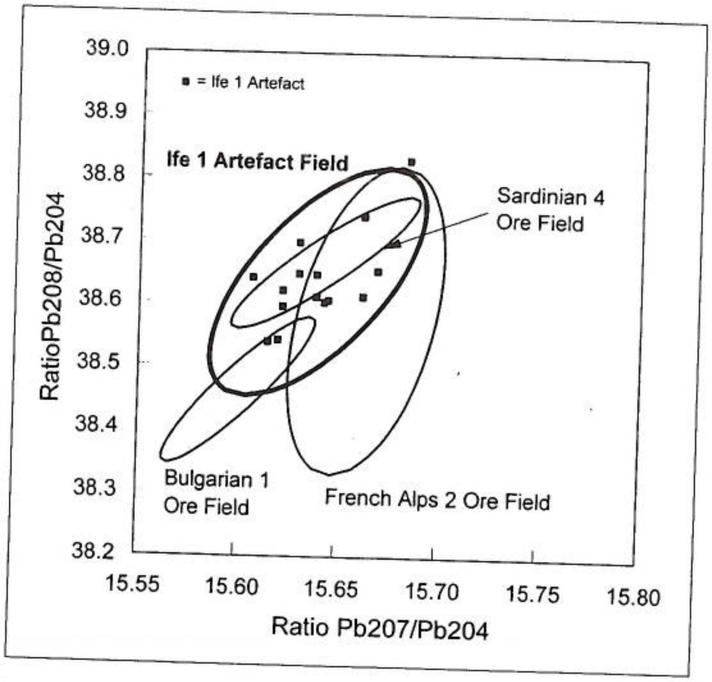

Fig. 6. $^{208}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ plot comparing Ife Artefact Group 1 Data and Field to the Sardinian 4, Bulgarian 1 and French Alps 2 Ore Fields.

It is interesting that Tada pieces should occur in an Ife group. Their presence would appear to support the tentative conclusion of Slater & Willett (1988), based upon Atomic Absorption analyses of the clay cores, that they might all have come from Ife. Nevertheless it is puzzling that only the seated figure is composed of a metal that occurs in Ife – a nearly pure copper – while the other Tada pieces are tin bronzes (*ca* 7 % Sn) with only 1.6 & 1.7 % Zn and 0.46 & 0.80 % Pb, respectively, whereas the Ife alloys are usually much lower in tin and higher in both zinc and lead. The late figure of an Ooni from Ife may well indicate that this Ife Group 2 metal was still in use during the period after copper alloys had begun to be cast in Benin, in the late fourteenth century.

Figures 4a and ***4b*** demonstrate that Ife Group 2 has isotope ratios that are significantly different from the Ife Group 1. ***Figures 7a*** and ***7b*** show that the Ife Group 2 artefacts all lie within the distribution of a group of French Massif Armoricain ores. They also lie within, or are peripheral to, the distribution of a group of the Belgian-German ores which are part of the same NW European zone of ore deposition. This belt of ore deposits, which extends on the continent from the Harz Mountains in Germany, through the Rhineland and Belgium, to the end of the Breton Peninsula in France, and also extends into Southern England through Wales and on into Ireland. It is not surprising that these deposits should extend over to the off-shore islands as the British Isles were formerly part of a continuous land mass connected to the mainland. This NW European ore mineralization zone is of particular importance in this study because a majority of the later artefacts, primarily those found in Benin or the Lower Niger Region which we will designate as Benin/Lower Niger Group 1 and discuss below, also are essentially included by all of these related ore fields.

Figures 7 and ***8*** show that both the Ife Group 2 and Benin/Lower Niger Group 1 artefacts all reasonably conform to the NW European ore mineralization zone, whether this deposit is found in Germany, Belgium, France, England, Wales or Ireland. Comparison of these figures makes it clear that the English, Welsh and Irish ore fields overlap the French and Belgian-German fields. They also show that Ife Group 2 and Benin/Lower Niger Group 1 are indistinguishable from each other on the basis of their isotope ratios. We have separated the two artefact groups only because it makes some sense to discuss the Ife artefacts separately from the later Benin and the Lower Niger artefacts. It is important, however, to make clear from the beginning the similarities in the isotope ratios of these two groups of artefacts.

Figures 9a and ***9b*** show that other European ore source fields that have isotope ratios similar to Ife Group 2 and Benin/Lower Niger Group 1 may only ac-

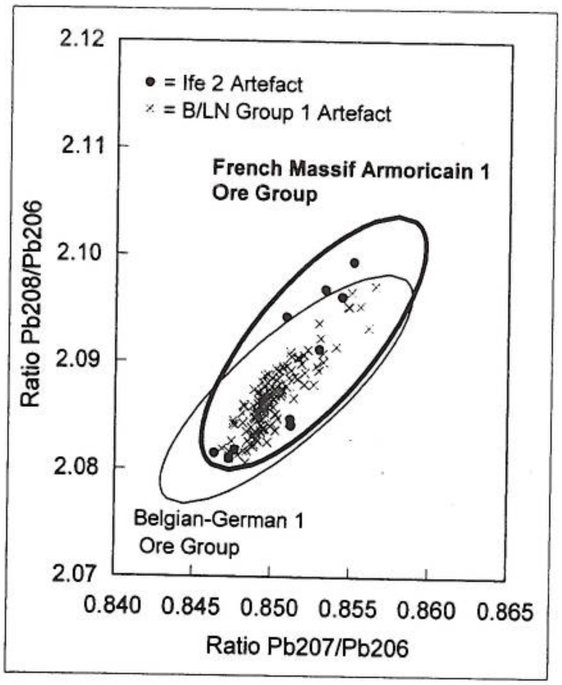

Fig. 7a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing matching Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data with the French Massif Armoricain Group 1 and the Belgian-German Group 1 Ore Fields.

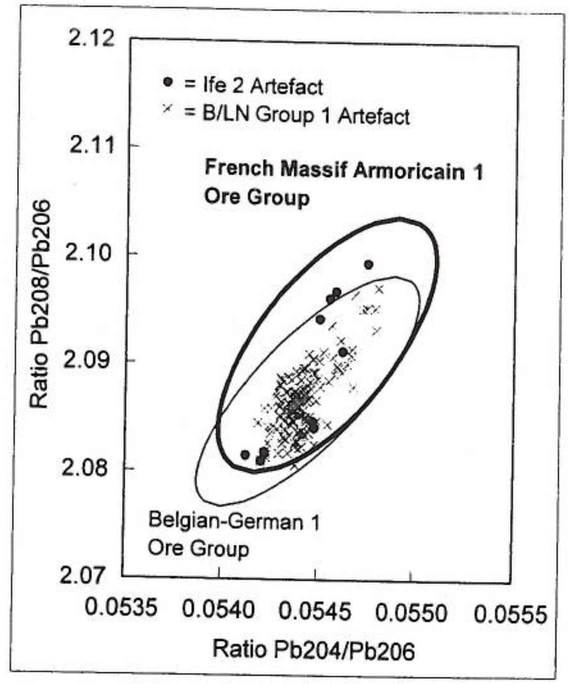

Fig. 7b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing matching Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data with the French Massif Armoricain Group 1 and the Belgian-German Group 1 Ore Fields.

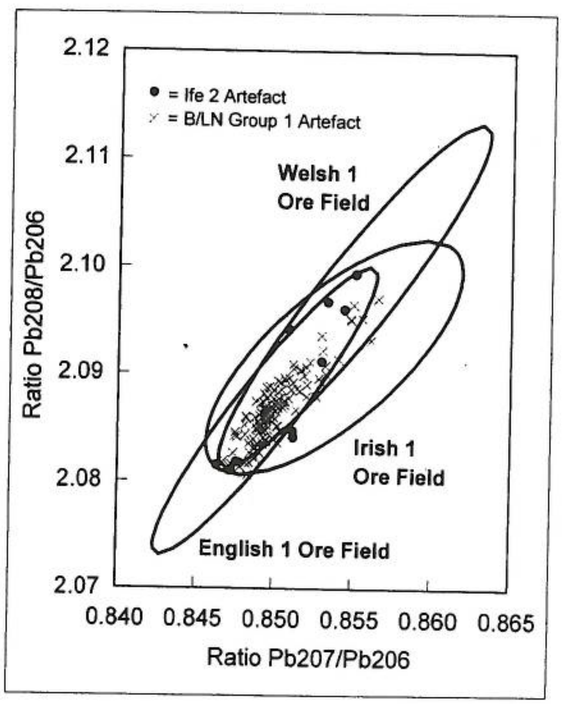

Fig. 8a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing the English 1, Welsh 1 and Irish 1 Ore Fields with the Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data.

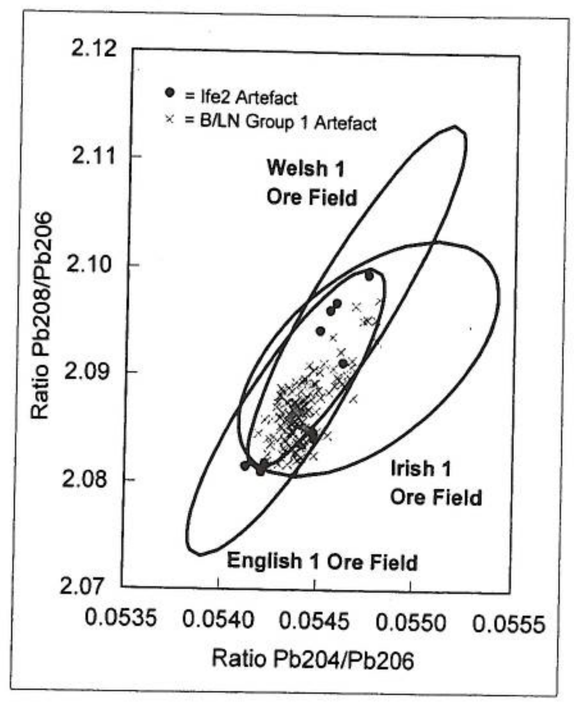

Fig. 8b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the English 1, Welsh 1 and Irish 1 Ore Fields with the Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data.

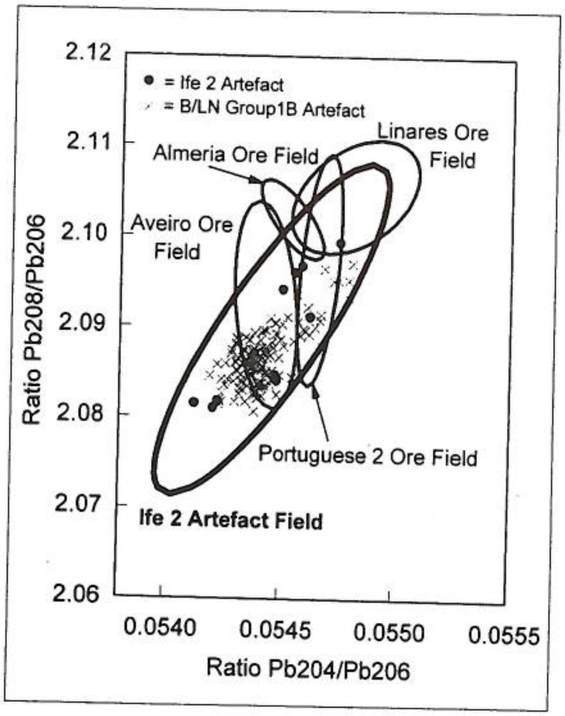

Fig. 9a. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the Portuguese 2, the Aveiro, the Spanish Linares and the Almeria Ore Group Fields with the Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data.

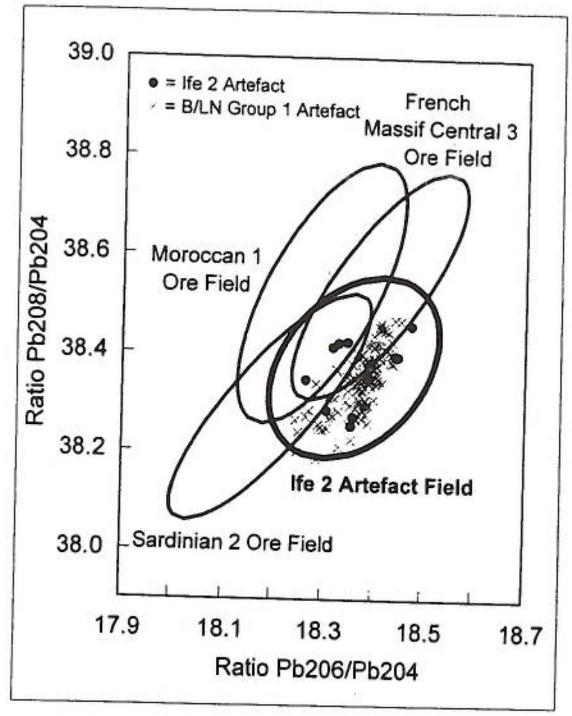

Fig. 9b. $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot comparing the Sardinian 2, Moroccan 1 and the French Massif Central 3 Ore Group Fields with the Ife Artefact Group 2 and Benin/Lower Niger Artefact Group 1 Data.

count for some of the specimens in these groups, and hence are not likely sources for them. These include the Iberian fields of Linares, Almeria, Aveiro, and Portuguese Group 2, southern European sources, such as the French Massif Central Group 3 and Sardinian Group 2 ore fields, as well as the North African Moroccan Group 1 ore field. Note that in ***Figure 9b*** the Moroccan 1 Ore Field overlaps four of the Ife Group 2 specimens. It is, therefore, possible that these four artefacts might have been formed from Moroccan metal, although it is obvious that the other Ife Group 2 artefacts could not have been. We would not rule out the possibility that the Ife Group 2 artefacts might have been derived from two metal sources. However, since they constitute a reasonably well-formed group that is totally contained within the field of a single European ore it seems to us to be more likely that they all came from that source. In all instances we are inferring probabilities not certainties.

In summary, it should first be noted that there were no African ores for which we have lead isotope ratios at present that are consistent with either the Ife Group 1 or the Ife Group 2 artefacts. In contrast ***Figures 5*** and ***6*** show that the Ife Group 1 is fully consistent with the French Massif Central Ore Group 4 but is only partially overlapped by other European ore groups that have similar isotope ratios. Similarly, ***Figures 7, 8*** and ***9*** show that Ife Group 2 is compatible with all of the fields of the NW European ore mineralization zone (whether sampled in France, Belgium, Germany, England, Wales or Ireland), but is only partially overlapped by other European and Western Mediterranean ore sources with similar isotope ratios. In contrast to Igbo Ukwu castings, for which only African ore sources were indicated, only NW European ore sources are indicated for Ife castings. Whilst it is possible that an African source that is not represented in our database was used in Ife, the fact that the NW European ore fields continued to supply the metal to Benin supports our view that it may have been the demand from Ife that first stimulated the supply of French metal, initially via the trans-Saharan trade routes. The probable sources of the Ife 1 and the Ife 2 Group metals in the Massif Central and the Massif Armoricain Ore Fields lie close to the ports of Nantes and Vannes, both of which were later to play important roles in the coastal trade. Moreover this demand for metal may have contributed its share to the pressure to open up a sea route to West Africa.

Many more Ife samples were obtained for this project, but they had not been run before we were forced to abandon our work. Eight of them are from castings in more or less pure copper which would have been interesting to compare with the others. Because of the technical difficulty involved, it seems likely that the Ife smiths learned to cast pure copper later than copper alloys, which have lower melting temperatures, and this might have given us an indication of whether the sources of our two groups were in simultaneous or consecutive use. The little evidence that we have suggests that both source were being exploited simultaneously.

Ma'aden Ijâfen

We have analysed two ingots from the famous "ship-wrecked" camel caravan excavated by MONOD (1969) at Ma'aden Ijâfen in southern Mauritania (***Tab. 3***). The calibrated radiocarbon dates from the matting in which the 2085 ingots were wrapped (1097 cal AD to 1325 cal AD at 2 standard deviations) shows them to be contemporaneous with the flourishing of Ife metal-working from the twelfth to early fifteenth centuries cal AD. We have found that the ingots have isotope ratios consistent with the same NW European ore deposit as the Ife 2 artefacts. This coincidence would indicate that during the Ife period metal from NW Europe was being shipped to North Africa, probably from the port of Antwerp, which is close to the Belgian-German ore deposits or from Nantes, which is close to the deposits in Brittany, and then was being transported to Nigeria by camel caravan.

Benin and the Lower Niger Bronze Industries

The city of Benin lies some 180 km south-southeast of Ife as the crow flies, close to the edge of the Niger Delta. It is far better known as a centre of copper alloy casting than is Ife because of its vastly greater production. Many hundreds of pieces were brought back to Europe after the British conquest of Benin in 1897, and subsequently dispersed to museums and private collectors throughout the world. Yet the oral traditions record that it was from Ife that the people of Benin learned the art of bronze-casting in the late fourteenth century, a century before the Europeans first set foot in Benin City[4]. Here too the commissioning of major bronze-castings was a royal prerogative.

With such a large body of evidence the Benin bronzes have been classified stylistically, chiefly through the work of William Fagg, the great pioneer in the study of West African copper alloy castings, into three periods, Early, Middle and Late (FAGG 1960, 1963). The craft lapsed when the king of Benin was deposed in 1897, but was revived and continues to flourish on a large scale right up to the present day. Indeed larger castings are being made than before, and excellent copies of older works are flooding the art market, causing great confusion.

FAGG (1960: 15-35) suggested that the copper alloys of several sites in the Niger River valley – between the delta and the confluence of the Benue, excluding Ife and Benin (but including pieces from Benin that were not in a Benin court style) – should be referred to collectively as the Lower Niger Bronze Industry. The discoveries at Igbo Ukwu had only shortly before 1960 set that centre apart, though FAGG (1963: 40) still believed that the Igbo Ukwu bronzes "seem closely allied to the group – or actually a part of it." He sensed that there was an underlying freedom of style at Igbo Ukwu when compared with the works from Ife and Benin that gave all of the castings from these three groups some degree of stylistic unity, even though "they did not give the impression of having a single origin" (FAGG 1963: 39). He regarded them as "the very pinnacle of Nigerian artistic achievement" (FAGG 1963: 39).

Fagg's main groupings were all represented in the collections of the British Museum. Since numerous different styles were involved, WILLETT (1971: 77) adopted the practice of referring to them collectively as the Lower Niger Bronze Industries. Fagg's idea was that the term should serve as a catchall to encourage further studies of these different styles. The British Museum kindly allowed Willett to sample many of these bronzes so that we might attempt to discover whether the composition of the metal used could distinguish between them.

The Tsoede Group of castings from Jebba Island in the River Niger now seem stylistically to be of Yoruba origin although some details can be paralleled in Benin. These are the figures of a male bowman (ECCLES 1962: 18; FAGG 1963: Plate 57; EYO & WILLETT 1980: no. 94) and of a woman (ECCLES 1962: 13-16;

[4] It is possible that this tradition refers only to the casting of heads (see WILLETT 1973: 13).

WILLETT 1971: Plate 50; EYO & WILLETT 1980: Fig 14), both from Tada, a seated figure (ECCLES 1962: 20-22; EYO & WILLETT 1980, no. 92) a warrior (ECCLES 1962: 19; EYO & WILLETT 1980: no. 93; PHILLIPS 1995: Plate 5.73a), a male figure with clasped hands (ECCLES 1962: 22; EYO & WILLETT 1980: no. 96), another male figure with a staff (ECCLES 1962: 23; EYO & WILLETT 1980: no 95), two ostriches (ECCLES 1962: 24; PHILLIPS 1995: Plate 5.73b), an elephant (ECCLES 1962: 25) and *Giragi* - a drummer (DEPARTMENT OF ANTIQUITIES 1958-62: 43). They include the largest figures ever cast by pre-industrial processes anywhere in Africa south of the Sahara. There has never been any serious doubt that the seated figure from Tada was made at Ife, and atomic absorption analyses of the clay cores suggests that all the above may have come from Ife (SLATER & WILLETT 1988). The Nigerian Commission for Museums and Monuments is now responsible for these pieces and gave permission for some of them to be sampled.

The Andoni Creek Group is the contents of a shrine seized by A. A. Whitehouse, the acting Divisional Commissioner, Eastern Division in 1904 and sent by him to the British Museum on behalf of the government of Southern Nigeria. The 79 objects are catalogued as 1905 4-13 1 to 79. Of these, 61 are copper alloys. The best-known piece is the seated figure illustrated in UNDERWOOD (1949: Pl. 61) and by PEEK & NICKLIN (2002: Pl. 1.20), but the rest of the pieces are quite different. There are two straight, double-edged swords, (PEEK & NICKLIN 2002: Pl. 1.28) two spears and a bifurcated staff of copper-alloy, a thinly cast leopard skull apparently built up originally from fine threads of wax, (PEEK & NICKLIN 2002: Pl. 1.24), a second leopard skull (PEEK & NICKLIN 2002: Pl. 1.22), a small fragment perhaps from another leopard skull, a thin-walled tubular bell (PEEK & NICKLIN 2002: Pl. 1.25), expanding slightly at both ends, with low relief decoration, a small horn (PEEK & NICKLIN 2002: Pl. 1.21), two heavy, square-sectioned, coiled anklets (or bracelets) with round, widely expanded ends (PEEK & NICKLIN 2002: Pl. 1.26a & b), three coils of different lengths (probably anklets), two tightly coiled objects with discoidal ends, eleven simple bracelets of various sizes, twenty-nine manillas of various sizes and four rods. There are TL dates for two pieces in this style: 1655 ± 40 AD and 1680 ± 40 AD (NICKLIN & FLEMING 1980: 105). The Andoni Creek lies close to the eastern edge of the Niger Delta.

The Forcados River Group is reported to have been dug-up on the Forcados River, Southern Nigeria, which debouches in the western Niger delta due south of Benin City. This group was presented to the British Museum, where it is registered as 1909 8-11 1 to 16, by Lady MacDonald, then at the British Embassy in Tokyo. Presumably she was the wife of Major Sir C. Claude MacDonald, K.C.M.G. who was High Commissioner of the Niger Coast Protectorate in 1895 (EGHAREVBA 1968: 97). Presumably the discovery was made at that time. It comprises a curved knife, a bell in the form of an antelope's head, four bells in the form of a human head with bulging eyes and heavy eyebrow ridges[5], a four-sided bell with a human face in low relief, a cylindrical bell with out-turned mouth, a cylindrical armlet with the representation of a corpse being pecked by birds, three bracelets with conical projections, and four manillas, one with its ends overlapping.

The area around the Cross River, which debouches to the east of the Niger Delta at the boundary with Cameroon, has produced a number of small bronzes from a variety of shrines. They are both human and animal figures and tulip-shaped bells. Several, in museums and private collections, have no provenance. We had samples from four pieces in the Menil Foundation Collection, Houston, Texas[6]. In 1977 Keith Nicklin took samples from this collection for thermoluminescence dating and for lead isotope analysis (NICKLIN 1982: 47-51). A carnivore skull from a burial at Oron gave a mid-seventeenth century TL-date (FLEMING & NICKLIN 1982). It closely resembles the thinly cast example from Andoni Creek, apparently built up originally from fine threads of wax and is, remarkably, cast in 98.2 % copper. Two human figures, still in a Cross River shrine, gave TL-dates in the early to mid-nineteenth century (NICKLIN & FLEMING 1980), while the figures of a human and a hippopotamus in the National Museum at Oron gave similar TL-dates[7]. FLEMING & NICKLIN (1982) give the elemental analyses

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5 FAGG (1968: no 153) illustrates one which was formerly owned by 'Sir Hercules Read of the British Museum' that he reports to be from the original find. This type of head is found in other collections but none of these appears to have a provenance (See for example JACOB & DRAGU 1974: 4, 7 and 16; LORENZ 1982: Pl. H 11; PEEK & NICKLIN 2002, Pl. 1.9; FOSS 2004: Cat. 18, 19, 20). One of them was copied in a European foundry. The copies have been made in a piece-mould and bear a number on the bottom edge at the back (unless it has been filed off).

6 MENIL FOUNDATION 1997: Pls. 93-95. One is illustrated in BRINCARD (1982: Pl. H 17); PEEK & NICKLIN (2002: Pl. 1.2).

7 These are illustrated in FLEMING & NICKLIN (1982: Pl. 1). The hippo is shown in WILLETT (1971, 1993: Pl. 52, 2002: Pl. 40).

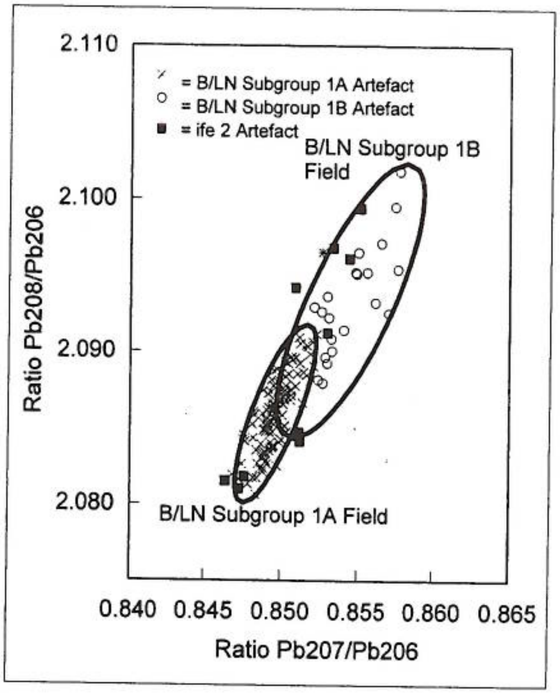

Fig. 10a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot showing the Benin/Lower Niger Artefact Group 1 Data, subdivided into Subgroup 1A and 1B Fields, and the Ife Artefact Group 2 Data.

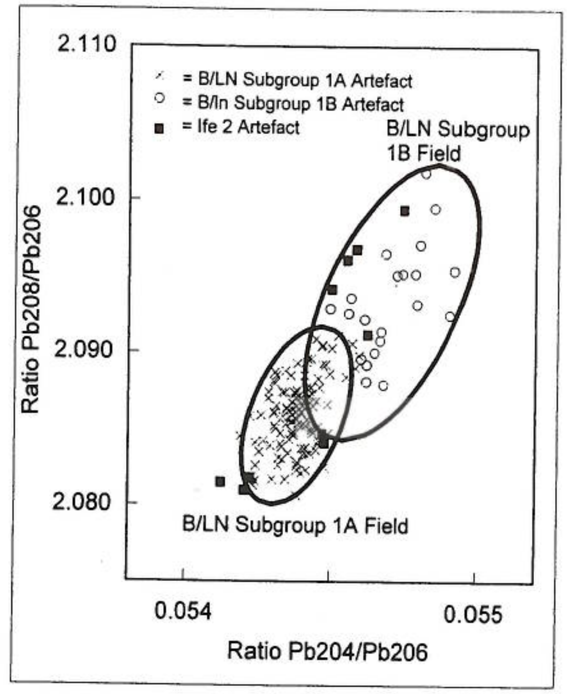

Fig. 10b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot showing the Benin/Lower Niger Artefact Group 1 Data, subdivided into Subgroup 1A and 1B Fields, and the Ife Artefact Group 2 Data.

of all four pieces, which show great variation in composition. Copper ranges between 62.2 and 92.5 %, tin from 1.6 to 3.56 %, lead from 1.5 to 31.6 % and arsenic from 0.83 to 4.50 %, while zinc ranges from 0.12 to 0.54 %. Clearly these do not come from a single melt. One supposes that the smiths were not greatly concerned about the precise composition of their metal. Decorative motifs, especially spirals on some of the castings from the Cross River and Andoni Creek remind one of those on the late first millennium works from Igbo Ukwu. While not too much emphasis should be laid on similarity in a such a simple motif, Nicklin believed that itinerant Igbo smiths may have been responsible not only for making many of the Lower Niger "bronzes" but also that they taught the craft to the local people.

Samples from the major centres of the Lower Niger Bronze Industries were examined separately from each other as well as from the Benin samples. Only those from Apapa, which will be discussed later, could be distinguished from the rest. Our analyses show that the Benin and the other Lower Niger results always occur together in each of the groups in which they are found. Clearly the same metals were used throughout the area and there seems to be little reason to consider them separately. We have therefore identified the groups containing primarily Benin and Lower Niger specimens as Benin/Lower Niger (B/LN) Groups 1 through 6. The isotope ratio data and individual identifications of these specimens are listed in ***Table 5***.

We arranged for the analyses of 220 samples from 212 objects which were cast at primarily Benin and the Lower Niger sites just described. Note that these figures do not include the Apapa and related specimens. The most noteworthy aspect of these analyses is that the majority of them, 140 samples, or 64 percent of the total, were found to be fully consistent with the same NW European ore deposition zone as were the Ife 2 analyses. We have designated these artefact analyses as Benin/Lower Niger (B/LN) Group 1 and have plotted them, along with the Ife Group 2 artefacts in ***Figures 7, 8*** and ***9***. ***Figures 7*** and ***8*** show that Benin/Lower Niger Group 1 is fully contained within all the regions of the NW European ore mineralization that have been analysed, whether they be in Belgium, Germany, France, England, Wales or Ireland. ***Figure 9*** shows that the fields of south-western European and North African ore deposits, with isotope ratios close to those of Benin/Lower Niger Group 1, overlap at most only a small portion of the Benin/Lower Niger Group 1 artefacts. Unfortunately the isotope data themselves do not permit one to infer where within the NW European ore zone the metal for the objects might have been extracted.

The inner structure of Benin/Lower Niger Group 1 is quite unusual in that the large majority of the specimens comprising it are crowded together in the lower half of the ranges of $^{208}Pb/^{206}Pb$, $^{207}Pb/^{206}Pb$ and $^{204}Pb/^{206}Pb$ ratios that define the entire group, as can be seen in ***Figures 7*** and ***8***. This high-density group of specimens can be separated out as a B/LN Subgroup 1A. This is a statistically complete group in that it contains all specimens that have 5 percent, or greater, probability relative to it. The remaining Benin/Lower Niger Group 1 specimens can be considered to be B/LN Subgroup 1B, which contains all specimens with 5 percent or greater probabilities relative to Benin/Lower Niger Group 1 except for those specimens already assigned to the Benin/Lower Niger Subgroup 1A. These B/LN Subgroups and the 95 percent probability ellipses that define their fields are shown in ***Figure 10***, together with the Ife Group 2 artefacts.

Benin/Lower Niger Subgroup 1A merits special consideration because in contains 113 artefacts, which is essentially half of those we have had analysed. In contrast, B/LN Subgroup 1B contains only 20 artefacts. B/LN Subgroup 1A is also special in being confined to a particularly tight range of isotope ratio values. One can interpret this unusually small field as indicating the possibility that at least a large portion of the Subgroup 1A artefacts were made from metal derived from a relatively small group of mines from a particular region. HERBERT (1984) reports that during the period when direct maritime trade from Europe to Africa was dominated by Portugal, 1460-1600 AD, copper and its alloys were primarily imported from Antwerp. The metal markets at that time in Antwerp were known to have been supplied from mines in Flanders and nearby Germany. In the seventeenth century, when the Dutch obtained dominance over the maritime trade to Africa, the port of supply changed from Antwerp to Amsterdam but they very likely continued to draw upon the same mines for their metal. Later, when the English competed strongly for this trade, they might well have continued to import the same metal from the nearby ports of Antwerp or Amsterdam though from the end of the 18th Century until the middle of the nineteenth century English and Welsh metals dominated the trade (CRADDOCK & HOOK 1995: 185). These ores have the same isotope ratio signatures as the Belgian-German ores.

One cannot argue that all of the B/LN Subgroup 1A artefacts were made from metal from the same source. However, the compactness of the distribution leads us to question HERBERT's statement that "Benin was conspicuous in the sixteenth century for continuing to prefer copper over brass from the Europeans" (1984: 177). This is probably based on statements that were deliberately intended to mislead other competitors for the trade. Unalloyed copper was very little used in Benin. WERNER (1970) found no copper objects in his 154 analyses of the Benin pieces in the Berlin national collection while CRADDOCK & PICTON (1986) found seven examples among 144 analyses of pieces in the British Museum collection – two rivets, a nail, a bracelet, a repair to an armlet and two small panels inlaid in alloy sculptures. If other metals had been added to copper locally in Benin, our samples would not have clustered so tightly.

The evidence is strong that the Ife Group 1 artefacts relate to some of the ores in the French Massif Central. It is fairly likely that Ife Group 2 artefacts also relate to a French source, the Massif Armoricain. Both ore sources are well connected to the port of Nantes, which could have been a common trade source for both metals. There is no reason to believe that the Portuguese, whose direct metal trade from Antwerp to the western coast of Africa started in about 1460 AD, would have been involved in earlier metal trade to Ife.

It is well to keep in mind, however, that the isotope ratios of both B/LN Subgroup 1A and B/LN Subgroup 1B objects are equally consistent with ores encountered throughout the entire length of the Northwest European deposition zone that extends across southern Ireland, Wales, southern England and Brittany up into Belgium and Germany. The lead isotope data alone do not permit one to infer from which of these regions the metal in either 1A or 1B objects was obtained. Only historical or chronological considerations, such as those cited above, can indicate that some of these sites were more probable sources of metal for either B/LN subgroup at particular times.

Among the remainder of the Benin and Lower Niger artefacts we have been able to separate out five other artefact groups, shown in ***Figure 11***, with distinctly separate isotope ratio fields. These have been labelled Benin/Lower Niger Groups 2, 3, 4, 5 and 6. ***Figure 12*** shows that the Benin/Lower Niger Group 2 artefacts are totally enclosed by the French Massif Central 3 Ore Field, the Benin/Lower Niger Group 3 is

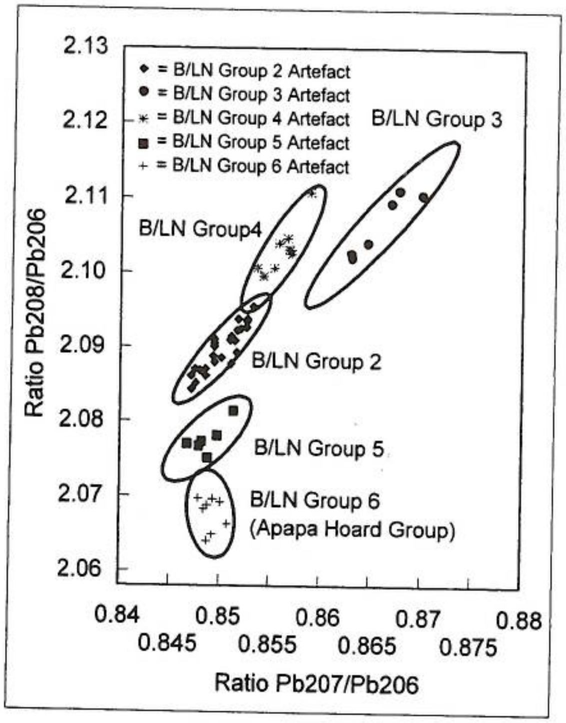

Fig. 11a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot of the Benin/Lower Niger Artefact Groups 2, 3, 4, 5 and 6 (Apapa Hoard Group) Data and Fields.

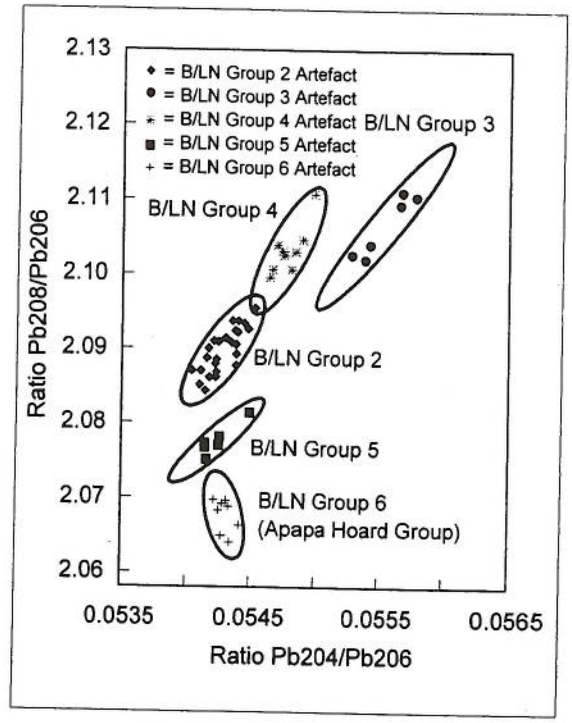

Fig. 11b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot of the Benin/Lower Niger Artefact Groups 2, 3, 4, 5 and 6 (Apapa Hoard Group) Data and Fields.

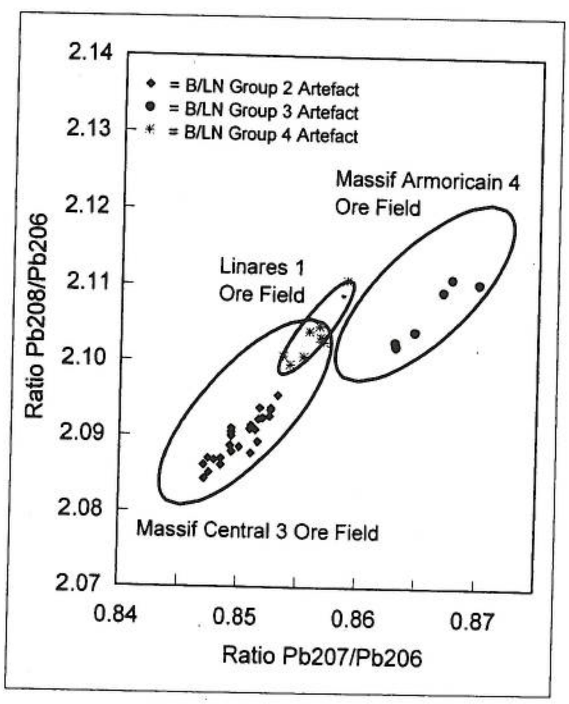

Fig. 12a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing the Benin/Lower Niger Artefact Groups 2, 3 and 4 Data with the French Massif Central 3, the French Massif Amoricain 4, and the Spanish Linares 1 Ore Fields, respectively.

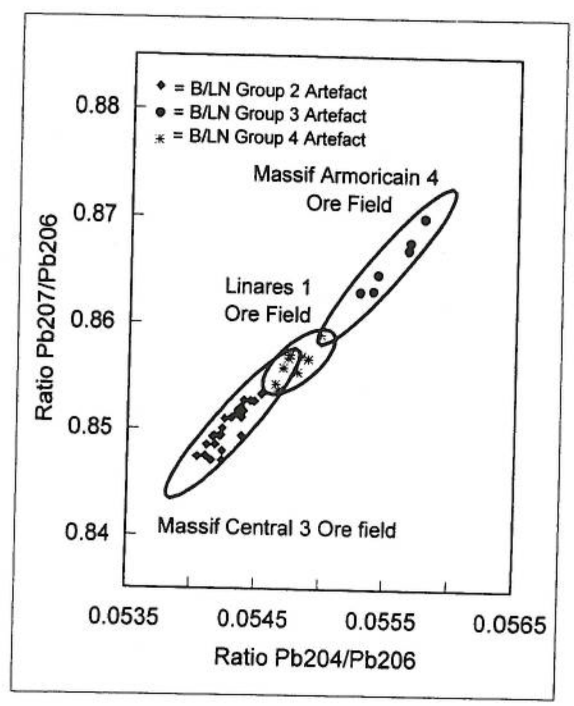

Fig. 12b. $^{207}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the Benin/Lower Niger Artefact Groups 2, 3 and 4 Data with the French Massif Central 3, the French Massif Amoricain 4, and the Spanish Linares 1 Ore Fields, respectively.

contained within the French Massif Armoricain 4 Ore Field and the Benin/Lower Niger Group 4 is contained within the Spanish Linares 1 Ore Field. The Linares mines are at the headwaters of the Guadalquivir River that flows through Seville. This river, supplemented by a series of canals, still gives Seville shipping access to the Atlantic Ocean. Up until 1718 AD, when it was supplanted by Cadiz, Seville was considered to be Spain's principal Atlantic port. It is worth noting that the Benin/Lower Niger Groups 1, 2, 3 and 4 all relate to probable ore sources that have good access by river to major European Atlantic ports.

The Benin/Lower Niger Groups 2, 3 and 4 show different degrees of partial overlap with other ore groups. In order to restrict the number of figures we will not try to show all of the partial overlaps in scatter plots but describe them in words. The Benin/Lower Niger Group 2 field is only superficially overlapped by the Sardinian 2, Poland 1 and Portuguese Aveiro Ore Fields (***Figs. 14a*** and ***14b***), but is substantially overlapped by the French Massif Armoricain 1 Ore Field and the fields of the other matching ores sampled in Belgium and Germany, England, Wales and Ireland. Benin/Lower Niger Group 3 is not overlapped by any of our African ore fields and is only very superficially covered by any of our other currently defined European ore fields. The Benin/Lower Niger Group 4 is partially overlapped by the Spanish Almeria, the French Massif Central 2, the Sardinian 2, the Moroccan 1 and the Massif Armoricain 1 ore fields together with the fields of the ores sampled in Belgium and Germany, England, Wales and Ireland that match the Massif Armoricain 1 Ore Field.

Turning to the objects assigned to our various groups, Benin/Lower Niger Subgroup 1A comprises:

- seventy-three samples from sixty-nine pieces from Benin from all three periods;
- twelve samples from eleven objects from the Andoni Creek site;
- six samples from the Forcados River site;
- five from three Udo pieces;
- four from the Cross River area;
- three from Owo;
- one from the smaller figure of an ostrich from Tada;
- one execution ring from an ancient Yoruba source (Ife, Owo or Ijebu);
- one unspecified Lower Niger bronze;
- one from a bracelet from "Jenne";

and a number of supposedly recent ethnographic items - eight Ashanti or Akan pieces, two from the Vere of the Mandara mountains on the NE Nigeria/ Cameroon border, one from Calabar and one from the Yoruba.

The Early Period samples in B/LN Subgroup 1A include two from Type 1 heads, two from Type 2 roll collar heads and two from early Queen Mother heads. We also have samples from three Udo pieces. These objects are modelled in a distinctive style that Fagg (1963: 38) first separated from the general corpus of Benin art. He named the style from the town of Udo, which is 20 miles west of Benin City, because three figures of European soldiers and an unusual head in this style were lent to the Benin Museum by the Iyashere of Udo on behalf of his council. Fagg did not claim they were made in Udo, but neutron activation analysis of cores remaining inside a number of Nigerian copper-alloy castings show that they were made somewhere other than in Benin City (Slater & Willett 1988). It is likely that these objects were made in Udo around the sixteenth century, the time of transition from the Early to the Middle Period in Benin art. The results from our analyses indicate that the metal used by the Udo smiths came from the same source as that used by the Benin smiths, despite the rivalry between the two kingdoms.

Benin/Lower Niger Subgroup 1B is composed of 21 analyses from 20 objects, one from Early Period Benin, five from Middle and Late Period Benin pieces; three from the Andoni Creek site; two from the Forcados River site; one from a Lower Niger bronze bell; one from a Yoruba ring of uncertain age and a number of supposedly recent ethnographic items, three from the Vere of NE Nigeria; and one from the Fon of Bénin (Dahomey), an Akan gold-weight from Ghana or the Ivory Coast and from the repair to a crocodile from a chief's costume in Owo. The range of Benin pieces indicates that this metal was in use alongside that of Subgroup 1A. Both Subgroups 1A and 1B, like the Ife Group 2, come from the NW European ore deposition belt.

Benin/Lower Niger Group 2 is composed of eight Benin pieces of the Early, Middle and Late Periods including an unusual globular head in the City Museum at Kelvingrove, one of only three objects known representing a more rustic style rather than that of the Benin court; three from the Andoni Creek site; one from the Forcados River hoard; four Lower Niger bronzes of uncertain provenance; a heavy ring with coiled ends from "Jenne"; two samples from Bwa(?) anklets; one Vere snuff-bottle and three Akan gold-weights. A long period of use is indicated.

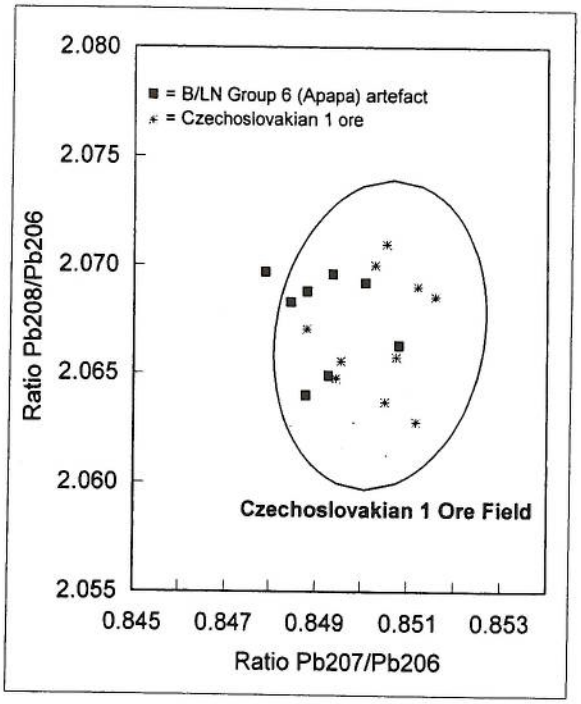

Fig. 13a. $^{208}Pb/^{206}Pb$ versus $^{207}Pb/^{206}Pb$ plot comparing the Benin/Lower Niger Artefact Group 6 Data (Apapa Hoard Group) with the Czechoslovakian 1 Ore Data and Field (data as published).

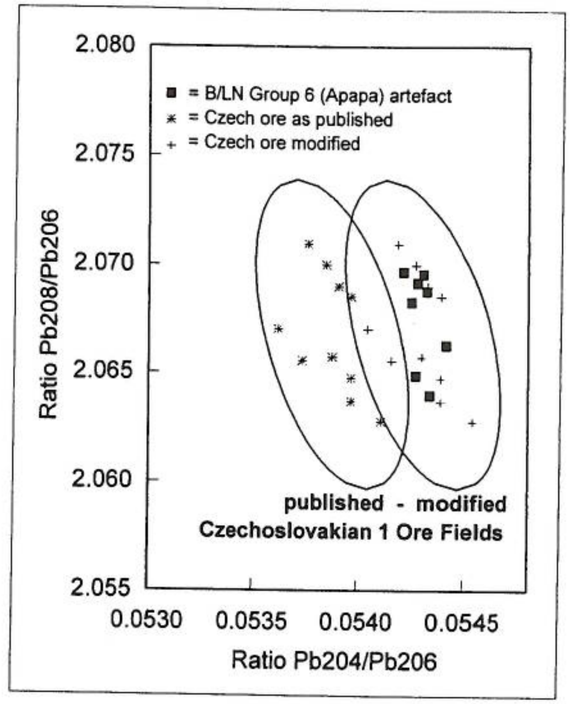

Fig. 13b. $^{208}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the Benin/Lower Niger Artefact Group 6 Data (Apapa Hoard Group) with the Czechoslovakian 1 Ore Data and Field (data both as published and modified).

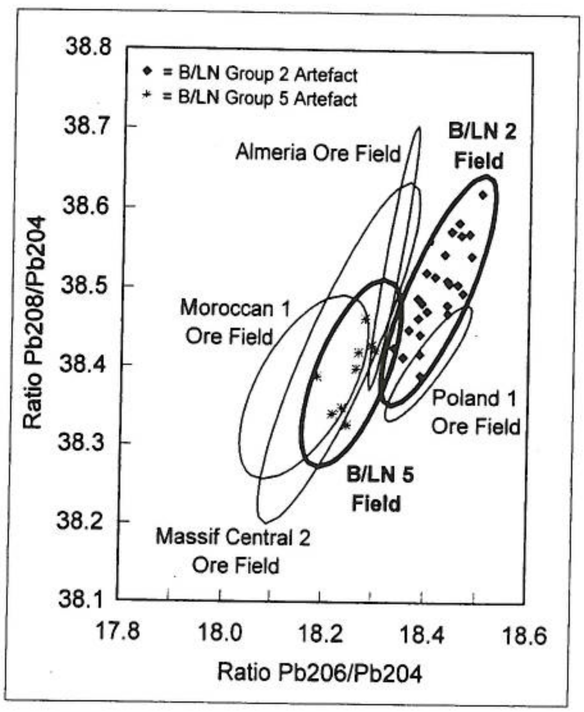

Fig. 14a. $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot comparing the partially overlapping Poland 1, Spanish Almeria, the French Massif Central 2 and the adjusted Moroccan 1 Ore Fields with the Benin/Lower Niger Artefact Group2 and 5 Data and Fields.

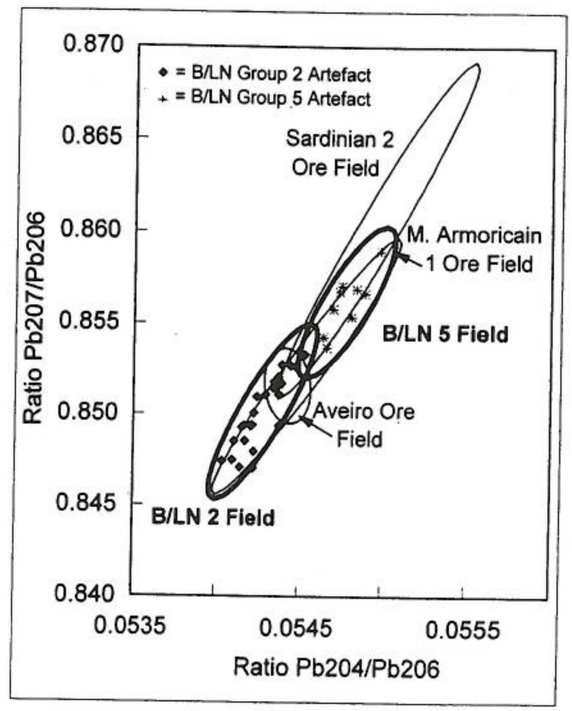

Fig. 14b. $^{207}Pb/^{206}Pb$ versus $^{204}Pb/^{206}Pb$ plot comparing the partially overlapping Sardinian 2, the French Massif Armoricain 1 and the Portuguese Aveiro Ore Fields with the Benin/Lower Niger Artefact Group2 and 5 Data and Fields.

Benin/Lower Niger Group 3 contains only six samples, one from the Forcados River, the remainder ethnographic pieces, all apparently recent, two from tobacco-pipes of the Vere of NE Nigeria and one each from the Baule in the Ivory Coast, from a manilla collected in Maiduguri in NE Nigeria and a bracelet from southern Mali. They could have been made or remade at any time, though it is remarkable that they were not mixed with other metals.

Benin/Lower Niger Group 4 also contains only six samples from five objects. The Jenne piece could be from the mid-first millennium AD onwards, two samples of the same nail from Benin are probably Middle Period, mid-sixteenth to seventeenth century, the LNBI horseman could be sixteenth century or later and the Andoni Creek hoard is undated, while the Adamawa cache-sex is ethnographic.

Benin/Lower Niger Group 5 also contains only six samples: from Benin, an Early Period head and a Late Period pendant showing a European with a horse; a manilla from the Forcados River site, and three Lower Niger bronzes of uncertain provenance. This is a group that may have been formed by mixing metals. It relates to none of our known African or European ore sources but, as ***Figure 11*** shows, it lies intermediate between Benin/Lower Niger Groups 2 and 6 and might represent mixing of these metals.

The Apapa Hoard, from which the Benin/Lower Niger Group 6 specimens were obtained, was found whilst digging a water hole in 1907 in Apapa, the port of Lagos, Nigeria. According to FAGG (1930), it was at a depth of 10 feet though this is not recorded in the British Museum's catalogue, where the hoard is numbered (1930 4-23.1 to 15). This hoard is generally known from a single piece, a ram-headed mask with an unusually wide flange, that Fagg called an aegis (FAGG 1930: 30; MACK 2000: 99, no. 23). Similar pieces with narrower flanges were already known from Benin (WILLETT 1973: Pls. 3 & 4; WILLETT 2004: T615C), and have since been found represented in terracotta in Ife (ELUYEMI 1975: 34, Fig. 4; WILLETT 2004: T615A & B). The other pieces in the hoard are still unpublished. They are very distinctive – two hollow cylinders with a wide flange part way up with jingles (called cascabels in the catalogue) attached by chains; four flat rings rather like the flanges, two edged with projections, the other two edged with circular holes but all four without surviving attachments; four slender rings, about three inches (75 mm) in diameter passing through slightly longer rods with loops cast on each end with jingles on the outer ends; two hinged bracelets in the form of a line of antelope heads; a bracelet turned back on itself at one end with the other end broken away; and some detached jingles and fragments. We know of nothing resembling these pieces in their form though the Igbo Ukwu people were fond of attaching jingles to ceremonial objects.

This group stands out from all the other Lower Niger Bronze Industries groups by having a distinctive isotopic pattern in most pieces. The eight Apapa Hoard specimens with matching isotope ratios form the Apapa Hoard Group. We list separately four other objects that match this group: the Obalufon mask from Ife, a Yoruba execution ring from late Ife, Owo or Ijebu, a ram-head hip mask typical of Early Period Benin (and thus resembling the principal item in the hoard) and a Lower Niger Janus-headed bell (a very thin casting consistent with the early Benin period). The Obalufon mask was cast in pure copper. The difficulty of casting in pure copper is so great that the technique was probably only acquired late in the Ife casting period, perhaps the fourteenth or fifteenth century.

The ring is one of a group showing a king with human sacrifices lying round him. This one has the king standing, usually taken to be diagnostic of those made in Benin but his face is striated, usually indicating Ife, and in terracotta objects, Owo. NEVADOMSKY (1989) has suggested the first half of the seventeenth century as the starting date for those in the Benin style while VOGEL (1984) derives the whole group from the pattern of motifs on ritual pottery found in Ife. There are a large number of these rings so they could cover quite a long time period. Vogel does not mention this example. The crown worn by the main figure is one that developed only after the Classical Period of Ife art and so could be contemporary with Early Period Benin, late fourteenth to mid-sixteenth century. The Apapa group would thus appear to date to the overlap of Ife and Early Period Benin. There are five Hoard objects that do not match this group, W470 and W474, that match the Ife 1 artefacts and have been mentioned with them, W476, a ring with jingles, that is very similar to the Apapa Group but sufficiently different from the group to warrant its exclusion, and W480 and W481, both discs with perforated edges, that have greatly different isotope ratios.

Initially, the Benin/Lower Niger Group 6, the Apapa Group, did not appear to match any of our

African or European ores. Upon closer evaluation it was found that there is a group of Czechoslovakian ores that match except for ratios including ^{204}Pb. This is the situation we found in the relation between some early Moroccan and Tunisian ore data and the Igbo Ukwu Groups 1 and 2. In that case a small adjustment in the ^{204}Pb concentrations in the early ore data brought them into agreement with our own data for the same ore deposits and our artefact groups. Differences between the calibrations of early and more recent isotope ratio measurement could account for the difference. The Czechoslovakian ore measurements were published by Van Breemen *et al.* (1982) which were still fairly early. If one makes the same kind of correction to the Czechoslovakian ores as we did to the Moroccan and Tunisian ores, subtracting 107 parts per million from the ^{204}Pb isotope concentrations and correcting the ratios accordingly, one finds that the modified ore data are totally in agreement with the Apapa 1 artefacts. This is shown in ***Figures 13a*** and ***13b***. We do not think this conclusively proves that the Apapa 1 objects were made from Czechoslovakian metal, but the possibility that this might be true must surely be considered. In considering the possibility that the Benin/Lower Niger Group 6 and the Apapa hoard Group specimens were made from Czechoslovakian metal, first consideration should be given to the route through which the metal might have reached Nigeria. The coincidence that two Apapa Hoard pieces, W470 and W474, have isotope ratios that match our Ife Group 1 and that the isotope ratios of the Ife Obalufon Mask, W542, match our Apapa Hoard Group, together with the similarity of the Apapa "aegis" to terracotta representations in Ife and to Early Period Benin hip masks suggests that the objects in Apapa group were cast before the Portuguese established a direct sea route to sub-Saharan Africa in the late fifteenth century. European metals for these castings would have to have been transported by ship to some site in North Africa and then carried overland to Nigeria. Herbert (1984: 114) states that "Genoa and Venice shipped large quantities (of copper) to North African ports from Ceuta to Egypt for re-export southward throughout the period from the twelfth to the sixteenth centuries." Both Genoa and Venice are situated relatively close to Bohemia (Czechoslovakia). In the fifteenth century both Bohemia and Genoa were part of the Holy Roman Empire. It would seem not unlikely that Genoa and/or Venice would have been shipping Bohemian copper to North Africa.

Owo

The Yoruba city of Owo is another centre in the Lower Niger area, lying roughly half way between the cities of Ife and Benin, William Fagg thought that it was the source of the finest ivory carvings found in Benin. Ekpo Eyo excavated terracotta sculptures there that have human heads that are almost indistinguishable in appearance from those of Ife but the details of clothing are less well executed (Eyo 1976; Eyo & Willett 1980: nos. 60-75). His excavation revealed a deposit with a radiocarbon date of the fourteenth to fifteenth century cal AD. The only copper-alloy castings we can attribute with certainty to Owo are mostly relatively poor in quality and appear to be related to late Benin works. Among the works that he attributed to Owo, Fagg distinguished what he at first called the Huntsman style (later corrected to Hunter), named after the piece that he regarded as the finest of the Lower Niger Bronzes. We were able to measure only six of our samples of works in Owo style, two heads, a bowl and two rings with scenes of execution of uncertain origin but likely to be from Owo and a repair to a crocodile pendant. The heads and the bowl are in Benin/Lower Niger Subgroup 1A, the repair to a crocodile is in Benin/Lower Niger Subgroup 1B. Since Owo was greatly influenced by Benin both culturally and artistically, this is not surprising. The other items do not match any of our groups.

Jenne

The ancient city of Jenne-jeno, three km. south of modern Jenne, in Mali, was occupied from about the third century cal BC and appears soon to have become involved in long-distance trade[8]. Its people were already iron workers but had to import the ore, the fuel and sharpening and hammering stones. Copper was imported from the middle of the first millennium cal AD from mines in the southern Sahara and tin-bronze was cast from about 850 cal AD, being replaced by brass from around the end of the millennium (McIntosh 1998: 216). Jenne-jeno was finally abandoned around 1400 cal AD after many years of decline in population. Modern Jenne may have been founded as early as 800

[8] A Han Dynasty (206 BC to 220 AD) bead of east or south-east Asian manufacture was found sealed in a second or third Century AD level (McIntosh 1998: 160).

cal AD (McIntosh 1998: 173). Both were involved in the trans-Saharan trade. We did not seek access to excavated material from Jenne-jeno but were able to obtain samples of thirteen pieces thought to originate from the Jenne area that are now in the Nesmith Collection at the Virginia Museum of Fine Art in Richmond, Virginia (Nesmith 1984). Ten of these were measured. Not only is there no archaeological context for these samples but the name of Jenne is applied to a wide area in the inland delta of the Niger.

Unfortunately we were unable to obtain a sample of the heavy ring with coiled ends in the National Museum of Ife Antiquities, the only substantial casting in tin-bronze found in Ife. It closely resembles in both form and elemental composition a similar piece which is claimed to be from Jenne (illustrated in Thompson & Vogel 1990: no. 1). This appears to be evidence of trade between the two centres and the lead isotopes might have confirmed it. The results of our examination show that the two samples from this ring have differences in their lead. W544, from the patina, matches B/LN Group 2 but a sample from the interior of the piece, W547, does not fit into any of our groups. Clearly the alloy was not homogeneous. One bracelet, VAN2826, falls into our Benin/Lower Niger Group 1a and a neck ring, VAN2828, into Benin/Lower Niger Group 4, both listed in ***Table 5***. Among the Ungrouped Artefacts listed in ***Table 6***, a piece of chain, VAN2827, matches an arm ring from the Andoni Creek, W433, but the remaining samples, VAN 2829, VAN2831, VAN2836, VAN2837 and W547 are completely individual. This is hardly surprising since all our "Jenne" pieces come from the market place whether in Mali or in the United States or in Europe.

Akan

One of the commonest forms among copper-alloy castings in West Africa is the small weight for gold dust made by the Akan-speaking peoples of southern Ghana and the adjacent Ivory Coast. Weighing a large number of them led Garrard (1972a, 1972b, 1973, 1980) to suggest that they reflected the standardised weights of successive peoples who traded with the area. The Islamic *mitkal* was used throughout the middle ages, then the Cologne standard ounce introduced by the Portuguese a little before 1500 AD, and then the troy ounce used by the Dutch and the English from about 1600 AD.

Garrard (1980) illustrates a number of Akan weights with suggested dates for the various types so it was decided to sample a number of such weights to see whether their composition might vary with suggested age. In the confident expectation that the metal would have been re-melted repeatedly and thus not reveal anything, this group was given the second lowest priority. However by administrative decision and contrary to Willett's expressed intentions a number of them were given priority over other samples and the results, though statistically inadequate, are intriguing and suggest that this work might be worth pursuing further. Eight of them fall into our B/LN Subgroup 1A, one into B/LN Subgroup 1B and three into B/LN Group 2. According to Garrard's classification four in B/LN Subgroup 1A date from 1400 to 1700 AD, three from 1700 to 1900 AD and one from the nineteenth century. The B/LN Subgroup 1B piece and the three B/LN Group 2 pieces date from 1400 to 1700 AD. It is surprising that only one of our Akan pieces does not fall into any of our groups. This suggests that the same sources of metal in the NW European deposition zone continued to be exploited widely in West Africa for half a millennium.

Ethnographic items

Copper-alloy objects from ethnographic contexts were made available by the Smithsonian's National Museum of Natural History and by the Hunterian Museum of Glasgow, Scotland. It was thought that these pieces might offer indications of whether lead isotope analysis might throw light on possible recent internal trade within West Africa. This was our lowest priority but the same administrative decision led to some of them being analysed ahead of their turn. The results of these analyses have been mentioned in describing the groups into which they fall but an overview may be taken here.

The metal that supplied the Benin and Lower Niger Bronze Industries also supplied most of these widely spread groups. The Vere, on the borders of Nigeria and Cameroon used metal of Benin/Lower Niger Subgroups 1A and 1B and Groups 2 and 3. The Bwa of Burkina Faso (or a neighbouring group) used metal of Benin/Lower Niger Subgroup 1B and Groups 2 and 3 as also did the Akan. Metal of Benin/Lower Niger Subgroup 1A turned up in Calabar in the eastern Niger delta which was itself an important trading centre while Benin was flourishing as an independent kingdom. Metal of Benin/Lower Niger Subgroup 1B was found among the Fon in Bénin (Dahomey) and among the Gwabi, a small group in Northern Nigeria. Metal of Benin/Lower Niger Group 3 was found in Maiduguri in NE Nigeria while that of Benin/Lower Niger Group 4 occurred in the Adamawa Highlands on the borders of Nigeria and Cameroon. The metal used by the Bwa, the Akan and possibly the Fon was probably traded through ports on the coast before the ships reached the Niger delta.

It is quite remarkable that so many of our relatively recent pieces could be identified as coming from the same European sources as our older material. This probably reflects a continuing importation of metals from the same geological deposits over more than half a millennium or the re-use of metal without mixing.

Conclusions

Monod (1969) showed that the copper-alloy bars from Ma'aden Ijâfen were being transported south across the Sahara long before the Europeans reached the West African coast. The trans-Saharan trade must have been enormous. Its metal clearly reached peoples all along the West African coast for they had already developed a very sophisticated taste for particular alloys that varied from place to place. This was complained about by many of the early coastal traders. The trans-Saharan trade continued into the nineteenth century, but the metals from the seaborne trade were probably cheaper and eventually dominated – though it is to be noted that Herbert (1984: 130) suggests that the Saharan trade simply could not satisfy the demand.

Some of the metal used in Igbo Ukwu could well have come from a nearby source but at present it appears that the rest came from Tunisia or Morocco by camel caravan across the Sahara Desert. Soon after, the Ife metal was being brought from even further afield, probably from France. The Ife Group 1 metal came from the Massif Central Group 4 ore deposits while the Ife Group 2 metal is likely to have come from the nearby Massif Armoricain Group 1 ore deposits. It should always be kept in mind that the Massif Armoricain Group 1 ore deposits are only a part of an extensive isotopically matching belt of ore deposition that extends from south-west Germany through Belgium into France and over into England, Wales and Ireland and one cannot be certain where along this zone of deposition the metal might have been obtained. It is primarily because France is such a probable source for Ife Group 1 metal that we believe that the French portion of this extended deposition zone is the most likely region from which the Ife 2 metal was obtained. The metal must have been shipped, perhaps via the port of Nantes (which later became the principal port for the French triangular trade with the Guinea Coast and the Americas) to the north coast of Africa for transport initially by donkeys to the edge of the desert and then transferred to camels. Monod has shown that the metal rods at Ma'aden Ijâfen were tied in semi-circular bundles weighing about 50 lbs. each, two of them making a load for one donkey. They were then tied in pairs to make cylindrical bundles of twice that weight and two of these formed the load for a single camel.

The tradition that knowledge of the art of bronze-casting was transferred from Ife to Benin leads us to expect that Benin would have had to rely, initially at least, on the same supply of metal as Ife did. Connah (1975) has shown that Benin had a supply of tin-bronze for smithing bracelets before the art of casting arrived from Ife but we were unable to obtain samples. The isotopic evidence presented here suggests that both Ife and Benin, in its early period, obtained their metal from France. Our analyses suggest that the Ife Group 1 metal and the Benin/Lower Niger Group 2 metal were both obtained from mines in the French Massif Central, although the metals for these two groups seem not to have been obtained from the same mines. Ife Group 1 relates to Massif Central Ore Group 4 and B/LN Group 2 relates to Massif Central Ore Group 3. However, the Ife Group 2 Artefact Isotope Field and the Benin/Lower Niger Group 1 Artefact Isotope Field coincide and hence the Ife 2 metal and at least some of the B/LN 1 could have come from the same mines, *i.e.* the French Massif Armoricain Group 1. France may have continued to supply metal for Benin and the Lower Niger Bronze Industries, initially by way of the trans-Saharan trade. French sources then may have continued to be used right through until the nineteenth century alongside what appears to have been a larger coastal trade perhaps from the Belgian-German Ore Group 1 mines or matching mines in the British Isles.

In discussing Benin art it has been the practice to refer to all the Europeans represented as "Portuguese" and the impression has been given that they were the dominant European nation trading in the Benin area for most of Benin's duration as an independent kingdom. In fact, the Portuguese held a monopoly only until the middle of the sixteenth century when the English moved in and, towards the end of the century, the Dutch. The French too played an important role. Our principal source of information on this trade is RYDER (1969). The French began as interlopers and pirates threatening the Portuguese monopoly as early as 1530 AD but no record has so far been found of what they traded. They frequented the Costa da Mina (now Elmina on the coast of Ghana) throughout the 1540's. This challenge faded by the 1570's. Neither the English nor the French seem to have been trading on the Benin River at the end of the late 17th Century. "At the moment there is no evidence of any French trade with Benin in the 17th Century but investigation in the French archives may well reveal a certain amount of small scale enterprise" (RYDER 1969: 128, fn. 3). Of Oghoton, the port of Benin, in the early 18th Century, Ryder writes, "French vessels rarely came here" (RYDER 1969: 176) (but those that did could have brought metal of course!). In 1757 a French squadron seized an English ship leaving the Benin River with 316 slaves.

Our information about European activities in the area of Benin in the latter part of the eighteenth century comes from the Frenchman Landolphe, a ship's captain who traded with Benin over a period of thirty years from 1769, indeed he had a French-speaking Edo (*i.e.* Benin) interpreter. At this time Nantes was "the home port of the triangular trade between France, Guinea and the French West Indies" (RYDER 1969: 199). If Nantes was the home port of the trade with Guinea it would not be surprising to find that the metal they traded came from the Massif Armoricain. Nor is the Massif Central very far away. Ryder mentions the trade goods involved in both directions, but specifically says that manillas, a regular source of copper alloys, were not involved in 1769. It is unfortunate for our purposes that all the nations involved in the trade had access to lead from the NW European zone of deposition. The wide distribution in West Africa of metal from these ore-fields suggests that this metal was being imported over a long period, probably through more than one port of entry. Trade by sea with Elmina was already established by 1439 AD (HERBERT 1984: 128).

The conclusions that can be drawn from our lead-isotope data are complicated, not only by the fact that so many sources in NW Europe were laid down during the same orogeny, but the metal was traded across Europe before being traded to Africa, the Americas and the Orient. HERBERT (1984: 130) tells us that "by 1500 Antwerp had usurped the dominance of Venice and Bruges as chief supplier to the Portuguese Crown. Until the political upheavals of the 1560s, raw copper from the mines of Thuringia, Saxony, the Tirol and Hungary and worked copper and brass from Dinant, Aachen and Nurnberg poured into the port of Antwerp." CRADDOCK & HOOK (1995: 184) tell us that in the early sixteenth century "most of the copper required by the Portuguese came from the mines of central Europe, down the Rhine and then by sea from Antwerp or other ports in the Low Countries." They also tell us "From mid-16th to mid-18th Century copper from continental Europe principally southern Germany and Sweden together with some imports from the East dominated world trade until overshadowed by the meteoric rise of the British copper industry, which by the late 18th Century supplied much of the total international market in copper. The majority came from Cornwall but Parys Mountain on Anglesey rose to prominence, peaking in the 1780's but declining in the 1790's, leaving the field open for Cornwall and West Devon to dominate the world market till the mid-19th Century when American and other ores took over" (CRADDOCK & HOOK 1995: 185). It follows that even if a specific source of the metal were identified, we could not safely conclude that the metal had been brought to West Africa by nationals of that mining area, nor even their neighbours. Moreover in the fifteenth and sixteenth centuries the Portuguese imported copper from Morocco for re-export in the coastal trade (GODINHO 1969: 374)[9].

Perhaps the most surprising feature of our results is the relative lack of evidence of the mixing of metals over the centuries. We have identified a few, relatively small, groups as possibly having been formed by mixing of metals and some of the Ungrouped Artefacts listed in ***Table 6*** might well have contained mixed metals. However, together these form only a small fraction of our analysed artefacts. Nowadays metals are frequently mixed in West Africa but it may be that such mixing is a recent phenomenon encouraged by the shortage of imported metal occasioned by the two World Wars of the twentieth century. It may be, of course, that most of the mixing in the past was of metal from the same source but if this is so it too is quite remarkable.

[9] We are grateful to Professor Alan Ryder for this reference.

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Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Ores of Nigeria			
BNIG2701	**NMS**	Zurak, Pankshin, Plateau Prov.	2.1292	0.86451	0.055316
BNIG2702	**NMS**	Zurak, Pankshin, Plateau Prov.	2.1292	0.86470	0.055269
RS-18	**StAUM**	Ririwai Lode, Ririwai Complex	2.1491	0.86387	0.055190
RS-13	**NHML** 1937,1606	Liruein Kano, Kano Prov.	2.1344	0.85445	0.054790
		Ores of Morocco			
RS-06	**NHML** 29930	Bou Becker Mine, Zellidja	2.1079	0.85860	0.054904
RS-07	**NHML** 29932	Haut Guir	2.1104	0.85849	0.054928
RS-09	**NHML** 29930	Bou Becker Mine, Zellidja	2.0997	0.85149	0.054439
RS-11	**NHML** 36578	Taouz	2.1059	0.85921	0.055097
RS-14	**NHML** 35681	Mibladen Mine	2.0991	0.85247	0.054509
RS-15	**NHML** 1987,306	High Atlas, Marrakesh	2.0687	0.85391	0.054840
		Ore of Algeria			
RS-10	**HNML** 34013	Mine near Tenez	2.1019	0.85550	0.054629
		Ores of Tunisia			
RS-01	**NHML** 1925,549	Sidi-Amor-ben-Salem	2.0716	0.83599	0.053367
RS-02	**NHML** 1925,698	Kef Lasfar	2.0674	0.83284	0.053150
RS-04	**NHML** 1925,699	Argoub-el-Amor	2.0587	0.83059	0.052990
RS-08	**NHML** 1925,697	Sidi-Amor-ben-Salem	2.0725	0.83632	0.053385
		Ores of the Congo Basin			
RS-03	**NHML** 33972	Kipushi Mine, Katanga	2.0876	0.86688	0.055484
RS-12	**NHML** 1965,153	Kipushi Mine, Katanga	2.0848	0.86594	0.055426
RS-05	**NHML** 1980,666	Shinkolobwe Mine, Likasi, Shaba	2.0857	0.84423	0.053843
		Ores of Namibia			
RS-16	**NMNH** 108704	Karawatu	2.1135	0.86472	0.055132
RS-17	**NMNH** 108722	Tsumeb Level 16	2.1094	0.86358	0.055034
RS-19	**HMAG** M12786	Tsumeb, Grootfontein	2.2338	0.96181	0.061594

* Source identification symbols are:

HMAG = Hunterian Museum and Art Gallery, The University of Glasgow, Glasgow, Scotland.
NMNH = National Museum of Natural History, Smithsonian Institution, Washington DC, USA.
NHML = Natural History Museum, London, England.
NMS = National Museums of Scotland, Edinburgh, Scotland.
StAUM = St. Andrews University Museum.

Note: With four exceptions all of the above ores were described as Galena or Galena with other lead or copper ores. The exceptions are RS-06, Ore, gangue, AMR host rock; RS-09, Gangue in AMR host rock; RS-16, Lead ore Wulfenite; and, RS-17 Lead ore.

Tab. 1. Unpublished stable lead isotope ratios for African ore samples.

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Igbo Ukwu Group 1 Specimens			
BIAF0019	F6 **BM** 1956Af15.6	Igbo Isaiah - Copper bracelet	2.1247	0.86310	0.055383
BIAF0020	F4 **BM** 1956Af215.3	Igbo Isaiah - Vessel	2.1281	0.86380	0.055439
BIAF0022	F2 **BM** 1956Af25.5	Igbo Isaiah - Scabbard support	2.1225	0.86110	0.055102
BIAF0023	F1 **BM** 1956Af15.6	Igbo Isaiah - Twisted bracelet	2.1282	0.86440	0.055322
BIAF3910	F16 **NML** 39.1.10	Igbo Isaiah - Conch shell	2.1307	0.86510	0.055525
BIAF3922	F9 **NML** 39.1.22	Igbo Isaiah - Animal head	2.1210	0.86170	0.055246
BIAF3923	F10 **NML** 39.1.23	Igbo Isaiah - Double egg pendant	2.1166	0.86050	0.055206
BIAF399	F7 **NML** 39.1.9	Conch shell (handle)	2.1267	0.86340	0.055340
BIAFIJ5	F11 **UI** 572	Igbo Jonah - Copper rod	2.1328	0.86760	0.055586
BIAFIJ6	F8 **UI** 626a	Igbo Jonah - Copper rod	2.1347	0.86610	0.055485
BIAN1194	**TS** 136a	Igbo Isaiah - Fragment	2.1256	0.86250	0.055398
BIAN1195	**TS** 136b	Igbo Isaiah - Fragment	2.1133	0.85677	0.055012
BIAN1196	**TS** 347y	Igbo Isaiah - Bowl, repair	2.1190	0.85821	0.055041
BIAN1197	**TS** 421c	Igbo Isaiah - Thick wire	2.1215	0.86087	0.055272
BIAN1201	**TS NML** 39.1.18	Igbo Isaiah - Staff ornament	2.1200	0.86016	0.055195
BIAN1206	**TS** 590	Igbo Jonah - Staff ornament	2.1266	0.86332	0.055492
BIAN1207	**TS** 626a	Igbo Jonah - Bar	2.1227	0.85982	0.055075
		Igbo Ukwu Group 2 Specimens			
BIAF0021	F3 **BM** 1956Af15.4	Igbo Isaiah - Manilla	2.0654	0.83610	0.053333
BIAF393	F13 **NML** 39.1.3	Igbo Isaiah - Bowl	2.0604	0.83320	0.053107
BIAF645	F12 **UI** 64.235/15	Igbo Jonah - Manilla	2.0692	0.83760	0.053359
BIAFIJ2	F15 **UI** Ij212	Igbo Jonah - Staff handle	2.0756	0.84050	0.053619
BIAN1198	**TS NML** 39.1.2(1)	Igbo Isaiah - Large bowl	2.0669	0.83243	0.053170
BIAN1199	**TS NML** 39.1.4	Igbo Isaiah - Small bowl	2.0651	0.83394	0.053157
BIAN1200	**TS NML** 39.1.13	Igbo Isaiah - Small snail shell	2.0795	0.84119	0.053742
BIAN1203	**TS NML** 54.4.24	Igbo Isaiah - "Knot" manilla	2.0708	0.83544	0.053283
BIAN1204	**TS NML** 58.6.10	Igbo Isaiah - "Knot" manilla	2.0740	0.83958	0.053678
BIAN1205	**TS** 196	Igbo Isaiah - Fragment of vessel	2.0707	0.83624	0.053444
		Igbo Ukwu Intermediate Specimens (Probable mixtures of Igbo Ukwu Groups 1 and 2 metals)			
BIAF018	F5 **BM** 1956Af15.2	Igbo Isaiah - Ram's head	2.0981	0.84960	0.054374
BIAF5812	F14 **NML** 58.6.12	Igbo Isaiah - Bird's Head	2.1005	0.85220	0.054552
BIAN1202	**TS NML** 39.1.35	Igbo Isaiah - Twisted manilla	2.0850	0.84697	0.054335

* Source identification symbols are:

BM = British Museum, London, England.
F = Artefact specimens analysed by Farquhar and reported in Table 2 of CRADDOCK *et al.* (1997). The source numbers are the Sample Nos. in that table. The specimens with an additional (Af) number were previously reported with slightly different isotope ratio values in CHIKWENDU *et al.* (1989), The isotope ratios listed in this table are the 1997 values published in 1997. The isotope ratios listed in our 1995 Interim Report are the values published in 1989.
NML = National Museum of Nigeria, Lagos, Nigeria.
TS = Artefact specimens supplied by Thurstan Shaw and analysed by Joel at NIST. The identification numbers are those used by SHAW 1970 in which photographs and elemental analyses of the objects will be found.
UI = University of Ibadan.

Tab. 2. Stable lead isotope ratios for Igbo Ukwu artefacts.

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Marandet (Niger) Group 1 Specimens			
BMAR2685	**FW** Crucible 1	Chip from bottom of crucible	2.0529	0.82901	0.052821
BMAR2686	**FW** Crucible 1	Grinding from inner surface	2.0536	0.82986	0.052780
BMAR2687	**FW** Crucible 2	Chip of green deposit on edge	2.0545	0.82888	0.052658
BMAR2688	**FW** Crucible 3	Corrosion residue	2.0574	0.83151	0.052830
BMAR2689	**FW** Crucible 4	Chip from deep inside	2.0542	0.82970	0.052820
BMAR2690	**FW** Crucible 3	Corrosion residue	2.0592	0.83156	0.052925
BMAR2691	**FW** Slag		2.0587	0.83101	0.052690
		Marandet (Niger) Group 2 Specimens			
BMAR2590	**DK** Bar A	Fragment of an ingot	2.0905	0.84937	0.054382
BMAR2591	**DK** Bar B	Fragment of an ingot	2.0925	0.85027	0.054521
BMAR2592	**DK** Bar C	Fragment of an ingot	2.1039	0.85580	0.054702
BMAR2642	**FW** M-6	Fragment of an ingot	2.1006	0.85536	0.054810
		Ma'aden Ijâfen (Mauritania) Group Specimens			
BMAN2621	**FW** Bar 18	Fragment of an ingot	2.0925	0.85704	0.054913
BMAN2622	**FW** Bar 10	Fragment of an ingot	2.0954	0.85764	0.054929

* Source identification symbols are:

DK = Sample submitted by David Killick, the University of Arizona. Analysed by Joel.
FW = Sample submitted by Frank Willett. Analysed by Joel.
All samples from both sites are by courtesy of the Institut Fondamental d'Afrique Noire, Dakar, Senegal.

Tab. 3. Stable lead isotope ratios for metal-working specimens from the Institut Fondamental d'Afrique Noire, Dakar, Senegal.

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Ife Group 1 Specimens			
BFAN2521	**NMIA** Head 1	Wunmonije Compound	2.0883	0.84632	0.054094
BFAN2523	**NMIA** Head 8	Wunmonije Compound	2.0821	0.84206	0.053874
BFAN2524	**NMIA** Head 9	Wunmonije Compound	2.0834	0.84416	0.054061
BFAN2526	**NMIA** Head 20	Wunmonije Compound	2.0907	0.84732	0.054246
BFAN2609	**NMIA** Head 12	Wunmonije Compound	2.0924	0.84872	0.054190
BFAN2611	**NMIA** Head 19	Wunmonije Compound	2.0878	0.84406	0.053893
BFAN2612	**NMIA** Head 9	Wunmonije Compound	2.0830	0.84314	0.053970
BFAN2613	**NMIA** Head 15	Wunmonije Compound	2.0872	0.84429	0.054044
BFAN2615	**NMIA** 57.1.1	Ita Yemoo - The Royal Pair	2.0791	0.83976	0.053543
BFAN2620	**NMIA** Head 1	Wunmonije Compound	2.0897	0.84566	0.054074
BFAN2692	**NMIA** 57.1.2	Ita Yemoo - Longer staff	2.0938	0.84881	0.054171
BFAN2693	**NMIA** 57.1.5	Ita Yemoo - Smaller mace head	2.0743	0.83784	0.053605
BFAN2696	**NMIA** Head 8	Wunmonije Compound	2.0845	0.84198	0.053948
W237	**NML** 79-R-12	Ita Yemoo - Figure of an Ooni	2.0889	0.84651	0.054115
W285	**NML** Head 14	Wunmonije Compound	2.0884	0.84589	0.054089
		Other artefacts matching Ife 1			
BFAN2527	**NMIA** Head 16	Copy of the "Olokun" head	2.0904	0.84730	0.054175
BBAN2630	**Kgr** A7917	Benin - Globular head type 1	2.0920	0.84677	0.054262
VMFA2833	**VMFA** 92.183	Mali/Jenne - Chain	2.0789	0.84069	0.053605
W470	**BM** 1930 (Af 4-23-15)	Apapa hoard - Rod supporting a jingle	2.0849	0.84568	0.054108
W474	**BM** 1930 (Af 4-23-4)	Apapa hoard - Bracelet with antelope heads	2.0875	0.84637	0.054025
		Ife Group 2 Specimens			
BFAN2522-	**NMIA** 323A	Bracelet, Ife, unlocalised	2.0912	0.85300	0.054624
BFAN2525	**NMIA** Head 2	Wunmonije Compound	2.0942	0.85090	0.054504
BFAN2530	**NMIA** Head 4	Wunmonije Compound	2.0968	0.85337	0.054587
BFAN2533	**NMIA** Head 10	Wunmonije Compound	2.0818	0.84760	0.054222
BFAN2534	**NMIA** Head 10	Wunmonije Compound	2.0810	0.84725	0.054204
BFAN2610	**NMIA** Head 11	Wunmonije Compound	2.0961	0.85441	0.054555
W538	**PC**	Late Figure of an Ooni	2.0994	0.85511	0.054750
W539	**NMIA** Head 11	Wunmonije Compound	2.0815	0.84636	0.054124
W541	**NML** 79-R-20	Tada - The Tada Warrior	2.0847	0.85118	0.054472
W543	**NML**	Tada - Large ostrich	2.0841	0.85123	0.054481
		Other Ife Artefacts			
W540	**NMIA** Head 17	The Obalufon Mask	2.0641	0.84820	0.054301
W542	**NML** 79-R-18	Tada -The Seated Figure of Tada	2.0564	0.84240	0.053772

* Source identification symbols are:

Kgr = City Museum and Art gallery, Kelvingrove, Glasgow, Scotland.
NMAA = National Museum of African Art, Smithsonian Institution, Washington, DC, USA.
NMIA = National Museum of Ife Antiquities, Ife, Nigeria.
NML = National Museum of Nigeria, Lagos, Nigeria.
NMNH =National Museum of Natural History, Smithsonian Institution, Washington, DC, USA.
PC = Private Collection
VMFA = Virginia Museum of Fine Arts, Richmond, Virginia, USA.

Tab. 4. Stable lead isotope ratios for Ife and related artefacts.

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Benin/Lower Niger Group 1 Specimens Subgroup 1A			
AFAW2762	**NMAA** 85-19-7	Benin - Type 5 head	2.0831	0.84882	0.054321
AFAN2763	**NMAA** 85-19-21	Benin - Warrior - altar group	2.0825	0.84973	0.054481
AFAN2764	**NMAA** 85-19-11	Benin - Cylindrical object	2.0817	0.84842	0.054345
AFAN2765	**NMAA** 85-19-14	Benin - Vessel	2.0813	0.84784	0.054233
AFAN2766	**NMAA** 85-19-15	Benin - Musketeer	2.0834	0.84896	0.054354
AFAN2767	**NMAA** 85-19-12	Benin - Late king figure	2.0806	0.84834	0.054383
AFAN2768	**NMAA** 85-19-16	Benin - Type 3 head	2.0847	0.85036	0.054493
BNAN1115	**FGA** P83152.1	Cross River - Menil Collection	2.0893	0.85027	0.054385
BNAN1116	**FGA** P83152.2	Cross River - Menil Collection	2.0888	0.84974	0.054345
BNAN1117	**FGA** P83152.3	Cross River - Menil Collection	2.0865	0.84957	0.054383
BNAN1118	**FGA** P83152.4	Cross River - Menil Collection	2.0819	0.84683	0.054231
BBAN1171	**TS NMBC** 38	Benin - Plaque, Portuguese trader	2.0857	0.84975	0.054377
BBAN1172	**TS NMBC** 32	Benin - Plaque, Ehioba & Inene	2.0865	0.84949	0.054403
BBAN1173	**TS NMBC** 45	Benin - Plaque, horse's head	2.0869	0.84949	0.054389
BBAN1174	**TS NMBC** 46	Benin - Plaque, catfish	2.0877	0.84953	0.054418
BBAN1175	**TS NMBC** 286	Benin - Snake's head	2.0865	0.84946	0.054312
BBAN1177	**TS NMBC** 18	Benin - Naked man figure	2.0872	0.84915	0.054391
BUAN1178	**TS NMBC** 21	Benin - Portuguese soldier	2.0873	0.84936	0.054378
BBAN1180	**TS NMBC** ExcNo.107/8	Benin - Ogba Road - Armlet	2.0823	0.84863	0.054383
BBAN1183	**TS NMBC** 145	Benin - Plaque, fish or snake	2.0863	0.84924	0.054349
BTAN1209	**TS NML** T/2	LNBI - Tada, Smaller ostrich	2.0856	0.84957	0.054383
BBAN2320	**NMAA** 85-19-15	Benin - Edo musketeer	2.0887	0.84955	0.054307
BBAN2528	**NMS** 1898-276	Benin - Type 2 roll collar head	2.0852	0.84911	0.054413
BUAN2529	**NMS** 1903-334	Udo - Head	2.0861	0.84909	0.054380
BUAN2531	**NMS** 1903-334	Udo - Head	2.0849	0.84888	0.054434
BUAN2532	**NML** 53.8.1	Udo - Figure	2.0853	0.84910	0.054386
BBAN2614	**NML** 79.R.17	Benin - Early queen mother head	2.0883	0.85032	0.054458
BBAN2616	**NML** 52.13.1	Benin - Leopard	2.0843	0.84816	0.054359
BUAN2617	**NMS** 1903-334	Udo - Head	2.0863	0.84919	0.054369
BEAN2618	**FMC** 89754	Modern bell (Dark 198)	2.0906	0.85204	0.054574
BBAN2619	**NML** 53.22.11	Benin - Stool	2.0892	0.85045	0.054473
BBAN2623	**Kgr** '98-193b	Benin - Type 5 head	2.0881	0.84939	0.054302
BBAN2632	**LM** 7.10.1897.4	Benin - Loop-handled Oba figure	2.0841	0.84765	0.054240
BBAN2706	**Berlin** III C 27506	Benin - Plaque. Lu. Abb. 156	2.0858	0.84824	0.054221
MER01	**LM** 7.10.1897.3	Benin - Loop-handled king figure	2.0826	0.84742	0.054241
MER02	**LM** 30.5.1889.1	Benin - "Messenger" figure	2.0853	0.84886	0.054346
MER03	**LM** 24.4.1899.20	Benin - Type 1 head	2.0847	0.84898	0.054364
MER04	**LM** 21.12.1897.4	Benin - Musketeer	2.0848	0.84888	0.054371
MER05	**LM** 11.10.1898.7	Benin - Type 4 flanged head	2.0816	0.84727	0.054237
MER06	**LM** 1978.2262	Benin - Horseman figure	2.0871	0.85065	0.054423
MER07	**LM** 21.12.97.3A	Benin - Leopard	2.0861	0.84944	0.054398
MER08	**LM** 24.4.99.24	Benin - Feline skull	2.0860	0.84946	0.054397
MER09	**LM** 27.11.19.08	Benin - Early Queen Mother head	2.0877	0.85031	0.054432
MER10	**LM** 24.4.99.21	Benin - Type 4 flanged head	2.0905	0.85124	0.054474
MER12	**LM** 26.4.98.2?3?	Benin - Box in form of house	2.0884	0.85164	0.054554
Rb-1	**NMAA** 82-5-2	Benin - Type 1 head	2.0879	0.85207	0.054511
VAN2826	**VMFA** 92.21	Mali/Jenne - Bracelet	2.0885	0.85048	0.054363
W077	**FMC** 89784	Benin - Pendant plaque (Dark 289)	2.0851	0.85021	0.054457
W083	**FMC** 210371	Benin - Pendant plaque (Dark 292)	2.0870	0.84985	0.054283
W109	**FMC** 89796	Benin - Face mask (Dark 237)	2.0880	0.84978	0.054307
W110	**FMC** 210346	Benin - Face mask (Dark 240)	2.0892	0.85122	0.054484
W111	**FMC** 89294	Benin - Face mask (Dark 235)	2.0845	0.84754	0.054189
W139	**FMC** 8258	Benin - Plaque (Dark 250)	2.0833	0.84882	0.054416
W152	**FMC** 89777	Benin - Pendent plaque (Dark 286)	2.0874	0.85065	0.054374
W157	**FMC** 210369	Benin - Pendent plaque (Dark 283)	2.0874	0.84985	0.054333
W207	**FMC** 210870	Benin - Pendent plaque (Dark 290)	2.0851	0.85026	0.054434
W241	**NML** 52.13.2	Benin - Leopard	2.0821	0.84881	0.054398
W245	**NML** 48.36.40	Benin - Plaque, sprue of repair	2.0856	0.84949	0.054419
W246	**NML** 48.36.40	Benin - Plaque, main Casting	2.0863	0.84944	0.054390
W247	**NML** 54.15.8	Benin - "Messenger" figure	2.0867	0.84993	0.054369
W254	**NMS** 1898.391	Benin - Type 5 head	2.0817	0.84818	0.054298

Tab. 5 *(continued on next pages)*. Stable lead isotope ratios for Benin/Lower Niger artefacts.
* Source identification symbols: *see end of table, p. 89.*

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Benin/Lower Niger Group 1 Specimens Subgroup 1A *(continued)*			
W255	**NMS** 1898.380	Benin - Altar piece	2.0823	0.84885	0.054416
W330	**FMC** 210361	Benin - Plaque (Dark 266)	2.0855	0.84905	0.054367
W331	**FMC** 210363	Benin - Plaque (Dark 268)	2.0846	0.84933	0.054371
W332	**FMC** 89770	Benin - Plaque (Dark 271)	2.0840	0.84991	0.054457
W334	**FMC** 210365	Benin - Plaque (Dark 275)	2.0868	0.85026	0.054407
W336	**FMC** 89790	Benin - Leopard - altar group (Dark 100)	2.0865	0.85015	0.054440
W337	**FMC** 210293	Benin - Human - altar group (Dark 95)	2.0865	0.84982	0.054419
W374	**NMAA** 85-19-22	Benin - Bell	2.0835	0.84839	0.054253
W383	**NMNH** 423531	Calabar - Waist jingles	2.0909	0.85118	0.054450
W386	**NMNH** 423471	Vere(?) - Cuff	2.0860	0.84821	0.054302
W392	**NMNH** 423534	Vere or Tiv - Tobacco pipe	2.0903	0.85172	0.054505
W398	**NMNH** 665074	Benin - Late king figure	2.0890	0.85208	0.054584
W399	**NMNH** 79290	Benin - Plaque	2.0873	0.85017	0.054436
W400	**NMNH** 79289	Benin - Plaque	2.0834	0.84932	0.054428
W401	**NMNH** 79231	Benin - Plaque	2.0839	0.84870	0.054292
W402	**NMNH** 79231	Benin - Plaque	2.0826	0.84846	0.054318
W403	**NMNH** 79288	Benin - Plaque	2.0836	0.84928	0.054451
W404	**NMNH** 79288	Benin - Plaque	2.0885	0.85002	0.054312
W405	**NMAA** 79286	Benin - Plaque - Court attendant	2.0838	0.84949	0.054416
W409	**NMAA** 665072	Benin - Late queen mother head	2.0833	0.84900	0.054404
W410	**NMAA** 665072	Benin - Late queen mother head	2.0828	0.84904	0.054386
W411	**NMNH** 79283	Benin - Type 4 head	2.0898	0.85188	0.054597
W413	**BM** 1954 Af 23.1514	Owo - Memorial head	2.0838	0.84955	0.054331
W421	**BM** 1983 Af 2.2	Owo - Bowl on a human head	2.0854	0.84934	0.054364
W426	**BM** 1905 4-13.58	Andoni Creek - Sword	2.0896	0.85096	0.054433
W427	**BM** 1905 4-13.59	Andoni Creek - Sword	2.0886	0.85145	0.054498
W429	**BM** 1905 4-13.49	Andoni Creek - Rod	2.0842	0.84752	0.054267
W431	**BM** 1905 4-13.48	Andoni Creek - Rod	2.0852	0.84812	0.054306
W432	**BM** 1905 4-13.47	Andoni Creek - Rod	2.0904	0.85163	0.054471
W435	**BM** 1905 4-13.8	Andoni Creek - King manilla	2.0872	0.85025	0.054425
W436	**BM** 1905 4-13.8	Andoni Creek - Patina from W435	2.0894	0.85071	0.054415
W442	**BM** 1905 4-13.64	Andoni Creek - Horn	2.0875	0.85066	0.054383
W443	**BM** 1905 4-13.3	Andoni Creek - Anklet/bracelet	2.0885	0.85108	0.054410
W446	**BM** 1964 Af 3.1	Benin - Body segment of snake	2.0847	0.84948	0.054437
W447	**BM** 1905 4-13.62	Andoni Creek - Leopard skull	2.0874	0.84885	0.054285
W448	**BM** Not numbered	Andoni Creek - Leopard skull fragment	2.0852	0.84954	0.054401
W452	**BM** 1952 Af 30.1	Udo - Head	2.0830	0.84872	0.054333
W454	**BM** 1954 Af 2.1	LNBI - Bell with rams' heads	2.0870	0.85017	0.054377
W456	**BM** 1909.8-11.14	Forcados River - Manilla	2.0847	0.84919	0.054327
W457	**BM** 1909.8-11.13	Forcados River - Manilla	2.0840	0.84932	0.054327
W458	**BM** 1909.8-11.16	Forcados River - Spiral manilla	2.0858	0.85009	0.054336
W459	**BM** 1909.8-11.2	Forcados River - Bell with antelope head	2.0896	0.85067	0.054421
W462	**BM** 1909.8-11.8	Forcados River - Face bell	2.0866	0.85140	0.054490
W465	**BM** 1909.8-11.1	Forcados River - Sword	2.0836	0.85022	0.054490
W486	**HMAG** 112816	Ashanti - Box for gold dust	2.0826	0.84910	0.054383
W488	**HMAG** 112820	Ashanti - Small geometric weight	2.0868	0.85060	0.054451
W490	**HMAG** 112821	Ashanti - Goldweight War horn	2.0858	0.84973	0.054360
W494	**HMAG** 112818	Ashanti - Goldweight Shield	2.0850	0.84912	0.054309
W506	**HMAG** E 1987-1	Yoruba - Edan ogboni	2.0911	0.85228	0.054526
W507	**HMAG** E 1931.7/74	Akan - Goldweight Class 1	2.0862	0.84945	0.054357
W508	**HMAG** E 1931.7/75	Akan - Goldweight Class 1	2.0837	0.84947	0.054410
W509	**HMAG** E 1977.6/19	Akan - Goldweight Class 2	2.0874	0.85024	0.054342
W514	**HMAG** E 1977.6/35	Akan - Goldweight Class 5	2.0861	0.84977	0.054304
W546	**BM** 1905 4-13.63	Andoni Creeks - Bell	2.0859	0.84880	0.054259
W558	**MMA** 1978.412.324	Benin - Type 2 roll collar head	2.0837	0.84939	0.054398
W559	**MMA** 1991.17.9	Benin - Unusual Type 1 head	2.0877	0.85092	0.054463
W564	**FMLA** X 65-9130	Owo - Head	2.0864	0.84962	0.054348
W565	**MMA** 1976.239	Yoruba - Ring	2.0842	0.85002	0.054460

(continued)

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Benin/Lower Niger Group 1 Specimens Subgroup 1B			
BFAN2770	**NMAA** 89-17-2	Yoruba - Execution ring	2.0892	0.85298	0.054622
MER11	**LM** 24.4.99.23	Benin - Fragment, Late queen mother head	2.0922	0.85309	0.054614
W343	**Kgr** 1914-17	Owo - Crocodile, repair	2.0965	0.85266	0.053948
W375	**NMAA** 85-19-5	Benin - Hip mask with fishes	2.0896	0.85286	0.054603
W376	**NMAA** 85-19-5	Benin - Hip mask with fishes	2.0879	0.85269	0.054681
W385	**NMNH** 423470	Vere(?) - Cuff	2.0965	0.85499	0.054687
W379	**NMNH** 349057	Gwabi - Manilla	2.1018	0.85775	0.054825
W387	**NMNH** 423510	LNBI - Bell	2.0971	0.85653	0.054808
W390	**NMNH** 414907 B	Vere - String of beads	2.0936	0.85298	0.054568
W391	**NMNH** 414907 A	Vere - String of beads	2.0951	0.85486	0.054727
W396	**NMNH** 402858	Benin - Type 3 head	2.0881	0.85238	0.054621
W412	**NMNH** 79 283	Benin - Type 4 head	2.0926	0.85259	0.054561
W430	**BM** 1905 4-13.46	Andoni Creek - Rod	2.0929	0.85210	0.054498
W434	**BM** 1905.4-13.10	Andoni Creek - Arm ring	2.0932	0.85612	0.054798
W437	**BM** 1905.4-13.4	Andoni Creek - Twisted manilla	2.0952	0.85480	0.054747
W464	**BM** 1909.8-11.6	Forcados River - Bell fragment	2.0914	0.85407	0.054672
W467	**BM** 1909.8-11.10	Forcados River - Bracelet	2.0908	0.85325	0.054668
W499	**HMAG** E 1987.22	Dahomey - Fon figure	2.0995	0.85744	0.054858
W502	**HMAG** E 1990.16/1	S.Mali - Small bracelet	2.0952	0.85557	0.054792
W513	**HMAG** E 1931.7/95	Akan - Goldweight Class 4	2.0900	0.85329	0.054648
W557	**MMA** 1979.206.86	Benin - Type 2 roll collar Head	2.0844	0.85114	0.054549
		Benin/Lower Niger Group 2 Specimens			
BBAN1192	**TS CUMAA** 1902.447	Benin - Repair on mudfish plaque	2.0851	0.84749	0.054099
BBAN2319	**NMAA** 85-19-12	Benin - Late King figure	2.0910	0.84937	0.054210
BLAN2625	**FMC** 89798	LNBI - Shield plaque (Dark 298)	2.0954	0.85331	0.054532
BBAN2697	**Kgr** A7917	Benin - Globular type 1 head	2.0937	0.85181	0.054352
W151	**FMC** 89776	Benin - Pendent plaque (Dark 285)	2.0909	0.85098	0.054248
W153	**FMC** 89775	Benin - Pendent plaque (Dark 284)	2.0908	0.85147	0.054345
W250	**NMS** A.1985.631	Benin - "Messenger" figure	2.0885	0.85007	0.054230
W382	**NMNH** 423514	Vere - Snuff bottle	2.0868	0.84795	0.054230
W415	**BM** 97.12-17.3	Benin - Type 1 head	2.0877	0.85109	0.054380
W439	**BM** 1905.4-13.7	Andoni Creek - King manilla	2.0926	0.85264	0.054478
W440	**BM** 1905.4-13.11	Andoni Creek - Coiled bracelet	2.0861	0.84853	0.054175
W444	**BM** 1905.4-13.2	Andoni Creek - Anklet/bracelet	2.0892	0.85166	0.054383
W455	**BM** 1949 Af 41.1	LNBI - Equestrian pendant	2.0870	0.84852	0.054110
W460	**BM** 1909.8-11.2	Forcados River - Bell w/antelope head	2.0870	0.84742	0.054039
W504	**HMAG** E 1990-15-1	S. Mali(?) / Bwa(?) - Anklet A	2.0922	0.85171	0.054394
W505	**HMAG** E 1990-15-2	S. Mali(?) / Bwa(?) - Anklet B	2.0937	0.85273	0.054398
W510	**HMAG** E 1931.7/4	Akan - Goldweight Class 2	2.0879	0.84941	0.054221
W511	**HMAG** E 1931.7/46	Akan - Goldweight Class 2	2.0914	0.85109	0.054301
W512	**HMAG** E 1932.10/9(?)	Akan - Goldweight Class 4	2.0924	0.85205	0.054374
W535	**BM** 1963 Af 9.1	LNBI - Head ex-Fuller Collection	2.0900	0.84938	0.054168
W537	**BM** 1965 Af 1.1	LNBI - Pendant w/mudfish-legged female figs.	2.0934	0.85270	0.054448
W544	**PC**	Jenne - Heavy Neck ring w/coiled ends	2.0843	0.84708	0.054145
W545	**BM** 1949 Af 46.156	Benin - Hornblower	2.0887	0.84928	0.054156
		Benin/Lower Niger Group 3 Specimens			
W380	**NMNH** 423519	Maiduguri, NE Nigeria - Manilla	2.1093	0.86697	0.055662
W466	**BM** 1909.8-11.12	Forcados River - Bracelet	2.1020	0.86313	0.055389
W484	**HMAG** 112827	Baule, Ivory Coast - Goli masquerade group	2.1026	0.86303	0.055285
W500	**HMAG** E 1990.10.1	Vere - Tobacco pipe	2.1104	0.86997	0.055785
W501	**HMAG** E 1990.10.2	Vere - Tobacco pipe	2.1040	0.86468	0.055426
W503	**HMAG** E 1990.16.2	S. Mali - Bracelet	2.1110	0.86771	0.055678
		Benin/Lower Niger Group 4 Specimens			
VAN2828	**VMFA** 92.14-1b	Mali/Jenne - neckring	2.1025	0.85706	0.054754
W393	**NMNH** 423484	Adamawa, NE Nigeria - Cache-sexe	2.1046	0.85665	0.054893
W406	**NMNH** 79286	Benin - Nail in plaque	2.1107	0.85895	0.054984
W407	**NMNH** 79286	Benin - Nail in plaque	2.1030	0.85689	0.054840
W441	**BM** 1905.4-13.9	Andoni Creek - Coiled bracelet	2.1006	0.85368	0.054663
W453	**BM** 1972 Af 2.1	LNBI - Horseman	2.0995	0.85426	0.054642

(continued)

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
		Benin/Lower Niger Group 5 Specimens			
AFAN2769	**NMAA** 85-19-9	Benin - Pendant of a European	2.0770	0.84668	0.054251
W238	**NML** 54.15.7	Benin - Type 1 head	2.0767	0.84787	0.054148
W341	**PC** (Ex-Pitt-Rivers Coll.)	LNBI - Head with "bulgy eyes"	2.0751	0.84878	0.054159
W449	**BM** 1954 Af 23.788	LNBI - Pendent plaque of woman	2.0781	0.84972	0.054259
W534	**BM** 1953 Af - 1.1	LNBI - Bowl with monkeys	2.0814	0.85136	0.054496
W536	**BM** 1909.8 - 11.15	Forcados River - Manilla	2.0773	0.84821	0.054145
		Benin/Lower Niger Group 6 (Apapa Hoard Group) Specimens			
W450	**BM** 1930 Af 4-23.1	Ram-head aegis	2.0692	0.85008	0.054283
W469	**BM** 1930 Af 4-23-15	Jingles and fragments	2.0649	0.84926	0.054277
W472	**BM** 1930 Af 4-23-2	Staff mount with jingles	2.0697	0.84789	0.054218
W473	**BM** 1930 Af 4-23-2	Detached link from W472	2.0640	0.84878	0.054343
W475	**BM** 1930 Af 4-23-3	Staff mount with nine jingles	2.0683	0.84845	0.054256
W477	**BM** 1930 Af 4-23-12	Ring with jingles	2.0663	0.85081	0.054416
W478	**BM** 1930 Af 4-23-13	Ring with jingles	2.0696	0.84935	0.054312
W479	**BM** 1930 Af 4-23-14	Ring with jingles	2.0688	0.84880	0.054330
		Other Apapa Hoard Specimens			
W470	**BM** 1930 Af 4-23-15	Rod supporting a jingle	2.0849	0.84568	0.054108
W474	**BM** 1930 Af 4-23-4	Bracelet with antelope heads	2.0875	0.84637	0.054025
W476	**BM** 1930 Af 4-23-11	Ring with jingles	2.0665	0.84380	0.053946
W480	**BM** 1930 Af 4-23-7	Disc with perforated edge	2.1031	0.85674	0.054741
W481	**BM** 1930 Af 4-23-6	Disc with perforated edge	2.0948	0.86713	0.055586
		Specimens that match Benin/Lower Niger Group 6 (Apapa Hoard Group)			
W252	**NMS** 1937.711	Yoruba - Execution ring	2.0723	0.84739	0.054151
W258	**NMS** 1906.551	LNBI - Janus head Bell	2.0623	0.84821	0.054311
W445	**BM** 1950 Af 45.452	Benin - Ram-head pendent mask	2.0678	0.84808	0.054251
W540	**NMIA** Head 17	Ife - The Obalufon Mask	2.0641	0.84820	0.054301

* Source identification symbols are:

Berlin – Ethnologisches Museum, Berlin; formerly: Museum für Völkerkunde.
BM = British Museum, London, England.
CUMAA = Cambridge University Museum of Archaeology and Anthropology, Cambridge, England.
FGA = Freer Gallery of Art, Smithsonian Institution, Washington DC, USA.
FMC = Field Museum, Chicago. The Dark numbers are catalogue numbers in *The Art of Benin: a catalogue of an exhibition of the A.W.F. Fuller and Chicago Natural History Museum collections of antiquities from Benin, Nigeria* by P.J.C Dark, Chicago Museum of Natural History, 1962.
FMLA = Fowler Museum, UCLA, Los Angeles, USA.
HMAG = Hunterian Museum and Art Gallery, University of Glasgow, Glasgow, Scotland.
Kgr = City Museum and Art Gallery, Kelvingrove, Glasgow, Scotland.
LM = Liverpool Museum, England.
Lu = F. von Luschan, *Die Altertümer von Benin*, Berlin and Leipzig, 1919.
MMA = Metropolitan Museum of Art, New York NY, USA.
NMAA = National Museum of African Art, Smithsonian Institution, Washington DC, USA.
NMBC = National Museum of Benin City, Nigeria.
NML = National Museum of Nigeria, Lagos, Nigeria.
NMNH = National Museum of Natural History, Smithsonian Institution, Washington DC, USA.
NMS = National Museums of Scotland, Edinburgh, Scotland.
PC = Private Collection.
TS = Sample submitted by Thurstan Shaw.
VMFA = Virginia Museum of Fine Arts, Richmond, Virginia, USA.

Tab. 5. Stable lead isotope ratios for Benin/Lower Niger artefacts.

Willett or SI No.	Source ID*	Description	$^{208}Pb/^{206}Pb$	$^{207}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
BBAN1176	**TS NMBC** No.42	Benin - Plaque of Snake	2.0856	0.84882	0.054460
BBAN1181	**TS NMBC** 107/3	Ogba Road Hoard - Bangle	2.0867	0.84927	0.054480
BGAN1193	**TS NAM** 2	Ghana - Great Brass Bowl of Bantama	2.0854	0.84625	0.054137
BGAN2638	**PC**	Ancient Ghana (Koumbi Saleh) - Droplet	2.1142	0.86067	0.055078
BOAN2700	**PC**	Yoruba - Ring	2.0899	0.84991	0.054468
BZAN2604	**TC** KMI-010-07	Zaire - Bracelet, Kisalian	2.0313	0.83053	0.052752
BZAN2605	**TC** MAK-27-6	Zaire - Ingot, Katanga Cross	2.0825	0.86506	0.055410
BZAN2606	**TC** MAK-27-4	Zaire - Ingot, Katanga Cross	2.0735	0.86158	0.055167
BZAN2607	**TC** MAK-27-14	Zaire - Ingot, Katanga Cross	2.0832	0.86500	0.055392
VAN2827	**VMFA** 92.184	Mali/Jenne - Chain	2.0937	0.85740	0.054837
VAN2829	**VMFA** 92.225	Mali/Jenne - Finger bell	2.0757	0.83913	0.053490
VAN2830	**VMFA** 92.185	Mali - Pendant	2.0847	0.85931	0.055146
VAN2831	**VMFA** 92.25	Mali/Jenne - Bracelet	1.9669	0.82351	0.052411
VAN2835	**VMFA** 92.167	Mali/Jenne - Bell	2.0760	0.84249	0.053789
VAN2836	**VMFA** 92.30	Mali/Jenne - Bracelet	2.0760	0.83664	0.053375
VAN2837	**VMFA** 92.27	Mali/Jenne - Bracelet	2.0926	0.86264	0.055364
VAM2834	**VMFA** 93.35	Mali/Jenne - Pendant	2.0822	0.84485	0.053982
W248	**NML** 79.R.19	Jebba - The Jebba Bowman	2.0871	0.85414	0.054383
W336	**FMC** 89790	Benin - Leopard - an altar group (Dark 100)	2.0920	0.84927	0.054677
W379	**NMNH** 349057	Gwabi, Nigeria - Manilla	2.1018	0.85775	0.054825
W381	**NMNH** 423524	Gombe, Nigeria - Manilla	2.1706	0.91585	0.059175
W382	**NMNH** 423513	Vere - Snuff bottle	2.0868	0.84795	0.054230
W388	**NMNH** 423472	Nigeria - Bell	2.0841	0.84574	0.054070
W389	**NMNH** 423473	Nigeria - Bell	2.0828	0.84473	0.053999
W394	**NMNH** 402858	Benin - Type 3 head	2.0969	0.85378	0.054351
W397	**NMNH** 66 5068	Benin - Recent hip mask	2.0987	0.86233	0.055399
W408	**NMNH** 665076	Benin - Altar Group with Prisoner	2.0861	0.84704	0.054227
W417	**BM** 1952 Af 30.1	Udo - Head	2.0844	0.85716	0.054297
W433	**BM** 1905 4-13.10	Andoni Creeks - Arm ring	2.0938	0.85654	0.054689
W438	**BM** 1905 4-13.5	Andoni Creeks - Manilla	2.1136	0.86762	0.055352
W451	**BM** 1964 Af 6.1	LNBI/Benin - Enowe style face mask	2.1414	0.89445	0.057557
W495	**HMAG** 112819	Ashanti - Shield goldweight	2.0793	0.84397	0.053827
W547	**PC**	Jenne - Heavy neck ring with coiled ends	2.0946	0.84876	0.053848

* Source identification symbols are:

BM = British Museum, London, England
FMC = Field Museum, Chicago. The Dark numbers are catalogue numbers in *The Art of Benin: a catalogue of an exhibition of the A.W.F. Fuller and Chicago Natural History Museum collections of antiquities from Benin, Nigeria* by P.J.C Dark, Chicago Museum of Natural History, 1962.
HMAG = Hunterian Museum and Art Gallery, University of Glasgow, Glasgow, Scotland.
NAM = National Army Museum, Sandhurst, England.
NMBC = National Museum, Benin City, Nigeria.
NML = National Museum of Nigeria, Lagos, Nigeria.
TC= samples supplied by S. Terry Childs.

Tab. 6. Stable lead isotope ratios for ungrouped artefacts.