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TWO CHEMICAL GROUPS OF DICHROIC GLASS BEADS FROM WEST AFRICA

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Introduction

Certain blue glass beads from West African archaeological sites have been found by x-ray fluorescence analysis to fall into two chemical groups. Each group includes beads which exhibit blue/yellow dichroism[1] and/or cords.[2] When held in the hand, they appear blue, but against the light they appear greenish-yellow.

One group of dichroic and corded beads appears to belong to the glass industry of Ife, and that relationship will be discussed in a forthcoming report. The present report presents the two chemical groups and discusses possible relationships between them.

The blue dichroic beads are the subject of a tangled literature dating back at least to 1603 (Zecchin 1955, 1964). It has not been previously recognized that the corded beads belong with the dichroic. In fact, forms intermediate between the two are found.

The dichroic beads are considered by modern scholars to be part of a wider problem known as the "akori bead" problem, the main goal of which is to define the word "akori". About two dozen accounts spread over some four hundred years allude to or partially describe "akori" beads (variously spelled accarey, aggrey, cori, etc.). Taken together the accounts are contradictory and ambiguous with respect to the name, color, material, and source of akori.

Reconciliation of these accounts by recent authors has yielded a consensus on akori beads (Fage 1962, Jeffreys 1961, Kalous 1966, 1968, Mauny 1958, 1961). However, the consensus has the drawback that historical accounts which may have applied to different things were blended to form a rather syncretic account, which therefore may contain anachronisms or other difficulties.

According to the consensus the existence of both "true" and "imitation" akori is postulated. The true akori were made of an unknown material, and the imitations of glass. True akori were retrieved from the habitat (generally either the ground, old graves, the water, or the hinterland) from Dahomey to Cameroons inclusive (Anon. c. 1749, Braun 1624, de Marees 1602, du Casse c. 1688, Ruiters 1623, Römer 1769, Ryder 1959), and in the sixteenth century in Manicongo as well (Anon. c. 1540); they were purchased by Europeans and taken to the Gold Coast (Ghana) where they were sold (Anon. c. 1540, Braun 1624, de Marees 1602, du Casse c. 1688, Pereira c. 1508, Ruiters 1623, Ryder 1959). By the nineteenth century they were found in the hinterland of the Gold Coast as well (Bowdich 1819). There are many other beads found in West Africa that are not claimed to be akori.

The color of akori cannot be restricted to any single color, but there is a place of honor among them for blue beads. True akori were said to be worth their weight in gold. They apparently softened at a higher temperature than did the glass imitation; such a heat test[3] is incompletely described (Anon. c. 1540). It was shaped like the tubular glass beads which imitated it ("a modo di cannellette", "condotti").[4]

The contradiction in the accounts of akori is best taken as evidence that the term has always been ambiguous. Indeed the very first European to write about "coris" gave two inconsistent accounts of them (Pereira, ed. Kimble 1937: 120, 128-9); and similar words are ambiguous in many African languages (Jeffreys 1961: 107-109). In its early days the term may have been confused with (Hindi) kaury or kaudy, cowrie shell, from which Jeffreys proposed it originated (1961). It is not unusual for words to change in meaning over a four-hundred year span. Indeed, if akori were any beads dug from genuine old graves, as has been proposed, then their nature would change as successive generations of graves became old, giving rise to ambiguities.

Because of its ambiguities the term "akori" will not be used. For maximum specificity dichroic (and corded) beads are treated as an independent unit. It seems likely that they may have fallen into the class "akori" at some time(s) in their history.

History of Blue Dichroic Glass Beads

Blue beads as an article of trade in West Africa have been reported numerous times since the early sixteenth century, when a significant European written record began to accumulate, that is, virtually from the beginning of European maritime trade with West Africa. Glass imitations of some undescribed blue substance are reported near the very beginning of this record.[4]

Isolated earlier accounts of trade beads, some blue, fall into the period of Arab trade with West Africa. In the eleventh and fourteenth centuries glass beads of unspecified color are mentioned by El Bekri (Markwart 1913: 282) and by ibn Battuta (ed. Gibb 1939: 333). In the twelfth century beads are mentioned by ibn Yakut, which are stated to be of blue glass in Markwart's rendition (1913: 181).

Neither the dichroism nor the cords are described until the early seventeenth century. Such artifacts are first reported in 1603 in correspondence dating to the period between 1601-1611 between a certain Emanuel Ximenes[5] and Antonio Neri,[6] of which only the letters of Ximenes survive.

Ximenes was interested in learning how to manufacture blue dichroic[7] glass beads to sell in Africa as imitations[8] of a stone already a success there, which would be worth their weight in gold,[8] and he solicited Neri's advice. Ximenes explained that in 1603 a glass factory in Amsterdam under the supervision of one Marten Papenbrouq had newly made an imitation, called corallina,[9] of the profitable dichroic substance. He wrote that the corallina was well received,[9] but later he wrote that it had yielded in popularity to another bead, which he described,[10] and which may be the blue corded bead.

The results of these attempts at imitation of a dichroic substance are not known. We do not know if the Dutch imitation was actually dichroic. Ximenes' own attempts to imitate the dichroic bead seem to have been abandoned when its popularity fell. In any case it seems unlikely that his attempts would have succeeded if he relied only on Neri. There is no evidence in <u>L'Arte Vetraria</u>, which was written after

Neri's exchanges with Ximenes, that Neri knew how to make a dichroic color (1662). Judging by Ximenes' criticisms[11] of Neri's attempt, Neri may have produced a layered bead, perhaps green or blue over a yellow core (a typically Italian bead design).

The next account describing a dichroic substance, "accarey", was that of Samuel Braun, who visited the West African coast in 1617.[12]

After the above accounts dichroism or cords are not indicated in West African accounts again until the twentieth-century awakening of interest in West African history and archaeology (Delafosse 1900, Fage 1962, Krieger 1943, Mauny 1958, Meek 1925). Blue dichroic beads began turning up in museums, excavations, African markets, and European antique shops. At Ife, in addition to beads, blue dichroic cullet and sherds are found.[13]

Outside Africa, blue/yellow dichroic glass is not uncommon in European contexts. We have analyzed cullet specimens from Glozel, a glass manufacturing site in France judged to be medieval (Franchet 1926, Garrod 1968), and a sherd from Vivegnis, near Liège, excavated from a room at the site of a Cistercian abbey which is tentatively judged to date from the sixteenth to eighteenth centuries (Philippe 1970).

In 1503, a jar of "clear green glass that looks blue", probably made in Barcelona, is recorded to have existed in the collection of Queen Isabella of Castile and Leon (Frothingham 1956: 9).

Johann Wolfgang von Goethe described blue/yellow dichroic glass in a review of Ars Vitraria Experimentalis, 1679, which is a translation of Neri's L'Arte Vetraria, by Johann Kunckel, a seventeenth-century glassmaker and experimenter, who added material of his own to his translation. Goethe's review hints that a recipe for blue/yellow dichroic glass is to be found in Kunckel's book;[14] however, it does not occur in the eighteenth-century edition of Kunckel (1756), nor does it occur in Neri (1662).

One blue/yellow dichroic bead was found on a set of bead sample cards, which bear no intrinsic dates but appear to belong to the early twentieth century.[15] It was analyzed by us and is further described below.

Similar color effects were very popular in European glass generally in the nineteenth century. The production of good opalescence was facilitated after 1880, as the Solvay process of producing commercial soda replaced the Leblanc process, which had tended to leave chloride and sulphate impurities in the salts that hampered development of opalescence in glass (Silverman 1951).

Of other colors, magenta/green dichroic glass was known in Roman times, and "chameleon glass" is recorded for ninth-century Syria (Brill 1965).

Description of Beads Analyzed in the Laboratory

A number of blue/yellow dichroic and blue corded beads from West African archaeological sites were analyzed by non-destructive x-ray fluorescence analysis.

The beads are drawn and not reheated tubular cane beads, usually about 2 cm. in length and about 0.5 cm. in diameter (Fig. 1). Some are fragmentary. The ends, apparently once sharp, are now slightly rounded by wear.

In incident daylight the dichroic beads (of both groups) exhibit a turbid, opaque, medium cobalt blue color, approximately Munsell No. 5PB,5/10 to 5PB,6/8. Transmitted daylight causes them to appear imperfectly transparent, often with cords, and colored an ordinary shade of yellowish-green like that commonly found in bottles, approximately Munsell No. 2.5GY,9/6.

The non-dichroic corded beads (of both groups) are medium cobalt blue in color in both incident and transmitted daylight, approximately 5PB,5/10 to 5PB,6/8. They exhibit cords to varying degrees.

Some examples show both cords and dichroism.

Results of Analysis

The results of x-ray fluorescence analysis are presented in Table I. Two groups of these artifacts are discerned. All dichroic beads analyzed by us, whether by x-ray fluorescence or by neutron activation analysis, fall into one or the other of the two groups. The results of neutron activation analysis will be reported in the future. All corded beads analyzed by us fall into one or other of the two groups.

Group A and Group B are radically different in their arsenic and lead content. The manganese of Group A is about ten times higher than that of Group B.

The data do not show the groups to differ with respect to iron, copper, zinc, rubidium, strontium, zirconium, tin, antimony, and barium (Table I), and the cobalt difference is slight.

Other Measurements

A crude measurement was made of the softening point of a small chip from one bead in each group. The sample from Group B (Old Oyo, #4) softened to the consistency of mucilage at approximately 740°C; the sample from Group A (Orun Oba Ado, #179a) reached this consistency at more than 900°C. Temperature was measured with a zinc-iron thermocouple. Upon cooling neither chip was visibly altered.

The specific gravity of bead samples from each group is presented in Table II. The measurement is crude, but the data do illustrate the difference in specific gravity which is apparent intuitively upon handling the material.

Discussion

Dichroism. The dichroic effect can be ascribed to simple light scattering, a phenomenon widely observable in nature. Particles in colloidal suspension selectively scatter a high proportion of the light of short wavelengths (blue) while selectively transmitting a high proportion of the light of longer wavelengths (yellow).

Particles, bubbles, or phases in suspension in glass have important effects on its appearance. Depending on particle size, number, and distribution, the glass may exhibit results on a continuum from transparency through opalescence and mild opacity to dense opacity. The dichroic beads have been called "opalised through their long stay underground" (Krieger 1943). The term "opal" (opaline) is usually applied to glass in the range from mildly to densely opaque, but it could be applied to the beads in question. However, the color effect is intrinsic and is not caused by burial underground. Deterioration of the surface of glass often gives an iridescent appearance, but this type of surface decay is not present in these beads.

Grouping. The data presented in Table I show that two groups of glass artifacts are represented. It is not yet possible to evaluate the meaning of the homogeneity manifested in each group, in other words, how many factories and/or years might have been involved. Intuitively one would guess that two basic recipes are represented, but that samples of more than one glass batch are present in each group.

The data are not sufficient to reveal trace element patterns, but are appropriate to reflect (incompletely) the level of recipe ingredients. Several major ingredients important in glassmaking were not analyzed, for example, sodium, potassium, or calcium. (For Group A these data were obtained by neutron activation analysis and will be reported in the future.)

Glasses made with an appreciable quantity of lead are known as "lead glasses", and Group B would fall into this major glass family. Therefore, the difference in lead content between the two groups is of greater importance than the similarity displayed by most of the other elements, all of which are common in glasses generally.

The high level of arsenic in Group B is also quite remarkable, and indicate conscious use. Trace amounts of arsenic, on the order of hundredths of a percent or less, are not unusual in many glasses containing cobalt, because arsenic is frequently found in cobalt ores.

Cobalt is probably responsible for the blue color of both groups of beads. The exact amount of cobalt placed in a glass depends upon the shade of blue desired and upon the other ingredients present. Similar considerations apply to manganese.

The remainder of the data is not remarkable, except perhaps that the iron, a persistent impurity in glass, is at a relatively low level in both groups.

Some beads in Group B have rather elongated indentations, parallel to the perforation, which appear to be stretch marks.[16] In addition to displaying apparent stretch marks, some beads are occasionally markedly opaque, while still appearing to scatter light. (No extremely opaque examples were available for analysis.) The few beads which appear to belong to Group B which are found in Europe, however (Cambridge, #1, and other possible examples below), do not show the apparent stretch marks or increased opacity.

It seems possible that beads belonging to Group B may have been altered in Africa. Heating and stretching of the glass may explain both the apparent stretch marks and the increased opacity of some samples. Various kinds of processing of imported glass beads have been reported for West Africa (Bowdich 1819: 268, Gluck 1937: 97, Loyer ed. Roussier 1935: 179-180, and others), and there are numerous reports of glass-making, bead-making, and similar activities in West Africa.

On the other hand, possibly Group B as outlined here is too comprehensive and should be split. The European example is apparently the most deviant example in Table I (Cambridge, #1), but the differences it shows are difficult to evaluate because of differences in precision of the measurements within Group B. We are not today in possession of sufficient data to form a basis for a split.

Material from Glozel and Liège are excluded from Group A (Table I) on the basis of the rubidium, barium, and further data obtained by neutron activation analysis.

Identification. Once their existence was realized, it was found that the two chemical groups could easily be distinguished by eye. The dichroic contrast in beads of Group A is more marked than in beads of Group B, in fact it is sometimes hardly visible in beads of Group B. The difference in specific gravity (Table II) can be used as a means of learning how to make the distinction between the two groups. (It is not necessary to heat the beads to the softening point in order to learn the distinction!)

Archaeological Discussion

Dating. Distribution and radiocarbon dating indicate that Group A belongs to the period of Arab trade whereas Group B belongs to the period of European trade (Map, Fig. 2).

Group A is found in relatively older inland sites. (It is also found in newer sites, but this is not important in view of the long record of grave-opening in West Africa.) Radiocarbon dates from Ife indicate that Group A falls into the period bounded by 430-1290 A.D. (Willett 1968: 73). It may perhaps be restricted to the period 430-690 A.D. (B.M. 265, 560 ± 130 A.D.), if only the date from the earliest site, Orun Oba Ado, Pit 11, is considered. Most glass historians would probably not readily accept this earliest date for a glass of the composition of Group A. The other four radiocarbon dates from Ife fall into the period 830-1290 A.D. (B.M. 261, 960 ± 130 A.D.;

B.M. 262, 1060 ± 130 A.D.; B.M. 259, 1160 ± 130 A.D.; B.M. 264, 990 ± 130 A.D.), a time period which most glass historians would probably accept for Group A.

Because of the shrine nature of some of these sites, one cannot be certain that the material which was dated is truly contemporary with the beads, due to the periodic excavations carried out in West African shrines. It seems that the wide time spread represented by all the radiocarbon dates is likely to include the correct dates.

Arab-period dating is supported by the occurrence of a bead of Group A in the excavations of Kumbi Saleh and Tegdaoust (Table I).

The two beads from Gao (Table I) have no firm archaeological associations.

Group B is found only in newer contexts. It is not found in any firm archaeological context, but occurs in surface collections, in markets, around the necks of well-preserved wooden sculptures,[17] on manufacturers' sample cards, and in like situations, none very firmly datable.

One example appears to belong to the early twentieth century. Cambridge, #1 (Table I), a specimen which is strongly dichroic and also displays cords, occurred sewn onto a bead-sample card which bore labeling in both the English and Italian languages (Fig. 3). Combined consideration of this labeling, of the style and state of preservation of the card and of the sewing, and of the general resemblance of this and associated beads to other dated material[18] leads to the conclusion that the date of the specimen named "Cambridge, #1" is early twentieth century.

The ingredients of a glass may sometimes be used to judge the date and place of origin of the glass within a broad time range. Both groups under discussion would fit into a European rather than an Islamic pattern of manufacture.

Group A seems to belong to a general class of imprecisely dated medieval and colonial-period European glasses which would include material as disparate as that from Glozel and Vivegnis, medieval cathedral windows, and utilitarian bottles of the colonial period. From neutron activation analysis it is known to be made with a potassium rather than sodium alkali and it contains the high levels of calcium commonly found in European medieval glass.

We are not certain of the opalising agent in either group of beads, but it seems likely that calcium and arsenic compounds perform this function. The first report of an opal composition similar to that of Group A was that of Kunckel, originally in 1679 (1756: 54), who used bone ash (calcium phosphate) as an opaliser. A calcium fluophosphate opaliser is reported in an enamel estimated to be fourteenth-century Syrian (Turner and Rooksby 1959).

Arsenic as an opalising agent in high-lead glasses came into use in the eighteenth century, and therefore the composition of Group B would place it most readily in the eighteenth century or subsequently, (Turner and Rooksby 1959). Neri, in 1612 (1662), was aware of uses of lead and arsenic in glass, but he does not tell of their use together.

The question of imitation akori. Because they were obviously made of glass, blue dichroic beads thus far found in West Africa have been tentatively classed with the imitation akori by some authors.

The finding of two kinds of dichroic beads might give rise to the speculation that one is an imitation of the other.

However, the question of imitation cannot be satisfactorily answered, because the actual specimens cannot be dated sufficiently close together to make imitation between them a credible possibility, there being a gap of hundreds of years, or even a thousand. No bead has been clearly described as both dichroic and an imitation. Indeed it is difficult to speak of imitation of an item which is so poorly understood in the original.

The only datable example of Group B, Cambridge, #1, appears to fall into the early twentieth century. Until found in firm archaeological context, Group B cannot be assumed to be the imitation reported in 1540 (Anon. c. 1540), in 1603 (Zecchin 1964), or to have existed at all before c. 1900.

It seems unlikely that both groups of beads are imitations of a third substance. Cordierite is the one natural mineral which the dichroic glass may have counterfeited (Davison 1970), but no examples of this have been reported from archaeological sites in Africa.

Summary and Conclusion

Dichroic beads were present in West Africa during an undefined period of time which may have included the latter part of the first millennium A.D. and continued into the twentieth century. At least two chemical groups of such glass beads existed. The earlier may belong to the period of Arab trade, and the later to the period of European trade.

It is possible that Africans of the past few centuries (in Nigeria, and perhaps in Dahomey, Cameroons, Congo, and Angola) excavated dichroic beads, among others, from still older graves; and, when it was realized that the dichroic beads brought high prices, attempts were made to imitate them in Europe. However, the precise results of these attempts are unknown.

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NOTES

[1]Glasses which exhibit any two colors, one at a time, are said to be dichroic. Dichroism is the case of pleochroism involving only two colors. Pleochroism, the exhibition of multiple colors singly, is due to crystal arrangement. Glass cannot exhibit true pleochroism since it is not crystalline, but nevertheless the terms are applied to glasses which appear to exhibit this phenomenon (Brill 1965, Weyl 1951). It is also applied to glasses which exhibit different colors depending on the type of light source (Herring *et al*. 1970: 316).

[2]Cords, usually considered faults, are morphological effects in glass which give it a stringy appearance, like pulled taffy.

[3]In West Africa the heat test would differentiate many assemblages of glass beads from other assemblages, regardless of color, because of differences in the alkali used in the glass.

[4]The anonymous Portuguese pilot of c. 1540 wrote of Elmina: "in questo luoco vi concorre similmente gran numero di Negri con grani d'oro, che trouano in li fiumi et fra la rena, et contrattano con li prefati fattori, prendendo da loro diuerse cose, et massime pater nostri fatti di vedro, et di unaltra sorte di pater nostri fatti di una pietra azurra, non dico lapis lazuli, ma di altra minera, liquali il nostro Re [Portuguese] fa venir del regno di Manicongo, doue nasce detta pietra, et sono fatti detti paternostri a modo di cannellette, sottili, et gli chiamano *Corili*, et per tal sorte danno assai oro, per esser grandemente esistimati da tutta li Negri, quali li mettono al fuoco per veder che non siano falsificati, perche pur ne vengono condotti fatti di vedro, che sono molto simili, et non stanno al cimento del fuoco" (Anon. *c*. 1540).

[5]Ximenes was a Portuguese resident of Antwerp, in 1603 still an important commercial city. He is mentioned in Neri's book. His letters indicate that he may have been rather a novice in the glass art.

[6]Neri is regarded as the father of modern glassmaking and is the author of the first modern textbook of glassmaking, L'Arte Vetraria, first published in 1612, with numerous subsequent editions in several European languages.

[7]Despite Ximenes' imperfect command of the Italian language, relevant extracts from his letters are given here and following: "Gli africani gli mesi adietro desideravono un certo colore (a me hactenus incognito) che risponde a certa loro mina o màlmero diafano che quivi scoprono.... pare di colore del lapis calsuino, vedendolo nelle mani, ma quanto si inalza verso la luce pare che gialleggi" (Zecchin 1964: 24).

[8]"...che se si trovassi il modo de imitare quella lor minera de pietre, ne darebbono tanto oro quanto il suo peso....(Zecchin 1964: 24).

[9]"Interim questi olandesi volendolo imitare per l'ingordigia del utile, poichè ne principi pare che sarà strapagato, ànno formato il colore dell'incluso modello, che chiamano corallina, che gionto in Africa fu alquanto grato" (Zecchin 1955: 104).

[10]"...e di grani tondi ed ovati, di colore azurro celeste, di grandezza di nochiole..., et che ogni grano habbi fino alie rigette bianche nelle superfitie, a lungo segundo il buso..." (Zecchin 1955: 105).

[11]"...quello che li neri della costa della mina vogliono, son conterie fatte de pasta che fondata sul giallo, per di fuora a la prima vista mostri azzurro come lo estrinseco de la inclusa mostra. In però,

mescolato a guisa che non si vega distinzione tra colore e colore, come fa in questa mostra" (Zecchin 1964: 24).

[12]"Accarey welches die Einwöhner für Edelgestein halten wachset im Meere wie die Corallen. Ist anzusehen wie Himmelblaw: wann man aber dadurch sihet ist es gantz meergrün..." (Braun, ed. Naber 1913: 31).

[13]The cullet (scrap glass) and beads are well known. The sherds are preserved in the British Museum. Only two have been observed, one bearing a pontil mark (the mark of a glassblower's tool).

[14]In translation: "We have long missed the turpid panes which show up yellow on a bright background and blue on a dark one....[This thing] can now be put at the disposal of the friends of the chromatics (science of colour) to their hearts' desire..." (Schweig 1953: 71).

[15]University Museum of Archaeology and Ethnology, Cambridge.

[16]Reference to photographs showing apparent stretch marks is found in note 17.

[17]For example, see Fischer (1968: 121). The center bead on the statue at extreme left resembles beads of Group B. It has an apparent stretch mark. Similar beads are shown by Mauny (1961: facing 274).

[18]One of us (C.D.) has observed three bead sample cards bearing blue beads which show a strong resemblance to the analyzed beads of Group B, except that they are not strongly dichroic. Analysis of these beads would be desirable. One occurs on a sample card of the former M.L. Levin Co. of London, and is now preserved in the British Museum. Another occurs on a bead sample triptych, as it were, bearing the label "Società Veneziana per l'industria delle conterie, edition 1909", now preserved in the Pitt-Rivers Museum, Oxford. A third

occurs on a bead sample card which appears to be the torn-off right-hand page of a triptych like the above, bearing the label "edition 1899", now preserved in the Museum of Glass and Bijouterie, Jablonec nad Nisou.

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Table I. X-ray Fluorescence Analysis of Blue/yellow Dichroic Glass Groups[a]

Site and Identification No.	Mn	Fe	Co	Cu	Zn	As	Rb
GROUP A:							
Orun Oba Ado, Pit 3, #17	0.2 ± 0.1	0.6 ± 0.2	~0.04				0.02 ± 0.01
Orun Oba Ado, Pit 11, #179a	0.3 ± 0.1	0.5 ± 0.2	~0.04				0.03 ± 0.01
Orun Oba Ado, Pit 5, #183	0.7 ± 0.2	0.3 ± 0.1	0.11 ± 0.04		0.04		0.02 ± 0.01
Orun Oba Ado, Pit 5, #207	0.3 ± 0.1	0.5 ± 0.2	~0.04				0.02 ± 0.01
Ita Yemoo, #27a	0.3 ± 0.1	0.6 ± 0.2	~0.04				0.03 ± 0.01
Ita Yemoo, #27b	0.5 ± 0.2	0.4 ± 0.1	0.10 ± 0.04				0.02 ± 0.01
Ita Yemoo, #855	0.5 ± 0.2	1.3 ± 0.3	~0.05				0.03 ± 0.01
Ita Yemoo, #1411	0.4 ± 0.2	0.4 ± 0.1	~0.04				0.03 ± 0.01
Ita Yemoo, #920	0.2 ± 0.1	0.4 ± 0.1	~0.03	~0.02	0.02		0.03 ± 0.01
Ilesha Grave, #233a	0.4 ± 0.2	0.6 ± 0.2	<0.05				0.02 ± 0.01
Old Oyo, #27	0.3 ± 0.1	0.4 ± 0.1	~0.05				0.02 ± 0.01
Gao, Mal-50-13	0.14 ± 0.04	0.22 ± 0.05	0.02	~0.005	0.01		0.04 ± 0.01
Gao, Mal-50-13	0.18 ± 0.04	0.24 ± 0.05	0.03	~0.005	0.01		0.03 ± 0.01
Kumbi Saleh, M-49-195	0.24 ± 0.06	0.27 ± 0.06	0.03	0.01	0.01		0.03 ± 0.01
Tegdaoust, 69WVII 61	0.5 ± 0.2	0.6 ± 0.2	<0.05	0.04 ± 0.01	0.02	<0.05	<0.02
Mean and Root Mean Square Deviation,[c] or Estimate Mean	0.3 ± 0.1	0.5 ± 0.2	~0.05	<0.05	<0.05	<0.05	0.03 ± 0.01
COMPARISONS WITH GROUP A:							
Glozel (France)	0.6 ± 0.2	0.8 ± 0.2	<0.05	0.01	0.02	0.01	0.07 ± 0.01
Liège (Belgium)	0.3 ± 0.1	0.9 ± 0.2	<0.05	0.01	0.04 ± 0.01	0.01	~0.005
If no result reported, amount is less than:				0.05	0.05	0.05	
GROUP B:							
Old Oyo, #1	0.09 ± 0.03	0.24 ± 0.06	0.02	0.02	0.01	~2.	b
Old Oyo, #2	0.04	0.30 ± 0.06	0.02	0.02	0.01	~2.	b
Old Oyo, #3	0.04	0.26 ± 0.06	0.02	0.01	0.01	~2.	b
Old Oyo, #4	0.05	0.31 ± 0.06	~0.007	0.02	0.02	~2.	b
Zaranou, #1	0.10 ± 0.03	0.27 ± 0.07	0.01	0.01	0.02	~4.	b
Zaranou, #2	0.04	0.19 ± 0.05	0.01	0.01	0.01	~2.	b
Dahomey, #1	0.06	0.30 ± 0.06	0.01	0.01	0.01	~2.	b
Dahomey, #2	0.05	0.46 ± 0.09	<0.01	0.01	0.01	~3.	b
Dahomey, #3	0.02	0.33 ± 0.06	0.01	0.02	0.01	~2.	b
Dahomey, #4	0.02	0.28 ± 0.06	0.01	0.06 ± 0.02	0.01	~2.	b
Dahomey, #5	0.09 ± 0.03	0.22 ± 0.05	0.02	0.06 ± 0.02	0.01	~2.	b
Dahomey, #6	0.03	0.18 ± 0.05	0.01	0.03	0.01	~2.	b
Cambridge, #1	0.06 ± 0.02	0.25 ± 0.05	<0.05	0.06 ± 0.02	0.04 ± 0.01	~2.	b
Mean and Root Mean Square Deviation,[c] or Estimate Mean	~0.05	0.28 ± 0.07	~0.01	~0.03	~0.01	~2.	b

[a] All data are given in percent. Differences in precision are due to improvements in our equipment, and the method used in such that relatively occur for elements in low concentration.

[b] Pb content too high to determine amount of this element.

[c] Where only upper limit values are given, these are excluded from calculations of means and deviations.

Sr	Zr	Sn	Sb	Ba	Pb	Figure 2 References
0.04 ± 0.01	0.01			0.05 ± 0.01		1
0.02 ± 0.01				0.01		1
0.02 ± 0.01	0.01			0.02 ± 0.01		1
0.04 ± 0.01				0.04 ± 0.01		1
0.03 ± 0.01				0.01		1
0.03 ± 0.01				0.02 ± 0.01	~0.03	1
0.02 ± 0.01				0.03 ± 0.01	~0.04	1
0.03 ± 0.01				0.02 ± 0.01		1
0.02 ± 0.01				0.01		1
0.02 ± 0.01				0.02 ± 0.01		1
0.02 ± 0.01				0.02 ± 0.01		3
0.03 ± 0.01				0.03 ± 0.01		4
0.03 ± 0.01				0.03 ± 0.01		4
0.03 ± 0.01				0.03 ± 0.01		5
0.05 ± 0.01	0.01	~0.004	~0.002	0.03	0.04	7
0.03 ± 0.01	<0.02	<0.01	<0.01	0.02 ± 0.01	<0.05	
0.07 ± 0.01	0.01	<0.005	<0.005	0.19 ± 0.03	<0.02	-
0.04 ± 0.01	0.02	<0.01	<0.01	0.06 ± 0.01	0.01	-
	0.02	0.01	0.01		0.05	
b	b	0.022 ± 0.005	0.013 ± 0.004	0.01	~25.	3
b	b	0.019 ± 0.005	0.05 ± 0.01	0.01	~25.	3
b	b	0.014 ± 0.005	0.028 ± 0.006	0.01	~30.	3
b	b	~0.005	0.035 ± 0.007	0.02	~30.	3
b	b	<0.005	0.035 ± 0.01	0.01	~30.	11
b	b	<0.005	0.03 ± 0.01	0.01	~30.	11
b	b	0.021 ± 0.005	0.030 ± 0.005	0.01	~30.	10
b	b	<0.005	0.026 ± 0.005	0.01	~40.	10
b	b	<0.005	0.035 ± 0.08	0.6 ± 0.1	~25.	10
b	b	0.06 ± 0.01	0.06 ± 0.01	0.07 ± 0.02	~25.	10
b	b	0.024 ± 0.005	0.07 ± 0.02	0.05 ± 0.01	~25.	10
b	b	0.035 ± 0.007	0.046 ± 0.008	0.03 ± 0.01	~25.	10
b	b	0.023 ± 0.005	0.07 ± 0.01	0.05 ± 0.01	17. ± 3.	12
b	b	0.025 ± 0.018	0.041 ± 0.018	~0.07	~27.	

large deviations

Table II. Apparent* Specific Gravity of Dichroic Beads

GROUP A		GROUP B	
Orun Oba Ado, #179a	2.60	Old Oyo, #2	3.08
Orun Oba Ado, #17	2.49	Old Oyo, #3	3.27
Ita Yemoo, #233a	2.48	Old Oyo, #4	3.13
Ita Yemoo, #1411	2.61	Cambridge, #1	2.83
Ita Yemoo, #27a	2.53		
Old Oyo, #27	2.45		
	2.53 ± 0.07**		3.08 ± 0.12**

*The measurement is crude because it rests on the approximation that glass contains no air bubbles or other inclusions.

**Mean and Root Mean Square Deviation.

Table III. Legend

Map Locality No. and Name	Source
Section 1. Examined Beads[a]	
● GROUP A, known by analysis	
1. Ife (Orun Oba Ado, Ita Yemoo, Olokun Grove)	F. Willett
2. Ilesha Grave	"
3. Old Oyo	"
4. Gao	R. Mauny
5. Kumbi Saleh	P. Thomassey, R. Mauny
6. Nikrowa (Onikroga), near Osse River	R. H. Hide, British Museum, Acc. 1946
7. Tegdaoust	D. Robert, R. Mauny
o GROUP A, judged by appearance	
8. Cameroons	M. D. W. Jeffreys, van Riet Lowe bead collection, Acc. 1942, University of the Witwatersrand
■ GROUP B, known by analysis	
3. Old Oyo	F. Willett, W. R. Bascom
9. New Oyo (partial analysis)	"
10. Dahomey	R. Mauny
11. Zaranou	"
12. Cambridge, bead sample card	University Museum of Archaeology and Ethnology, Cambridge

Table III (continued)

Map Locality No. and Name		Source
◘	GROUP B, judged by appearance	
1.	Ife	British Museum, Acc. 1946
13.	Oboum	University Museum of Archaeology and Ethnology, Cambridge
14.	in markets and on wooden sculptures	Numerous museums (Fischer 1968, Mauny 1961), also Lowie Museum, University of California; Corning Museum of Glass.
△	UNCERTAIN which group	
15.	Ilorin	British Museum, Acc. 1946
16.	Southern Nigeria	" " " 1956
17.	Ashanti	" " " 1896, 1900
18.	sample card, M. L. Levin, Manufacturer, of Bevis Marks, London	" " " 1960
19.	sample triptych, Società Veneziana per l'industria delle conterie, edition 1909	Pitt-Rivers Museum, Oxford
20.	sample, probable triptych, right page preserved, edition 1899	Museum of Glass and Bijouterie, Jablonec nad Nisou

Section 2. Literary References

●	DICHROIC	
21.	St. Louis	(Mauny 1958: 214)
22.	Bamako	"
23.	French Sudan	(Krieger 1943: 60)

Table III (continued)

Map Locality No. and Name	Source
24. Northern Nigeria	(Meek 1925: 55)
25. Afréboka	(Delafosse 1900: 680)
26. Gold Coast ("costa della mina")	(Zecchin 1964: 24)
27. Ibadan	(Mauny 1958: 214)
28. Ambosy, Rio de Angra, Rio del Rey	(Braun, ed. Naber 1913: 31)
29. Angola (corded)	(Zecchin 1955: 105)
♦ AMBIGUOUS, BUT BLUE COLOR SPECIFIED[b]	
30. Guinea Coast	(Bosman 1705: 126)
31. Issyny[c]	(Delafosse 1900: 681)
32. Gold Coast	(du Casse ed. Roussier 1935: 14; Ruiters, ed. Naber 1913: 80; de Marees, ed. Naber 1912: 231)
33. Elmina	(Pereira ed. Kimble 1937: 129; Anon. ed. Blake 1942: I, 153; Anon. ed. Blake 1942: II, 343)
34. Ashanti and neighbors	(Bowdich 1819: 267)
35. Popo Piguenine	(du Casse ed. Roussier 1935: 14)
36. Popo, Grand Popo	(Bowdich 1819: 267; Bertho 1944: 2; du Casse ed. Roussier 1935; 14; Isert 1793: 156-7[d])
37. Rio de Ardra	(de Marees ed. Naber 1912: 231)
38. Whydah	(Spieth 1906: 554; Isert 1793: 156-7)
39. Formosa (Benin) River	(du Casse ed. Roussier 1935: 15)
40. Forcados River	(Periera ed. Kimble 1937: 128)
41. New Calabar	(Barbot ed. Churchill 1752: V, 464)

Table III (continued)

Map Locality No. and Name	Source
42. Benin to Cape Lopes	(du Casse ed. Roussier 1935: 15)
43. Manicongo, Angola and Loango	(Anon. ed. Blake 1942: I, 153; Wiener 1922: 213; Battel ed. Pinkerton 1814: 319, 322)
44. In the gold trade to Ancient Ghana	(Markwart 1913: 181)

[a]Section 1 comprises beads which have been examined by one of us (C.D.). Some sites are placed on the map on the basis of data which is not presented here but which will be presented in the future. It was thought advisable to make the map as complete as possible.

[b]This group includes autochthonous and imported blue beads, stones, or other items except shell. References not stating the blue color or describing polychrome items are excluded. Secondary and tertiary accounts are omitted (e.g., those of Krieger or of Dapper).

[c]The passage which Delafosse attributes to Loyer appears only partially in Roussier's edition of Loyer (ed. Roussier 1935: 179-80).

[d]Isert's remarks deserve comment. He wrote that the inhabitants of Whydah and Popo dug up two kinds of stones [at both places]. One type seemed to contain "grains de métal qui paroissent de l'or, ou du pyrite sulphureux". This is probably only aventurrine, a type of glass marked by the presence of small but visible flakes of copper. It gives a flashy appearance to the glass and is very commonly found in cheap jewelry today. It was probably invented in the first half of the seventeenth century (Zecchin 1955: 63) in Murano. The other sort of "stone" dug up resembled a tube and was already pierced.

Figure Captions

Fig. 1. Diagram of bead. The length measured is that of the perforation.

Fig. 2. Distribution of blue dichroic and corded beads in West Africa. See Table III for legend.

Fig. 3. Bead specimen "Cambridge, #1" on bead card. The print is in black ink and the hand writing in red ink.

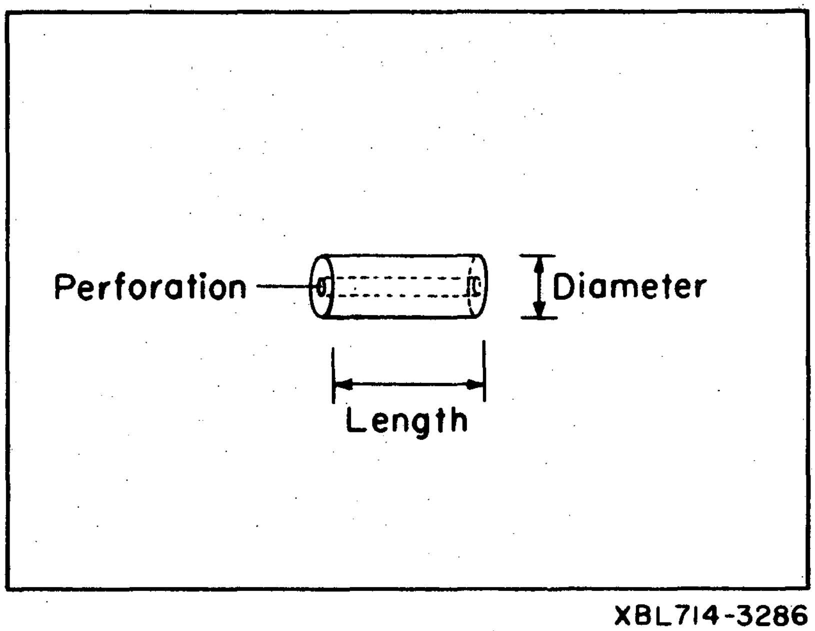

Fig. 1

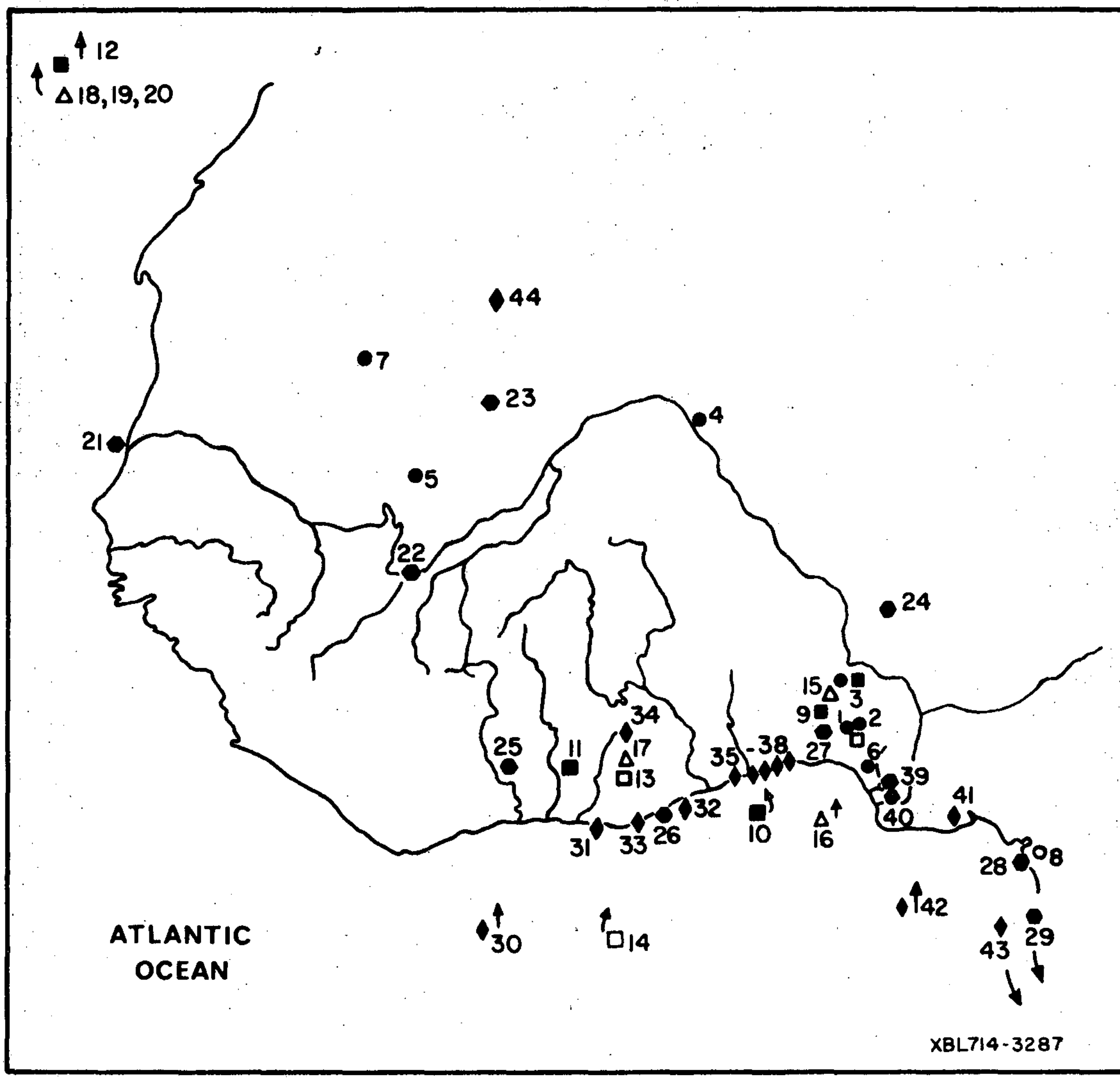
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Fig. 2

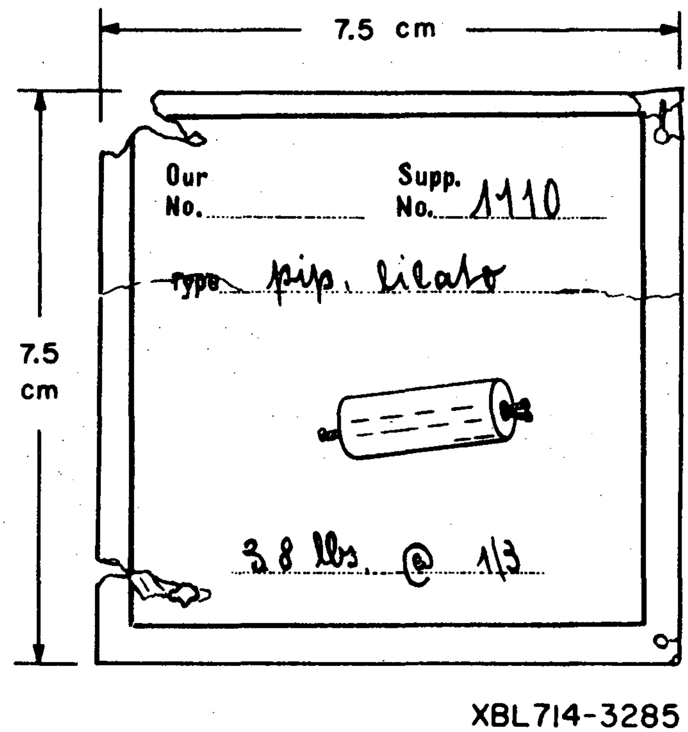

Fig. 3

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