ON THE EXISTENCE OF CHRONOLOGICAL VARIATIONS IN THE COMPOSITION OF ROMAN BRASS[1]

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In spite of some literary allusions to the contrary, the experimental evidence indicates that the copper-zinc alloy which we call brass was first produced intentionally by the Romans. This alloy was first used by them only for coins, and there are strong indications that its manufacture was practiced by the Roman mints as a monopoly of the state during most or all of the period when brass was struck. The earliest known Roman brass coins were issued under Julius Caesar about 45 B. C., but the abundant issue of such coins did not begin until about 23 B. C. under Augustus. Vast numbers of these coins were issued under various emperors between this date and 200 A. D., the approximate time of the end of the ancient coinage of this alloy.

In the course of listing and comparing all known chemical analyses of Roman brass coins, including some made recently in his laboratory, the author observed the existence of systematic chronological changes in the composition of the alloy. The nature and extent of these changes are illustrated by the results of a series of careful analyses of closely dated coins shown in table 1. Five of these analyses were made by Mr. W. H. Deebel as part of a thesis for the M. Sc. degree at The Ohio State University. The remaining one was made by Messrs. A. Randall and N. Lovegren working in the author's laboratory. A more or less regular chronological increase in the proportion of copper and a corresponding decrease in the proportion of zinc is evident throughout this series. Furthermore, the number and total proportion of the various impurities tend to increase with time, though these changes are much less regular than the changes in the proportions of copper and zinc. Shown in table 2 are figures for the average proportion of zinc and the maximum proportion of zinc in coins of a series of four successive emperors. These figures represent all known reliable determinations of the zinc content of brass coins of these emperors. The more or less regular decrease in the proportion of zinc is obvious. In table 3 are shown the average proportions of zinc, tin, and lead in Roman brass coins by half-century periods, as given by all known reliable analyses. Here again the chronological decrease in proportion of zinc is obvious.

TABLE 1

Analyses of closely dated Roman brass coins

Date	Cu %	Ag %	Au %	Sn %	Pb %	Fe %	Ni %	Zn %	Total %
23 B.C.	77.36	none	none	0.17	0.16	0.38	none	21.88	99.95
39–40 A.D.	81.03	none	none	none	0.05	0.22	0.03	18.55	99.88
96–98 " "	84.69	none	none	0.57	0.49	0.38	0.05	13.59	99.77
141 " "	86.28	0.06	trace	0.06	0.32	0.51	0.02	12.71	99.96
154–155 " "	86.51	0.10	trace	1.69	0.11	0.33	0.03	11.14	99.91
161–162 " "	88.96	0.05	trace	2.43	0.18	0.31	0.04	7.87	99.84

[1]Paper presented at the Sixty-third Annual Meeting of the Ohio Academy of Science, Athens, Ohio, April, 1954.

Also obvious is a corresponding more or less regular increase in the average proportions of tin, and lead, with the average proportion of tin always greater at each period than the average proportion of lead. The proportions of these two principle impurities increase to such an extent that their sum in the last period almost equals the proportion of zinc.

This chronological decrease in the proportion of zinc in Roman coinage brass was probably caused by a practice that has been followed almost of necessity by mints in all countries at all periods. This is the use of coins badly worn by circulation as the principal source of metal for the issue of new coins. Often the new

TABLE 2

Zinc content of coins of a series of successive emperors

Emperor and period of reign	Number of determinations	Average zinc content %	Maximum zinc content %
Trajan 98–117 A.D.	10	14.1	16.7
Hadrian 117–138 A.D.	12	12.7	16.8
Antoninus Pius 138–161 A.D.	8	10.5	13.6
Marcus Aurelius 161–180 A.D.	10	6.6	10.3

TABLE 3

Average zinc, tin, and lead content at successive periods

Period A.D.	Number of analyses	Zn %	Sn %	Pb %	Sn+Pb %
1–50	5	21.10	0.10	0.08	0.18
51–100	4	12.45	0.50	0.28	0.78
101–150	20	10.62	1.35	0.72	2.07
151–200	18	6.05	3.54	2.33	5.87

metal that is added corresponds only to the amount of metal lost through circulation. When a nearly pure single metal is used for coins, this practice does not lead to much change in the composition of the coinage metal on remelting, but when an alloy is used a considerable change may occur because of the preferential loss of one component by oxidation. With brass this change in composition tends to be especially large because the zinc is not only more easily oxidized than the copper but is also lost by volatilization. Even if the Roman coiners had added a considerable proportion of new brass on remelting, the resulting coinage brass would generally have contained less zinc than the worn coins, for they were apparently unable to manufacture brass that contained more than about 25 percent zinc. This indicates that all their brass was made by a cementation process, that is by the reduction of zinc ores with carbon in the presence of molten copper. There is no evidence that they ever produced metallic zinc. Therefore they could not compensate for the loss of zinc on remelting worn brass coins by the addition of brass containing a high proportion of zinc or by the addition of zinc itself. Hence the general downward trend in the proportion of zinc in the coins as they were repeatedly remelted and reissued. Moreover, the analyses indicate that the manufacture of new brass ceased entirely some time before the end of the issue of brass coins. The increasing proportions of tin and lead in the coins of the second century, especially in those issued after the middle of this century, indicate the addition of bronze rather than brass in the remelting of worn coins. Significant also is the more rapid decrease in the proportion of zinc in the coins after the middle of this century. A likely explanation for the stoppage in the manufacture of brass and the consequent later stoppage in the issue of brass coins is the exhaustion of the zinc deposits known to the Romans.

These rather systematic chronological changes in the composition of Roman coinage brass may serve as a rough index for dating various kinds of Roman brass objects. For example, brass coins found in excavations that are illegible because of wear or corrosion could be analyzed and approximately dated by comparing their composition with that of a series of dated coins. Moreover, this might

TABLE 4

Dating of objects other than coins

Object	Source	Zn %	Sn %	Pb %	Probable lower date limit
Fibula	Mainz, Germany	24.45	0.20	none	20 B.C.
Needle	Southwark, England	13.00	1.03	1.07	100 A.D.
Earring	Euboea, Greece	10.87	0.91	0.75	" " "
Fishhook	Putzig, Germany	8.48	2.59	none	150 " "
Fibula	Rhineland, Germany	8.22	2.00	1.70	" " "

make possible the dating of other kinds of objects closely associated with such coins. Since there are strong reasons for believing that all Roman brass was produced in the mints and that the coins themselves were the usual, and perhaps the sole, source of metal for manufacturing other brass objects, it seems likely that these also might be dated in the same way. An interesting possibility is the dating of the many small brass objects that have been found, and are still being found, in the outlying parts and beyond the borders of the area covered by the Roman Empire. It has long been suspected from their weight and chemical composition that these objects were fashioned from Roman coins received in trade by peoples who had less use for the coins than for the various ornamental or useful small objects that readily could be made from them. Some partial analyses of such objects are listed in table 4. Numbers 1 and 3 were analyzed by Fellenberg (1861, 1863), No. 2 by Church (1865), No. 4 by Helm (1895) and No. 5 by Bibra (1869). The dates shown in the table, based on the proportions of zinc, tin, and lead in the objects as compared to those in coins of known date, are suggested lower date limits, that is dates prior to which each of the objects probably could not have been made. The actual dates of manufacture were possibly a few years or even decades later, since it is likely that the coins did not reach the regions where the objects were made until some time after they were struck, and there is also the possibliity that the coins were kept for some time before being fashioned into other objects. In spite of these elements of uncertainty, the possibility now exists at least for suggesting lower date limits for objects of a kind that previously could not be dated in any way from internal evidence. Obviously this method of dating is safest when applied to a group of similar objects rather than to an isolated individual object which might accidentally deviate widely in composition from the average or normal object of its period.

Analyses of undoubtedly genuine Roman brass objects are also useful for detecting forgeries of such objects. Partial analyses of two forged objects are shown in table 5. The coin was analyzed by Göbel (1842) who apparently did not suspect that it might be a forgery. However, no other example of a coin of this type is apparently known, which in itself should be a cause for suspicion. Its

TABLE 5

Composition of suspected objects

Description	Zn %	Sn %	Pb %
Coin of Julius Caesar	10.50	5.89	1.70
Bust of Germanicus	15.34	10.33	4.45

chemical composition is radically different from that of genuine coins of Julius Caesar, which have been found to contain the highest proportion of zinc of all Roman brass coins and very little tin or lead. Both the type of the coin and its composition agree in indicating a forgery. The metal of the bust was analyzed by the author. The zinc content is lower than that of genuine objects of the early part of the first century A. D., and both the tin content and lead content are very much higher. In fact the composition of both these objects is very different from that of any known genuine Roman brass object.

LITERATURE CITED

Bibra, E. von. 1869. Die Bronzen und Kupferlegirungen der alten und ältesten Völker. Erlangen. p. 70–71.

Church, A. H. 1865. Analyses of some bronzes found in Great Britian. Jour. Chem. Soc. 18: 216.

Fellenberg, L. R. von. 1861, 1863. Analysen von antiken Bronzen. Mitteilungen der Naturforschenden Gesellschaft in Bern, 1861: 173–187; 1863: 135–142.

Göbel, F. 1842. Ueber den Einfluss der Chemie auf die Ermittelung der Völker der Vorzeit oder Resultate der chemischen Untersuchung metallischer Alterthümer. Erlangen. p. 30.

Helm, O. 1895. Chemische Untersuchung westpreussischer vorgeschichtlicher Bronzen und Kupferlegirungen, inbesondere des Antimongehaltes derselben. Z. für Ethnologie **27**: 2.