CHEMICAL COMPOSITION OF ANTONINIANI OF TRAJAN DECIUS, TREBONIANUS GALLUS, AND VALERIAN[1]

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The principal silver coin of the Roman republic and the early empire was the denarius. In the time of the republic and during the reign of the first few emperors this coin consistently contained a very high proportion of silver. Gradual debasement began at about the time of Nero (54–68 A. D.) and subsequently increased with slow acceleration, until at the time of Caracalla (211–217 A. D.) the silver content was down to about 60 percent. This emperor introduced a silver coin of new denomination known as the antoninianus, which was equal to 1½ denarii in weight but contained about the same proportion of silver as the denarius. The weight of silver in this new coin was about equal to that in the denarius of the middle of the first century A. D.

However, the same forces which caused the debasement of the denarius apparently continued to operate, for the antoninianus in turn began to be debased very soon after it was first issued. As is shown in table 1, this debasement at

TABLE 1

Weight and Fineness of Antoniniani Issued Prior to About the Middle of the Third Century A. D.

Emperor	Date	Average Weight	Average Silver Content	
		gm.	%	gm.
Caracalla	211–217	5.01	58.9	2.95
Elegabalus	218–222	5.10	42.8	2.18
Alexander Severus	222–235		None issued	
Maximinus	235–238		None issued	
Gordian III	238–244	4.42	41.7	1.84
Philip I	244–249	4.18	43.7	1.83
Trajan Decius	249–251	4.02	41.9	1.68

first took the form of a marked decrease in fineness, which was followed by a decrease in weight, the total result being a considerable decrease in the weight of silver in the coin over the period covered by the table. The data on the average weights shown in this table are those given by West (1941) and are derived from the weights of considerable numbers of coins. The data on the average fineness are based on relatively few coins and are largely derived from the results of fire assays first published by Rauch and republished by Bibra (1873). Apparently the proportion of silver in the antoninianus remained at almost a constant level from the time of the initial decrease up to about 250 A. D., but it must have dropped very rapidly between about 250 A.D. and 270 A.D., for the results of both fire assays and chemical analyses show that the proportions of silver in antoniniani issued in 270 A.D. and later are almost always less than 5 percent.

One purpose of the present investigation was to determine the exact time at which the second and final decline in the proportion of silver began to occur; the other was to make some careful chemical analyses of antoniniani since no really

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satisfactory analyses have been available. It is true that Bibra (1869, 1873) made a number of analyses of such coins, but the procedures he used were in various respects defective. His most satisfactory analyses are shown in table 2. Those excluded were made on corroded coins that contained considerable silver chloride, for such analyses are very probably not representative of the composition of the original coinage alloys. As with nearly all the chemical analyses of ancient alloys published by Bibra, the summations shown in the table total to exactly 100 percent, either because some one component was determined by difference or because the analytical results were prorated to obtain this exact summation. Aside from the errors introduced by this undesirable practice, the correctness of certain of his determinations may be questioned in other grounds. For example, most of his results for nickel are probably much too high, as is indicated not only by the method of determination he employed but by the results of the present investigation. However, it is likely that his results for silver are essentially correct.

TABLE 2

Analyses of Antoniniani by Bibra

Coin No.*	Ag %	Au %	Cu %	Sn %	Pb %	Fe %	Ni %	Zn %	Sb %
1	47.52	0.37	50.31	0.42	0.83	0.55	tr	——	——
2	21.43	1.53	75.86	0.11	0.46	0.30	0.31	——	——
3	17.31	——	81.83	tr	0.85	0.01	tr	——	——
4	12.14	tr	86.42	0.88	tr	0.10	0.44	——	0.02
5	6.01	tr	87.88	0.77	3.00	0.10	0.13	2.11	tr
6	5.02	——	92.20	0.42	0.51	0.37	0.33	1.15	——
7	4.89	——	93.64	0.50	0.27	0.08	0.62	tr	——
8	4.22	——	88.07	5.17	2.27	0.27	tr	——	——

*Attributions and Notes

No. 1. Philip I, 244–249 A.D. Bibra, 1873, p. 37.

No. 2. Valerian, 254–260 A.D. Bibra, 1873, p. 37.

Nos. 3 and 4. Posthumus, 259–267 A.D. Bibra, 1869, pp. 64–65. No. 4 also contained a trace of arsenic.

Nos. 5, 6 and 7, Gallienus, 260–268 A.D. Bibra, 1869, pp. 64–65. No. 5 contained a trace of cobalt, and Nos. 6 and 7 each a trace of sulfur.

No. 8. Claudius Gothicus, 268–270 A.D. Bibra, 1869, pp. 56–57. This coin also contained a trace of sulfur.

The figures for percentages of silver shown in tables 1 and 2 indicate clearly that the second marked decline in the fineness of the antoninianus must have begun sometime in the decade beginning with 249 A.D. However, because of the lack of chemical analyses of antoniniani of this period, the exact determination of this time has not been possible up to now. Therefore, twelve coins representative of the antoniniani issued by the principal rulers of this period were carefully analyzed. These coins, which were obtained by purchase, were in very good to very fine condition and could be accurately attributed to the rulers who issued them. By the method of analysis employed, which was essentially that outlined in a previous publication (Caley, 1950), all the principal components and all the usual minor components of the coinage alloys were accurately determined. The results are shown in table 3. Numbers 1a to 4a inclusive were coins of Trajan Decius (249–251 A.D.); numbers 1b to 4b inclusive were coins of Trebonianus Gallus (251–254 A.D.); and numbers 1c to 4c inclusive were coins of Valerian (254–260 A.D.). Each of the individual percentage figures for the components of these coins shown in the table is the average of two closely agreeing determina-

tions, and consequently each average percentage figure is based on eight determinations.

The sharp decline in the proportion of silver in the antoninianus in the period from 249 A.D. to 260 A.D. is clearly evident from both the individual and average figures shown in table 3. On the basis of these average figures this decline amounts to approximately 50 percent. However, by reason of the rather wide range of the individual figures for the coins of each emperor, it is obvious that a great many more analyses of coins of these emperors need to be made before exact average figures can be obtained and an exact figure given for the percentage decline in the proportion of silver. These rather wide variations in the proportion of silver in the coins of each emperor may be due merely to accidental variations in composition because of lack of proper control in minting, but this does not seem an adequate explanation since the fineness of Roman coins in general was controlled moderately well. A more likely explanation is that the proportion of silver in the coins not only decreased from reign to reign but also within each reign. In other words,

TABLE 3

Results of Analyses

Coin No.	Ag %	Au %	Cu %	Sn %	Pb %	Fe %	Ni %	Zn %	Total %
1a	42.21	0.33	56.18	0.11	0.43	0.08	0.08	0.11	99.53
2a	39.53	0.30	59.02	0.43	0.48	0.16	0.04	0.09	100.05
3a	38.33	0.27	59.00	1.40	0.64	0.11	0.04	0.11	99.90
4a	21.52	0.71	74.93	1.45	1.05	0.05	0.04	0.51	100.26
Av.	35.40	0.40	62.28	0.85	0.65	0.10	0.05	0.21	99.94
1b	36.80	0.17	61.31	0.65	0.50	0.10	0.03	0.05	99.61
2b	35.28	0.48	61.83	1.25	0.80	0.05	0.06	0.08	99.83
3b	29.96	0.22	65.94	2.63	1.07	0.03	0.05	0.09	99.99
4b	23.76	0.19	73.87	0.74	0.72	0.10	0.06	0.49	99.93
Av.	31.45	0.27	65.74	1.32	0.77	0.07	0.05	0.18	99.85
1c	24.44	0.24	73.44	0.78	0.75	0.08	0.07	0.08	99.88
2c	17.32	0.16	79.87	1.63	0.91	0.07	0.06	0.05	100.07
3c	15.10	0.15	80.87	2.74	1.02	0.13	0.06	0.04	100.11
4c	14.92	0.14	83.60	0.18	0.55	0.31	0.05	0.09	99.84
Av.	17.95	0.17	79.45	1.33	0.81	0.15	0.06	0.07	99.99

coins of higher fineness were issued earlier and those of lower fineness later in a given reign. However, the usual minor variations in fineness due to lack of very close control probably occurred also. If this explanation for the rather wide variations in the proportion of silver is substantially correct, chemical analysis would appear to offer a means of dating antoniniani of the emperors of this period more closely than is now possible from the inscriptions alone. Contrary to what seems to be indicated by the data of table 1, the second marked decline in the proportion of silver in the antoninianus had its beginning with the reign of Trajan Decius. Hence, with a possible error of a year one way or the other, the date of the beginning of this decline was 250 A.D.

The percentages of gold shown in table 3 are somewhat higher than might be expected in ancient silver coins of such low finenes. Though gold is nearly always present in ancient silver coins, the ratio of the percentage of gold to percentage of silver does not usually exceed about 0.005, and is very often less. But in these antoniniani as a whole this ratio is about 0.010. The actual ratios for each of the coins, as well as the several average ratios, are shown in table 4. The ratio for number 4a is unusually high and has not been included in computing the

averages since it is clearly atypical. If it were included, the overall average ratio would be 0.011 instead of the 0.009 shown in the table. Since there is a general tendency for the ratio of gold to silver to increase as the percentage of silver decreases and the percentage of copper increases, some of the gold in the coinage alloys was evidently introduced along with the copper or copper alloys that were used for debasement. A possible source of such gold could have been small proportions of gilded bronze or copper in scrap metal used for debasing the coinage alloys. Whether an unusually high ratio of gold to silver, such as was found for these coins, is characteristic of late Roman silver coins in general cannot be known until many additional careful analyses of such coins have been made.

TABLE 4

Ratios of Gold to Silver and of Nickel to Copper in the Coins Analyzed

Coin No.	% Au / % Ag	% Ni / % Cu
1a	0.008	0.0014
2a	0.008	0.0007
3a	0.007	0.0007
4a	[0.033]	0.0005
Av.	0.008	0.0008
1b	0.005	0.0005
2b	0.014	0.0010
3b	0.007	0.0008
4b	0.008	0.0008
Av.	0.009	0.0008
1c	0.010	0.0010
2c	0.009	0.0008
3c	0.010	0.0007
4c	0.009	0.0006
Av.	0.010	0.0008
Gen. Av.	0.009	0.0008

As may be seen from the data in table 3, copper was the principal metal used for debasing the coins. The percentages of tin, lead, and zinc are generally too low and the ratios of these to the percentages of copper too small to indicate that brass or bronze in the form of coins or in any other form was used exclusively for this debasement. Brass or bronze in small proportion may have been used, but the indications of the data are that impure copper was the principal material used for debasement. Probably this was added in the form of scrap metal or old worn coins from previous reigns, since the use of new metal for this purpose at this period seems unlikely.

The relationship that the percentages of nickel bear to the percentages of copper appears to be the only one among the percentages of the base metals that is in any way regular or systematic. As may be seen from table 4, the average ratio of these percentages for the coins of each emperor is the same. This indicates that the nickel is associated only with the copper in these coinage alloys. In all likelihood it was contained in the ores from which the copper was smelted. The actual percentages of nickel are very different from those found by Bibra (table 2) in his analyses of coins of this class.

In table 5 are listed the weights of the coins that were analyzed and their actual silver content in grams as computed from these weights and the corresponding

percentages of silver. It will be seen that the average weight of the coins of each of the three emperors is substantially the same. On the basis of proportion of silver the intrinsic value of these antoniniani for this period was reduced a little less than 50 percent (actually 49.4%) and on the basis of silver content by weight a little more than 50 percent (actually 51.7%). Evidently the intent was to decrease their value solely by decreasing the proportion of silver and not by decreasing their weight.

TABLE 5

Weight and Silver Content of Coins Analyzed

Emperor and Date		Weight gm.	Silver Content %	Silver Content gm.
Trajan Decius				
249–251 A.D.		3.64	39.5	1.44
		3.61	42.2	1.52
		3.46	38.3	1.33
		3.12	21.5	0.67
	Av. =	3.46	35.4	1.24
Trebonianus Gallus				
251–254 A.D.		3.86	23.8	0.92
		3.34	36.8	1.23
		3.18	35.3	1.12
		2.79	30.0	0.84
	Av. =	3.29	31.5	1.03
Valerian				
254–260 A.D.		3.85	14.9	0.57
		3.48	24.4	0.85
		3.42	17.3	0.59
		2.68	15.1	0.40
	Av. =	3.36	17.9	0.60

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