The development of the Roman Imperial coinage alloys during the third century AD

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Our story begins in reality towards the close of the second century - since it was in AD 193 that Septimius Severus, faced with economic difficulties, took the drastic step of a more severe debasement of the silver denarius (the principle coin of the Roman Empire) than any of his predecessors since Nero.

The earlier denarii of Septimius had been minted in plain silver-copper alloys made by diluting a libra bar of silver with 5 unciae of copper - thus rendering the alloy nominally 12/17, or 70.6%, fine. In this one fell swoop Septimius actually trebled the amount of copper added to the libra of silver - from 5 to 15 unciae (as show by Guey's analyses of coins minted both before and after AD 193), thus making the alloy so base that its modern metallurgical description changes from 'silver-copper' to that of 'copper-silver' - since the silver content was henceforth destined to be the lesser alloy component. At 44.4% this was to be the prelude to further debasements, and to later alloy and surface coating developments, as emperors made desperate attempts to whiten silver coinage alloys which began to look more and more coppery as their debasements proceeded. These alloys corrode more readily due to their copper content.

We emerge then, at the beginning of the third century of the Christian era, with a debased but simple binary copper-silver alloy, whose oxidation characteristics in the various stages of button melting, flan preparation, blanching in acid and hot-striking, led fortuitously to the consolidation of a superficial layer of silver on the surface of the coins, so long as the microstructural silver-phase was sufficient to remain continuous with itself and with the enriched surface silver. This is illustrated by the following slides ....

This fortuitous metallurgical phenomenon continued to be exploited by succeeding Roman Emperors, who, faced with the age-old problem of balancing national income and expenditure, resorted to a repetition of the inflationary device of debasing the alloy of the coinage - thus apparently conserving silver, but always consuming it and issuing more coins in the process. Since debasement can proceed to somewhere between 8 and 12% of silver before the silver-rich phase becomes completely discontinuous (and so incapable of leaving a complete surface layer on conventionally hot-struck coins) this is the extent to which debasement proceeded, in easy stages, for some 50 to 60 years.

The chronological decline is revealed by some outdated and not too reliable assays completed by the beginning of this century and compiled by J.Hammer in 1912, but which, nevertheless, fairly reasonably represent the downward trend over several centuries. They blur the real detail, however, particularly for the swift decline during the decade of the sole reign of the Emperor Gallienus AD 258-268, and the ultimate nadir, under Claudius II in the succeeding two years followed by the moderate two-stage reform of Aurelian, in 272 and 274; and a stable 20 years before Diocletian's reform of AD294 restored a real silver coinage on the Neronian 1/96 libra weight standard of 230 years earlier, together with an abundance of silvered bronze.

Metallurgical interest, however, begins with the development of new silver denomination alloys in the middle of the third century, and of the influence the inflation had upon the lower copper alloy denominations, which gradually became more expensive to make in the old alloys and sizes, and fully ceased to be produced. "When silver is virtually bronze, what can become of the bronze."

In AD 214 the Emperor Caracalla introduced a new silver denomination which gradually displaced the hallowed denarius. It was distinguished by the radiate crown (in place of a laurel wreath) on the obverse image of the emperor. It was also minted at exactly 1.5 times the weight of the denarius. Numismatists still argue whether it was worth, in face value, 1.5 or 2 times that of the denarius; and, in an attempt to resolve this problem, I analysed nearly contemporaneous coins of both denominations, and found them to be minted in an identical copper-silver alloy. Intrinsically, then, the antoninianus - as it has come to be called - was

originally worth 1.5 times the denarius, in terms of its silver content, but it could quite well have been tariffed as a double piece - which is what the radiate image on earlier imperial bronze coins had always indicated - and to the financial advantage of the Treasury.

Not long after its introduction the antoninianus was also debased; and we discover that by the middle of the third century small proportions of tin - of no more than about 2% at first - began to be added to the coinage alloys. Not until the sole reign of Gallienus, however, were tin levels raised to 6% or more as the silver content declined further - reaching ~8% (or one ounce to the pound) when the silver content fell to its lowest level of about 2%. Now the addition of tin to a copper-silver alloy (and particularly if a similar proportion of lead is present as in much of the coinage) has the effect of substantially reducing the malleability, and hence increasing the incidence of edge and radial cracking of the Gallienic antoniniani. The late Professor A.H.M.Jones, of Cambridge, in his history of the Roman Empire was moved to describe this as a “vile coinage and virtually copper”. His metallurgical description of the material is now known to be incorrect, but we can excuse an historian who was judging a metal entirely by its appearance; but few would disagree with the description “vile”. Here is a slide or two of the better pieces, showing how all semblance to a silver denomination was finally lost due to the considerable metallurgical adjustments made to the alloy in the short space of 3 or 4 years when the worst inflation was at its height. Note the rough and defective fabric of the later piece made in an argentiferous leaded bronze.

In some empirical way the alloy composition was eventually optimised at a maximum tin content of around 8%; but in AD 268-70 Claudius Gothicus took the coinage to its metallurgical nadir by adding even more lead - to the stage where it oozes out of the microstructure, as beads of liquid metal, if a coin of Claudius is gently heated. Since the insoluble lead-phase is anodic to the remainder of the alloy in aqueous corrosion conditions, and particularly if they are non-aerated, it is not surprising that many of the coins of Gallienus, and almost all those of Claudius, are to be found nowadays encrusted with lead-rich corrosion products deep into the coin. Indeed some are now so friable that they will break with finger pressure.

From this pathetic situation the succeeding Emperor Aurelian extricated himself - for his coinage alloys show a remarkable return to much better optimised proportions of lead and tin (~3-5%) as well as in improvements in the silver content (up to nearly 4%) which had the fortunate effect of refining the overall grain size and the uniformity of the microstructure. But the improved silver proportions did not show on the surface of the minted coins, although the mark XX· I - which has been variously interpreted, but which I believe matches a declaration of 20 obols of silver to 1 libra of bronze - and is confirmed by numbers of analyses of the XX· I pieces, - distinguishes the reformed coinage minted for the next 20 years, AD 274-294.

Numerous explanations have been given for the silver coatings which appear on all the post Aurelianic reform radiate coinage of similar base alloy compositions. They have been mistaken for tin coatings and various enthusiasts have experimented with amalgamation and wet chemical and paste treatments, hot dipping and oxidising and blanching experiments. But the original secret process is not recorded, and none of the laboratory experiments had succeeded in reproducing both the composition and structure and bonding of the coatings on the coins themselves. Twenty-three years ago I directed my attention to this problem and have slowly come to the conclusion that the argentiferous bronze coins were silvered at the pre-striking stage by dipping the blanks for a few seconds in a pot of molten silver chloride - which would have been available to the Romans as the mineral called ‘horn-silver’. In contrast with the slightly finer alloys which derive their surface silver from their interiors, the electron probe microanalyses show the surface coating to consist of a thin layer sometimes containing tin, lead and silver. The thermodynamics are such that in molten silver chloride all the alloying constituents of a tin-lead bronze will be replaced by metallic silver at the reaction interface, and in the short time involved diffusion will not proceed to any significant depth but the silver will remain as a thin surface layer - generally of not much more than 5 microns in depth.

The base metal coinages of this period were in leaded bronze instead of the orichalcum of the first century or the zinc bronzes of the second: and this sestertius of Trebonianus Gallus is typical of their appearance.

The squarish shape of this period was once thought to be due to the blanks having been chopped from long cast strips; but their X-ray examinations (for lead segregation) and internal microstructure are much more consistent with their having been struck on vertically cast blanks having a squarish section somewhat spread by a flattening operation before striking. The structure is fully anoded alpha bronze with lead and duplex sulphide inclusions containing iron and zinc (if present) for zinc is a powerful desulphurer.

Perhaps you will allow me to conclude with a short reference to some work which is currently in progress on the metallic constitution of the later Alexandrian tetradrachms of the third century. Twenty years ago, Professor E.R.Caley of Columbus, Ohio, published a classical work on the chemical composition of the earlier tetradrachms; but since then no-one has attempted to study the later issues, to seek parallels in economic policy, or in practical metallurgy, with the contemporaneous Roman imperial coinage issues. Alexandria enjoyed the privilege of minting its own style of coinage from AD 20 until circa 297, under Emperors who possessed Egypt, and its abundant corn supply, as a special perquisite whereby they fed the Roman populace and kept them happy with “bread and circuses”. The influence of the economic problems of the empire at large on the coinage of Alexandria is only just beginning to be resolved. And, as we might expect, Alexandria was not completely sheltered from the coinage debasements and reforms which derived from Rome. But chronological parallelism is not to be found, and this makes the study the more fascinating - especially when we consider the consequent exchange problems, which brought the Egyptian bankers out on strike on at least one occasion.

Compared with the imperial coins, the Alexandrian tetradrachms were dumpy, and struck with a great depth of moulding - in true Greek style and tradition - despite close metallurgical similarity at the beginning of our period. By ~ AD 250 they comprised pieces of 1/36 libra (circa 9.03g) made in a plain copper-silver alloy debased to about 6 to 8% silver. Small proportions of tin are sometimes present, and zinc, but both are low enough to be regarded as impurities. The first dramatic change occurs in the sole reign of Gallienus when the silver content dropped swiftly, in 265; again in 266; and reached its nadir (at around 2% silver) in the final year of the reign. His successor Claudius Gothicus maintained this level, and it did not fall again until Aurelian recaptured Alexandria from the rebellious Vabalathus. Professor Caley gives two isolated assays of circa 1.4% silver for tetradrachms of Aurelian’s 4th year, which I can also confirm. This was the true nadir in fineness; for Aurelian went on to reform both the imperial and Alexandrian coinages within the next two years. His improvements in fineness (to around 3% silver), however, were doomed to failure at Alexandria, for Probus, within the next 4 years, reduced the tetradrachms to simple leaded bronzes - while preserving the Aurelianic fineness standard for the antoninianus coinage of the rest of the empire.

Our metallurgical interest centres, however, on the Alexandrian practices which followed Gallienus’ policy decision, in 265, to reduce the fineness - for the coinage alloys show an immediate increase in their tin contents. At first this amounted to little more than 2.5 to 3% with, occasionally, similar additions of lead. But once the concept of the tetradrachms as a true silver denomination was abandoned by Probus the proportion of tin was increased to 6% or more, and the lead likewise. The next stage seems inevitable - further increases in lead content such that the coin fabric of the Diocletianic issues is noticeably inferior, as manifest by rough coin rims possessing multiple edge cracks, into which corrosion has made further easy inroads in the majority of cases. So far I have obtained one analysis showing more than 22% lead in association with nearly 4% tin; but 16% or more of lead is common for the concluding tetradrachm coinage of Diocletian and Maximinian, whose general coinage reform of circa AD 294 tolled the knell of the tetradrachm era, for Alexandria became absorbed in the tetrarchic mint-city redistribution which marked the beginnings of a new phase in its minting of a

universal imperial coinage, based now on a new silver piece, with smaller denominations in argentiferous bronze, and the smallest in plain copper. This called for a dramatic change in Alexandria's minting metallurgy, as evidenced by my analyses of the post-reform coins issued right at the end of the third century, and into the fourth; for Alexandria now began to work with a high quality low-leaded argentiferous bronze for the principal follis coinage, which strangely, was matched in quantity only by the products of the mint of London, at the other extremity of the Roman Empire, for the Gallic and Central mints were then inclined to use much more tin and lead than was necessary for good long-lasting fourth century coinage bronzes.

Source note.
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