The Decline and Fall of the Roman *Denarius*

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The basic silver coin of the early Roman Empire was the *denarius*. By decree of Caesar Augustus in 15 B.C.E., it was nearly pure silver, 95%–98%, and had a fixed weight and value in relationship to the rest of the Roman monetary system. Over the next 270 years, the silver content of the *denarius* declined gradually and then precipitously to about 2%. This degradation occurred more rapidly in the provinces than in Rome. The microstructures of a series of Roman *denarii* taken from this time period are used to illustrate these changes.

The final stage of the *denarius* was a duplex plated coin with a nearly copper core and a silver surface. This produced a lower-cost coin with an apparent value equal to the previous ones. Eventually, the surface coating was so thin that it quickly rubbed off after the coin left the mint. By this time (280 C.E.), the silver coinage of the empire had almost totally lost its value and had to be reconstituted by Diocletion. Among the coins studied is an early duplex plated *denarius* of Caesar Augustus, probably an early forgery produced during his lifetime in clear violation of his edict.

INTRODUCTION

The coinage of the Roman Empire, even in its early periods, was relatively consistent and orderly. By 269 B.C.E. [1], it was based primarily on silver and copper coins, although gold coins also were occasionally minted. The original copper coinage was weight based, and was related to the Roman pound, the *libra*, which was about 325 g. The basic copper coin, the *as*, was to weigh 1 Roman pound. This was a cast coin of some size and subdivisions of the *as* were used, as will be described later. The copper coins are of note because the ghost of this unit is to be found in the British monetary system, which still uses the pound, abbreviated as £.

The other fundamental Roman monetary unit was the *denarius*. This was a silver coin initially worth 10 *asses*, but eventually equal to 16 *asses*. There were intermediate brass coins, the *sestertius*, four of which equaled one *denarius* (equal to four *asses*), and the *dependius*, which was equal to two *asses*. The *denarius* also lives on today, after a sort, in the British system of coinage as the abbreviation used for the pence, "d." The gold coin, when issued, was the *aureus*, and was equal to 25 *denarii*, or the *quinarius*, equal to $12\frac{1}{2}$ *denarii*.

While the as was a cast coin in the early part of this period, it was an inconvenient unit and did not facilitate trade with the economic world of the time, which already used struck coinage. Thus, the smaller denominations were all wrought coins, as the *as* itself became, in time, as its size and weight decreased over the next 200 years.

By the time of Julius Caesar, the system was badly out of control. The *as* had shrunk to one Roman ounce ($\frac{1}{12}$ *libra*), and Caesar Augustus (Octavian) in 15 B.C.E. established monetary decrees that stabilized the system [2]. The relationship between the coins remained as described earlier, but the *aureus* was set at 7.5g, the *denarius* at 3.9g, the *as* at 10g, and the *sestertius* at

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24g (not at 40g, as might be supposed). This was not necessarily intrinsic value coinage, because the metal value between silver and copper was about 240 to 1.

THE ROMAN *DENARIUS*

The basic Roman silver coin, as described earlier, was the *denarius*. In size, it was a little larger than a dime, about 20mm diam., and in the republican and early empire period was of a high level of fineness (purity), about 95 wt.%–98 wt.% silver. This was maintained through the reform of Augustus. To provide an idea of the value of this coin to Romans, a Roman army private in the time of Augustus earned between 200 and 300 *denarii* a year, paid every 4 months. An officer could earn 10,000 per year; a high officer, as much as 25,000 [3]. As is true of military bureaucracies everywhere, the private never saw much of it. Because he had to pay a number of deductions for food, uniforms, and even funeral expenses, should he not survive to retirement, he finally received only 15–20 each payday—and the next payday was 4 months away!

The attraction of service in the army was, at first, not monetary but patriotic. As time passed, the army was increasingly made up of career soldiers. By the time of Augustus, the army numbered about 250,000 men, almost all in the army for life. The benefits were a steady, if hard, job; food; clothing; shelter; and a retirement after 20 or 25 years with an allotment of land (usually in a province). It included Roman citizenship (if the soldier did not already have this). In the Empire period, the last was an attraction because the Italian Roman Legions were gradually supplemented by large numbers of auxiliary forces drawn from conquered provinces. For these, citizenship was to be desired, not only for themselves, but for their children, because many were stationed more or less permanently on their own frontier and had families there.

Relating the *denarius* to the pay of the army is of great practical significance. The pressure of supporting, increasing, and eventually keeping the political favor of the legions became one of the primary reasons for debasement of the *denarius*. Other reasons included maintaining the imperial lifestyle, providing for public works and entertainments, and supporting grain imports. In the Later Empire, after 200 C.E., emperors ruled only through the support of the army, which now numbered 500,000. As the army demanded more and more for its maintenance, a very significant pressure was created for more coinage than there was bullion metal to support. Paying, or more accurately, paying off, the army was the name of the game. (During one 67-year period, there were 29 emperors, only 4 of whom died of natural causes.) The need for money was acute. The solution that quickly suggested itself was simply debasing the silver *denarius* with copper, a process that started in the 1st Century and increased for the next two.

COIN PRODUCTION AND AVAILABILITY

The coinage of the Roman Republic was under the responsibility of designated moneyers, but the actual coins were produced by a professional staff of skilled workers. In the republican period, coin production was the responsibility of the senate. With the birth of the Empire, the emperor took control of silver and gold coinage and left only the copper coinage to the senate. The work was originally done in association with the Temple of Moneta in Rome, but mints were later established in major cities in the provinces. The senate had given its military generals the right to mint coins to pay their troops in the 2nd Century B.C.E., so the mint also traveled with the army in some cases.

Die engraving and manufacturing of coins were already long-established technologies [1] by the time of the Roman Empire. Dies were made of iron and high tin bronzes, and coins were struck by hand, i.e., each coin blank was heated and struck individually between a hand-held upper die with the "reverse" pattern, usually a

god, a goddess, or a symbol, and a stationary lower die, with the "obverse" or portrait pattern. There was generally no particular angular orientation relationship between the two patterns. The blanks were usually cast in round flat molds. Because the priority at the mint was on production and not quality, the coins were not necessarily centered or well struck, although weights and compositions were relatively uniform at any time and location.

It is these latter characteristics that have made it possible to study the debasement of the *denarius* over time, even with only a relatively limited number of samples. The number of available samples is not small, however. If you consider the whole army of legionnaires and auxiliaries at the time of Augustus, 250,000 men, the total annual requirement of the army for silver *denarii* (or equivalent copper coins) was at least 75,000,000 per year! While there was considerable reuse of coins (some of which were melted down and later reissued) over a 500-year period, the number minted was enormous. If 1 in 15,000 of these coins persists until today (as has been estimated), then the number of samples available for study from, say, a 10-year period, could be as many as 50,000. This is why coin auctions today with thousands of *denarii* for sale are not uncommon, and a coin in reasonable, but not outstanding, condition ("fine"), can be purchased for as little as $50.00 for an emperor who ruled a relatively long time and consequently had a number of coins minted in his name. Poorer-quality *denarii* (broken, corroded, scratched, cut) can be purchased for as little as $10.00. The cost rises rapidly with condition and rarity, up to possibly several hundred thousand dollars. The key to preparing an article like this economically is therefore to select samples for study in poorer condition from the common emperors.

STUDIES OF THE *DENARIUS*

There have been many studies made concerning ancient Roman coinage from the historical, artistic, philosophical, political, technological, and economic viewpoints. From the metallurgical viewpoint, some outstanding studies and collections of studies have been produced. Important among these was a symposium held by the royal Numismatic Society in 1970 [4] dealing primarily with the chemical analysis of coins. Other comprehensive studies specifically of the *denarius* are available, both from the symposium papers described previously, and elsewhere [5]. This article proposes no such comprehensive study. As well demonstrated in an article by Cope [6] in the 1970 Symposium proceedings, a truly comprehensive study of debasement of coinage can only be undertaken using a large number of samples and relatively sophisticated chemical analysis techniques. The latter are required because of selective corrosion effects, differences in manufacturing techniques, normal variation in composition resulting from mint practice, and the tendency to use duplex coins in the later empire period. Fortunately, the excellent work on chemical analysis by Cope and others has provided us a base on which to stand and allows a useful study even with a limited number of samples.

The purpose of this article is to illustrate the results of changes in the minting standards of the Roman *denarius* through selected examples. The emphasis is on microstructure and what it can tell us about the manufacture, composition, and changes in these coins in their historical context. Bulk chemical analysis was not attempted, although much about compositional changes can be understood from microstructure. Indeed, in some instances, bulk chemistry alone would be less helpful. Microchemical methods were also not undertaken, and some reasons for not using these techniques are listed in detail by Cope [6]. These primarily rest on the complexity of coin processing and corrosion, which rendered the final local composition of the coin quite different from its original one. Microchemical analysis would undoubtedly have added to the

study, but it was judged that microstructural analysis, supplemented by the prior chemical analysis studies, was sufficient to understand the means used for the devaluation of the *denarius*.

COIN SELECTION AND PROCEDURES FOR THE STUDY

The chemical analysis record for Roman silver coins has been fairly well established and the results, shown in Fig. 1, are a composite from a number of sources [2, 5, 6]. Based on this work, the procedure in coin selection for this study was to obtain some representative samples from critical time periods in the history of the silver issues that would illustrate the reported changes in silver content. Ultimately, 13 coins were selected for study. These included coins for M. Tullia (109 B.C.E.); Julius Caesar (54–51 B.C.E.); Augustus (29 B.C.E.—14 C.E.); Nero (54–68); Titus (79–81); Trajan—two coins (98–118); Faustina I, wife of Antonius Pius (138–141); Caracalla (211–217); Severus Alexander (222–235); Trajan Decius (249–251); Postumus (259–268); and Aurelian (270–275).

The position in time of these coins, indicated in Fig. 1, spans the late republic (Tullia) to just before the monetary reform of Diocletion (286). They are intended to correspond to reported change in composition and also to confirm the periods of relative constancy in fineness. The fineness of the *denarius* declines gradually from Tullia through Caesar, Nero, Titus, and Trajan up to the time of Antonius Pius, after which it starts a sharp decline to the level characteristic of the coins of Caracalla. The next drop corresponds to the reigns of Trajan Decius, Postumus, and finally Aurelian. The coins selected should show by their microstructure the gradual decline over 250 years, and then the precipitous drop over the next 100 years.

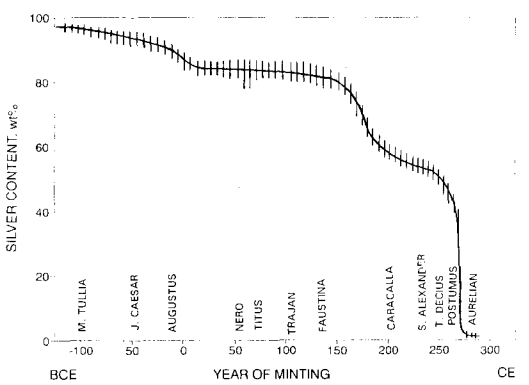

FIG. 1. The changing silver content of the *denarius*.

We are aided in this analysis by the fact that this was basically Ag–Cu coinage and by the nature of the Ag–Cu system (Fig. 2). This is a simple eutectic system, with some solid solubility on each end of the diagram. Thus, the nearly pure Ag Tullia *denarius* should be a solid solution alloy, but coins with more than 9 wt.% (15 at.%) Cu should be within the eutectic region. If one assumes the coin blanks were cast and were not able to come to equilibrium at a lower temperature, microstructure can be used to estimate position in the phase diagram, and thus, roughly, composition. This was done by point counting fields from the specimens to determine percentage of primary phase and eutectic or the amounts of each phase. The equilibrium assumption may not be entirely accurate, because we have some reason to believe the coin blanks were reheated for striking, but it is still a reasonable one for the purposes of this analysis. As will be seen, the cast structure appears to have come through the striking process substantially unaltered in many instances.

The coins were prepared using standard metallographic techniques. These included, for most samples, mounting and grinding through 600 grit SiC paper, polishing with 6 μm diamond followed by 0.3 μm Al_2O_3 or 1 μm diamond and finishing by vibratory polishing with SiO_2. For the Cu–Ag alloy samples, ferric chloride etchant was effective, as was 2% nital with the high Cu samples. The high Ag sample required special chemical polishing using a saturated solution of chromic acid containing a small amount of hydrochloric acid. This sample was etched with a weak solution of potassium dichromate and sulfuric acid.

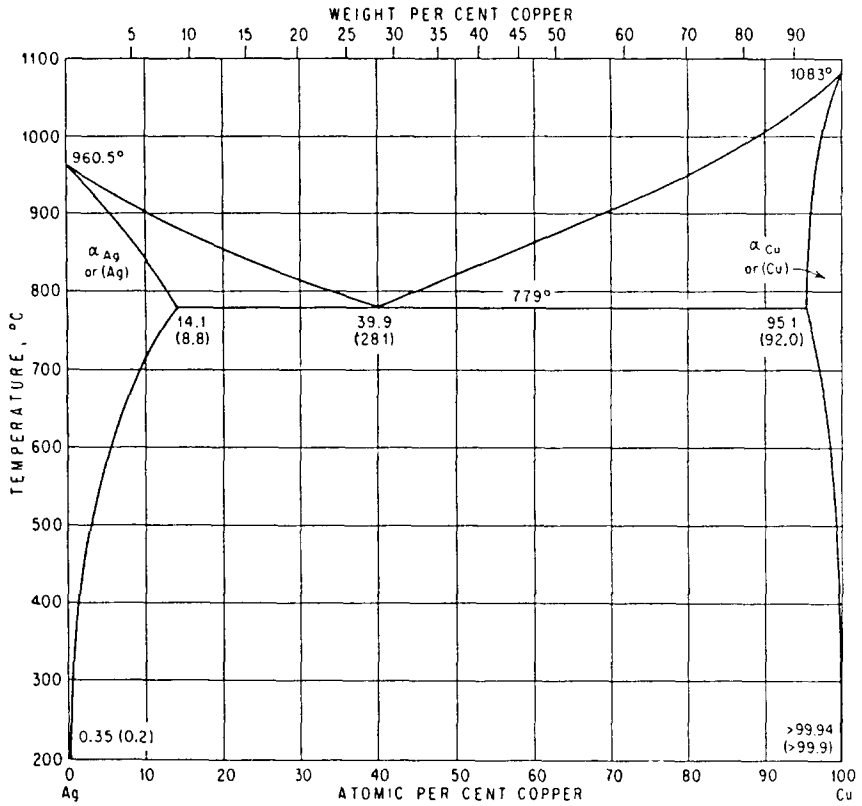

FIG. 2. The copper–silver phase diagram.

SAVING FACE WHILE REDUCING COST

For any coinage to circulate freely, it must be accepted. This is a subtle but real effect, as the promoters of the Susan B. Anthony $1 coin discovered. If the size, color, weight, or appearance of the coin are not acceptable, it will simply not circulate, at least not very far. For Rome, as for any state, its coinage had two audiences. The first was its citizens. Their acceptance was critical, but more controllable. They had little choice. This was not true for trade between nations. Large as the empire was, it still needed foreign acceptance of its money. The *denarius* had circulated very far (to India) and was widely accepted. It was in the emperor's best interest to maintain the acceptance of the coin, hence, to maintain its appearance. The more it looked like pure silver, as it started out to be, the better its acceptance. On the other hand, there just wasn't enough silver to go around, so the trick was to make the *denarius* look like pure silver when it was not.

Here, the rules of metallurgy favored the mint. First, in the solid solution region, the presence of copper was virtually unnoticeable. It made the coin harder, which was good, but not much less silver colored. An example of such a coin is the denarius of M. Tullius (Fig. 3). The microstructure of this coin is indeed a single-phased structure, consisting of relatively fine grains with some annealing twins present. This suggests that for this blank, mechanical working and heating prior to or during striking caused recrystallization.

There is a debate among numismatists about how much working was done to coin blanks after casting and before striking. Some, arguing from practical economics, say none was necessary because even globular blanks could be struck to coins if heated. This appeared to be the case with Greek coinage of early periods. Others,

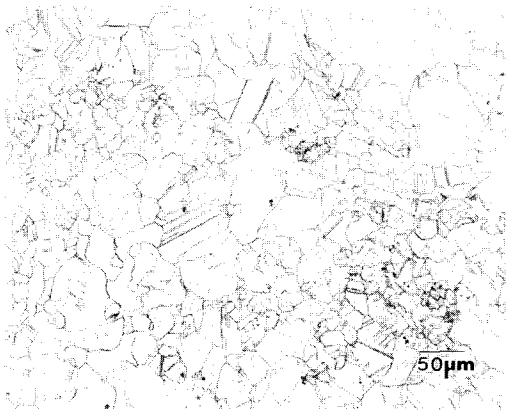

FIG. 3. *Denarius* of M. Tullia; single phase, <9wt.%Cu, $K_2Cr_2O_2$-H_2SO_4 etch.

based on evidence such as that shown here, argue that flattening of the blank and reheating before striking was common Roman practice. As will be seen later, the evidence of this study is not conclusive with respect to a standard Roman coining practice. Perhaps the practice was variable, depending on location and time.

For coins in the eutectic region of the diagram, other principles favorable to silver color in these coins applied. As might be predicted from the phase diagram, the continuous phase in the eutectic is the silver-rich one. Thus, even in the eutectic region, large amounts of copper (~30 wt.%) can be tolerated, and the "silvery" color of the coin is still maintained. An example of this is a denarius of Julius Caesar, the microstructure of which is illustrated in Fig. 4. This structure consists of primary Ag-rich dendrites with some Cu–Ag eutectic; the coin is about 14 wt.% copper. The effect of mechanical working is not evident in this coin.

At this point one would be inclined to ask, based on Fig. 1, if this is a coin minted prior to Augustus, why is it 86 wt.% silver, not 95 wt.%? The answer illustrates another general trend in the decline of the *denarius*. This coin was minted far from Rome. The farther from Rome, the less likely people are to know, care, or check on coin fineness. In general, the decline of the *denarius* always occurred first in the provinces. In this case, it probably was minted by Julius Caesar in the field for his troops. So even the first Caesar felt the economic pressure of maintaining the army. From the appearance standpoint, however, it was quite satisfactory, even if he did cheat a little on its inherent value.

Similar analysis of the microstructure of the coin of Titus (Fig 5) shows it to be about 12 wt.% copper. Once again, primary Ag-rich dendrites and some eutectic are present, with little effect of the coining process visible. Actually, Titus was said to have increased the silver content of the *denarius* after a decline under Nero, but this study did not confirm this claim.

If we now move across time, we should find little microstructural change in the *denarius* for Trajan, but this proves not to be entirely true. Two coins of Trajan were

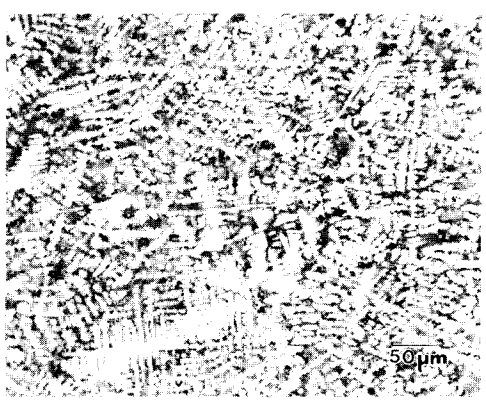

FIG. 4. *Denarius* of Julius Caesar; ~14 wt.%Cu, Ferric chloride etch.

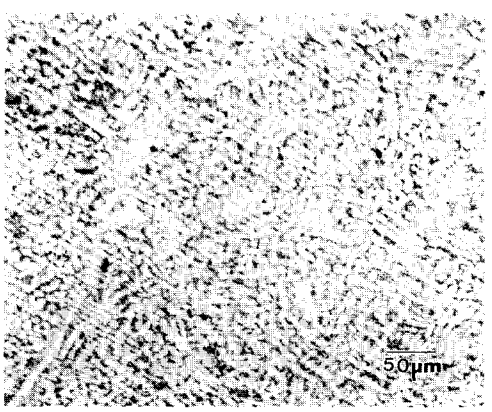

FIG. 5. *Denarius* of Titus; ~12 wt.%Cu, ferric chloride etch.

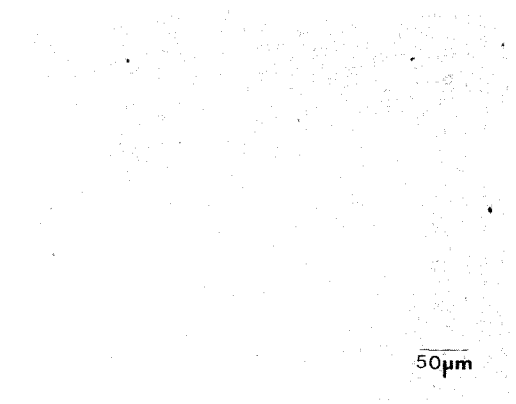

FIG. 6. *Denarius* of Trajan (Rome); ~14wt.%, ferric chloride etch.

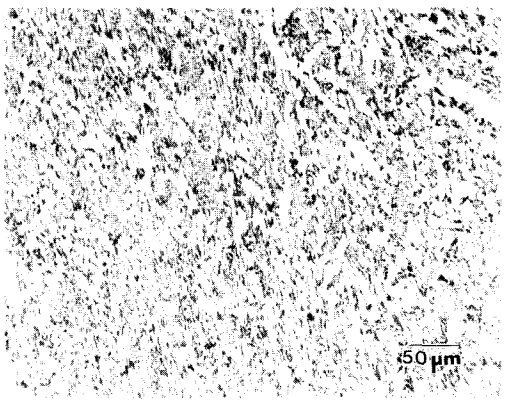

FIG. 8. *Denarius* of Faustina, ~22wt.%Cu, ferric chloride etch.

studied, one minted in Rome and the other in Caesarea in Cappadocia. The Roman coin (Fig. 6) has about the expected copper addition, 14 wt.%, while in the coin from Caesarea (Fig. 7), it is much greater. The microstructure consists of primary copper-rich phase with copper–silver eutectic. The structure indicates an alloy well to the copper side of the eutectic at about 50 wt.% Cu. Still, it looked reasonably good as a *denarius*.

If we proceed to the *denarius* of Faustina, wife of Antonius Pius, it should illustrate a coin of about 140 B.C.E., and should be about 80 wt.% silver, somewhat less than the eutectic. The microstructure of this coin (Fig. 8) demonstrates this to be true, although the coining process in this case appears to have left an aligned structure with the primary Ag-rich phase less evident and the silver-rich continuous phase in the eutectic more evident. This coin is also quite "silver" in appearance. The silver content is actually about 78 wt.% (22 wt.% Cu).

Progressing with time, we would now expect to find a substantial decrease in silver content. This proves to be true. Surprisingly, even if we move to a coin like that seen in Fig. 9, the *denarius* of Caracalla (211–217), with a content of 40 wt.%–50 wt.% copper and with a substantial amount of primary copper-rich phase in the microstructure, it retains enough "silver" appearance to be acceptable to most people as a silver coin. So far so good, as far as the mint and the emperor are concerned. The "continuous phase" was still

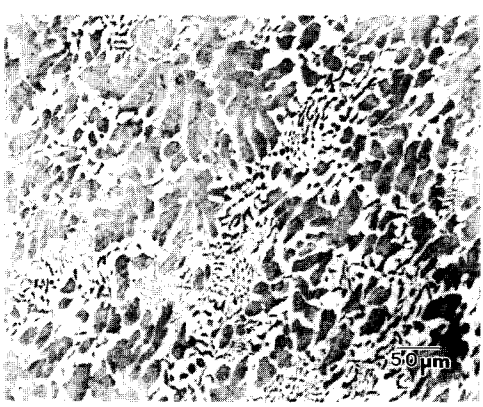

FIG. 7. *Denarius* of Trajan (Cappadocia); ~50wt.%Cu, 2% nital etch.

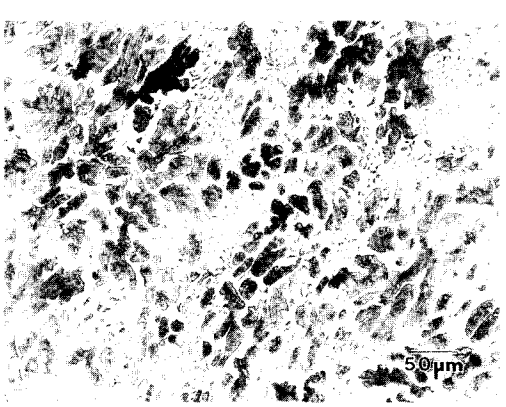

FIG. 9. *Denarius* of Caracalla; 40–50wt.%Cu, ferric chloride etch.

working for them, but it had about reached its limit.

The fact was, however, that the mint was increasing the apparent wealth of the Empire by simply taking money obtained from taxes or existing bullion and increasing its quantity by adding more copper, but very little silver, to the circulating coinage. Before long, people knew, and inflation began. The inherent silver content of older coins began to exceed their face value, and they were gradually converted to silver by citizens as well as being converted to cheap money by the mint. Thus an early example of Gresham's Law came into effect, i.e., bad money drove the good off the market.

This inflation resulted in the introduction of a new coin by the emperor we call Caracalla, the *Antoninianus*, or "double *denarius*" (named after himself, of course, Caracalla being his nickname, Antoninus his real one.) It was larger than the *denarius*, but weighed only about 5g (about 1½ *denarii*). It had no greater fineness, and this did little to improve things. This coin, being of equal fineness and twice the value, but only half again the weight of the *denarius*, also drove the *denarius* off the market and eventually became the "silver" coin used in commerce.

The story does not end here, because the need for coinage, and the things it bought, was ever increasing. The final step was one we have adopted even in modern times, the sandwich coin—silver on the outside and copper on the inside. The introduction of these coins corresponds to the precipitous drop in the silver value of the *denarius* between 250 and 260 C.E. The composite coin was probably made by hot dipping blanks of low silver content in a silver chloride bath before coining [7], or so it appears. The microstructure of one such coin of Trajan Decius is seen in Fig. 10. The external silver layer was relatively thick, probably about 0.1 mm, but corrosion has undermined much of it, leaving a gap from removed corrosion product and some attack of the underlying core.

In time, the coating became thinner and thinner. This is exemplified by the composite coin of Postumus (259–268) (Fig. 11). Here the external coating is relatively thin, a few microns. The zone between the coating and the core is, once again, probably a result of corrosion. The core, surprisingly, is not pure copper, but has a small amount of silver-rich phase present. In fact, there is no logical reason for this, but perhaps it represents some concession to the fact that this was supposed to be a "silver" coin, so it needed to have some silver throughout. Even the core of the coin of Aurelian (270–275) (Fig. 12) has some silver present (as well as some lead). This was apparently official mint policy, i.e., a small but intended amount of silver was still put into the *denarius*, or *Antoninianus*.

The use of "plated" or composite coins was not new; they had been found in isolated examples from the provinces for several hundred years before this time. We are not sure whether they are contemporary counterfeits or official products of mints in distressed circumstances [7], but they were rare. An example of one such *denarius* is shown in Fig. 13. This was officially a *denarius* of Augustus, the architect of the system through his edicts of 15 B.C.D. It is obviously not what he intended! Perhaps it is refreshing, in a way, to see that official edicts had as much power then as they do now. This was probably a forgery, but we do not know who profited, a clandestine entrepreneur or an unscrupulous mint master.

In the late 3rd Century, it was a different story. Now they were official and the only coin of the realm. The end of silver coinage was in sight. In the next few years, the external coating became thinner and thinner until it was nothing more than a thin silver wash, like that of the coin of Postumus, rubbed off by use shortly after the coin left the mint. The *denarius* had fallen completely. One gold *aureus* was equal now to about 2250 *denarii*. Only a major reform could save the monetary system. Diocletian's Reform starting at 296 C.E. did just this, creating a new life for silver coinage.

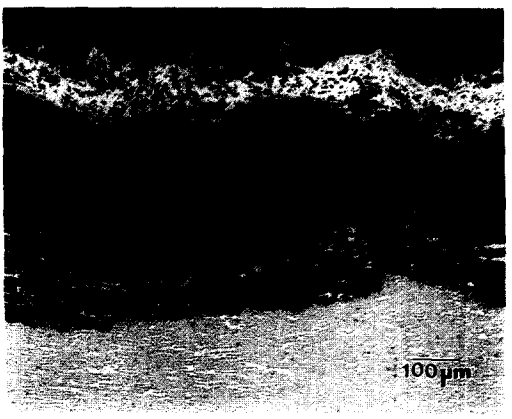

FIG. 10. Coin of Trajan Decius; 2% nital etch.

CONCLUSION

The fall of the *denarius* had a number of monetary and economic implications, only some of which are discussed here. The *denarius* retained its size, but it was now essentially copper. This made the larger copper coins (which now had a smaller face value but a similar composition and, thus, a greater intrinsic value) unstable. These were now driven off the market. Thus, as the *denarius* fell, it took other coins with it.

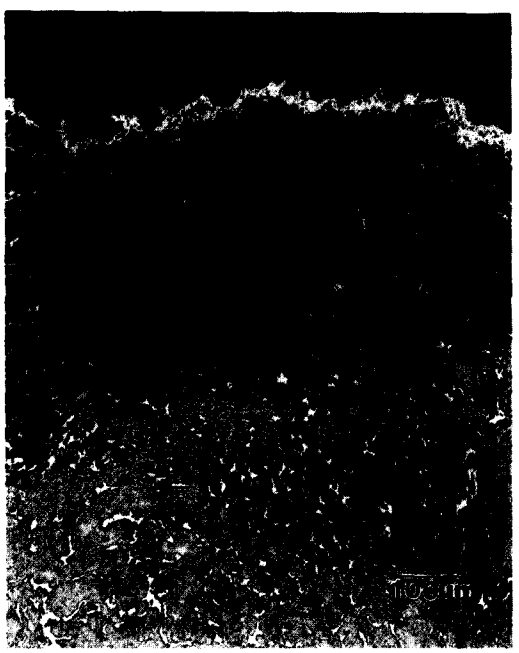

FIG. 11. Coin of Postumus; ferric chloride etch.

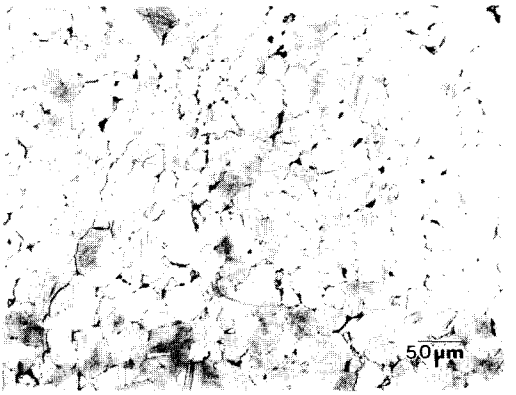

FIG. 12. Core of coin of Aurelian; ferric chloride etch.

It was a symptom of the times, a result of chronic overspending of the budget, something we still do.

The microstructures of these coins do tell an interesting story. Human nature has not changed too much over history. People still seek more for less, and history repeats itself. The copper–silver system served the emperor well because it allowed appearance to conceal fact. In the end, greed exceeded common sense, and it brought the monetary system down. This may, in the end, be the most useful lesson we can learn from this slice of history.

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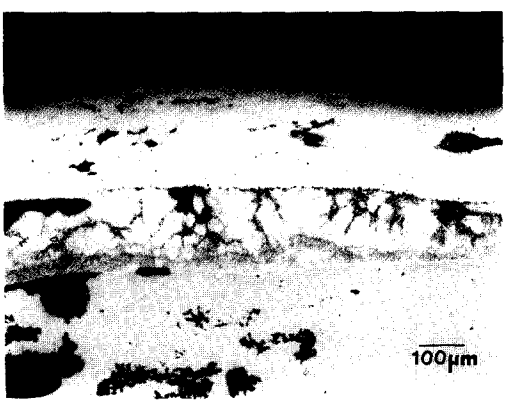

FIG. 13. Plated *denarius* of Augustus, unetched.

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