Statue of Liberty Blemished by Artificial Patina

To The Editor:

I read with great interest the article by Ambrose and Bendale on the beneficial aspects of environmental instability of materials in the September 1993 issue of the *MRS Bulletin* (p. 53–58). Their concluding remarks about the costs and benefits of the artificial patina developed for the Statue of Liberty deserve further discussion.

As the authors stated, significant effort was expended to find a suitable recipe to produce an artificial patina for those areas of the Statue where the original skin had to be replaced with patches of bare new copper. Eventually, these patches would develop a natural patina. However, for copper, this process can take decades. Therefore, the artificial patina was developed so that the Statue would have a uniform appearance for the 1986 celebration.[1] However, a few years later the artificial patina had vanished from the rain-washed areas. This indicates that the mineral assemblage in the artificial patina was not stable under the environmental conditions at the Statue's site.

This situation can be explained by consideration of the phase diagram for copper minerals under these conditions.[2] The stable mineral will be the copper hydroxy sulfate, brochantite [$Cu_4(OH)_6SO_4$], on areas where the surface is regularly washed with rainwater, while on those areas sheltered from rainwater the hydroxy chloride, atacamite [$Cu_4(OH)_6Cl_2$] will be stable. These two greenish-blue minerals have different hues and reflectivities. Therefore, the variations in the appearance of the Statue's patina from place to place result from this microclimate effect. Further consideration of this phase diagram leads to the counterintuitive conclusion that acid rain, at prevailing pH levels, has a negligible effect on the patina mineral assemblage.

The various recipes used to create the artificial patina on the Statue contained primarily chloride ions. Consequently, the patina would be predominantly copper chloride minerals. Even if the main mineral were atacamite, the patina would be unstable in rainwater. Simple copper chloride minerals would be even more soluble.

Sadly, this problem of an unstable artificial patina is not limited to the Statue of Liberty. In the last decade many outdoor bronze statues have undergone artificial patination. In this process the existing natural patina is sandblasted off, using any one of a number of abrasives.[3] The bare metal is chemically treated to produce an artificial patina, which is then usually covered by a protective wax or lacquer coating.[4] This drastic intervention is rationalized on the basis of two different kinds of arguments: corrosion protection and esthetics. The corrosion protection argument assumes that the existing corrosion layer contains reactive compounds that promote corrosion, and hence these must be removed to slow the corrosion rate. The esthetics argument is that patches and streaks of corrosion products and other deposits camouflage the sculptor's original design. Replacing these patterns with a uniform patina would make it possible to read the Statue as the sculptor intended.

However, the mineral stability diagram casts doubt on both these arguments. From a corrosion protection standpoint, the natural patina that develops over long periods of exposure is by definition the most benign because it consists of the minerals that are closest to equilibrium with the prevailing environmental conditions and thus produce the lowest dissolution rates. Artificial patinas such as those applied to the Statue are more soluble and thus increase metal loss. Regarding the esthetics argument, regardless of the sculptor's intent, the surface pattern that actually develops is determined by the local interactions between atmospheric chemistry and the flow of water and wind around the Statue. A uniform appearance can be imposed temporarily by artificial patination, but the original pattern will eventually reassert itself. An organic protective coating, unless it is regularly maintained, will eventually degrade. Thus it only slows down the process of recovering the natural patina.

Consequently, the patina eventually returns to its original condition, but in the process the loss of metal is temporarily accelerated, first by the sandblasting of the original patina, and second by the increased dissolution of the artificial patina. Thus the public suffers two kinds of costs, the monetary loss of paying for a futile artificial patination job, and the cultural loss of the reduced lifetime of the Statue.

Ambrose and Bendale's article describes the benefits that can be gained from understanding the environmental instability of materials. The experience with artificial patination of outdoor bronze sculpture shows the costs of failing to understand these environmental processes.

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References

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