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METALLOGRAPHIC EXAMINATION OF THE SAN GABRIEL BELL FRAGMENT

By COLIN G. FINK AND E. P. POLUSHKIN

Introduction

The bell fragment was submitted to us by Mrs. Marjorie F. Tichy, Curator of Archaeology of the Museum of New Mexico at Santa Fé. Mrs. Tichy reported that the fragment had been found some months ago at a site called San Gabriel del Yunque. This site is not far from the San Juan Indian Pueblo where the original capitol of New Mexico was founded by Oñate in 1598. The fragment was possibly part of a church bell of Oñate's San Gabriel Mission.

To establish more positive evidence of the old origin of the bell, we submitted the fragment to an examination of the metal, its workmanship and composition. We also examined the patina and other products of corrosion. It was presumed that on the basis of the information thus obtained it would be possible to form a definite opinion as to the age of the metal of the bell, in particular whether the bell had been made before or after 1598.

General Characteristics of the Fragment

The fragment is of triangular shape with a rounded front surface and a plain flat base (Fig. 1). The front view discloses a crudely designed baluster in relief. The maximum height of the fragment is approximately 3 inches, and the maximum width of the base is approximately 3 inches. The inside surface of the bell is concave and smooth.

The fracture is coarse-grained and somewhat unusual. (Figs. 2, 3, and 4), reflecting the poor quality of the alloy. It is very porous, especially near the base. There are numerous blow holes (Fig. 4). This indicates that the bell was a very crudely made casting.

The Patina

The patina is particularly interesting and noteworthy. The relatively smooth surfaces are covered with a continu-

ous thin layer of a lark green patina. The patina of the fracture is more variegated: Besides the green hydrous carbonate (malachite) there are the blue hydrous carbonate (azurite) and the red cuprous oxide distinctly visible. There are also some gray and brown mineral particles imbedded in the fracture.

Careful examination of the surface of the fragment did not disclose any artificial patination or vestiges of some other recent treatment of the specimen aside from scratches due to overzealous cleaning. It has the typical surface characteristics of a genuine old bronze. The malachite and azurite are products of slow disintegration or corrosion of the surface.

Microscopic Examination

In order to examine the structure of the metal under the microscope, a very small piece was cut off from a protruding section of the base. Its dimensions were approximately 7.5 mm. by 4.5 mm. The location of the sample is shown in Fig. 3.

The specimen was imbedded in mounting material and finely polished.

Examination of the polished section under the microscope proved that the fragment contains a considerable amount of lead, mostly mineralized. In Figs. 5, 6, and 7 which represent typical views, lead appears as dark shaded areas. The lighter areas represent copper oxide and some calcareous substance. Examination under polarized light revealed the presence of red copper oxide (Cu_2O) and black and gray minerals. At the edge of the polished section many foreign inclusions were revealed (Figs. 8-10). Very likely these were taken up from the soil in contact with the metal and cemented to the metal by silica solutions or by some other bonding material.

In order to develop the metal structure, the polished section was etched with ferric chloride solution plus hydrochloric acid. Figs. 11 and 12 show typical views of the microstructure after normal (Fig. 11) and after prolonged etching (Fig. 12). In both photomicrographs the back-

ground is a solid solution of tin in copper. Deeper etching (Fig. 12) proved that this solution is not entirely homogeneous. The white specks represent tin-rich constituent in excess (delta), and black areas represent lead.

This structure differs essentially from that of the modern bell metal which contains much more tin and does not contain lead. Due to this difference in chemical composition the modern bell metal has a large proportion of tin-rich component (delta & alpha) and is free from lead. On the other hand, lead is almost always found in old bronzes.

Summary

1. The examination of the surface of the bell fragment revealed a genuine, old, slowly formed patina, such as is frequently encountered on old bronzes that have lain buried in relatively dry soils. The patina contains the red oxide of copper and the two basic carbonates of copper (malachite and azurite). This patina requires some moisture for its formation. But on the other hand, too much rain will tend to disintegrate buried bronzes relatively fast.

2. Examined under the microscope the evidence is very clear that the bell fragment is composed of a genuine old bronze. Its structure and chemical composition differ from those of the modern bell metal or, for that matter, from the modern bronzes in general.

3. The date of the metal of the fragment cannot be definitely determined as earlier or later than 1598. Examination has revealed no "hall marks", no inscriptions, no numerals or initials of any kind. And secondly, the composition and metallographic characteristics of the fragment are those of bell bronzes extending over a period of many hundred years. Before the advent of modern metallurgy strict specifications as to composition of bell metal and casting procedure were either not available or else, seldom adhered to.

Conclusion

The bell fragment is composed of a lead-bearing bronze. The characteristic composition and metallographic struc-

ture of the bronze as well as the patina on the bronze definitely establishes that the fragment is very old. But whether it is a 16th, 17th or 18th century product cannot be determined due to lack of sufficient evidence. This evidence might be obtainable upon further excavation at the site where the fragment was found and discovery of other articles unquestionably assignable to 1598.

FIG. 1. Natural Size

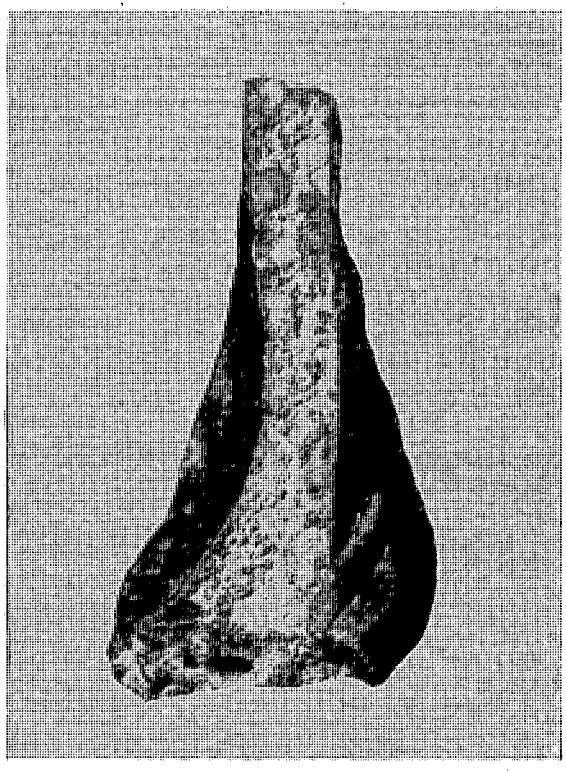

FIG. 2. Natural Size

FIG. 3. Natural Size

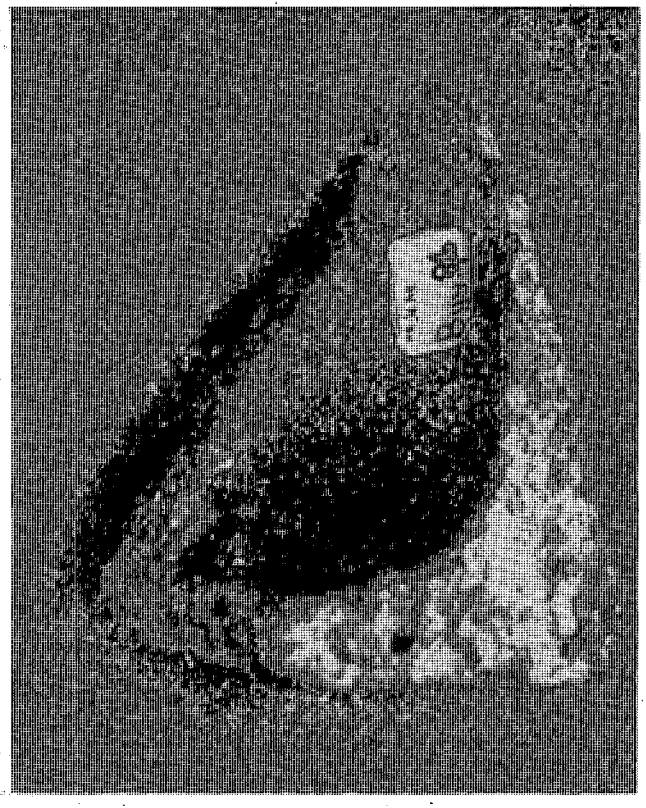

FIG. 4. Natural Size

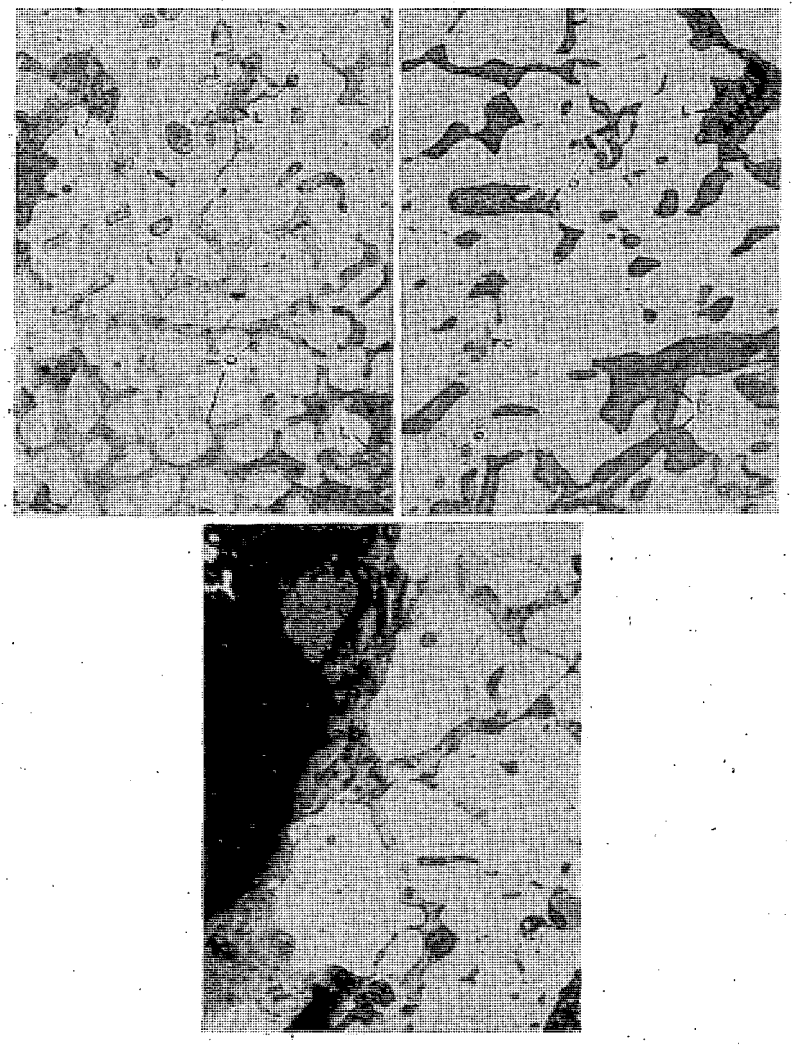

Fig. 5. Upper left. Unetched. x 200 dia.

FIG. 6. Upper right. Lead (l) and oxidation (o) products. x 200 dia.

FIG. 7. Lower. x 200 dia.

AGGLOMERATION OF FOREIGN PARTICLES ON THE SURFACE

FIG. 8. Upper left. Unetched. x 750 dia.
FIG. 9. Upper right. Unetched. x 200 dia.
FIG. 10. Lower. Unetched. x1000 dia.

VIEWS OF MICROSTRUCTURE

SS—Solid solution of tin in copper. d—Tin-rich constituent. l—lead

FIG. 11. x 200 dia.

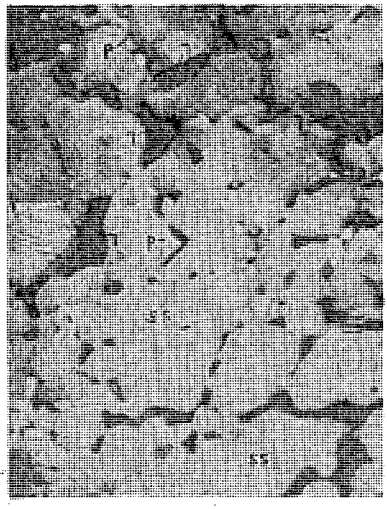

FIG. 12. x 200 dia.