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Photograph: Detail from 'Bridge No. 2' from the series *Rust Never Sleeps*, John Moore, 1996

BRINGING CONTEXT TO THE SMITHSONIAN COLLECTIONS OF PRE-COLUMBIAN GOLD FROM PANAMA THROUGH TECHNICAL EXAMINATION AND ANALYSIS

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Abstract

The study of pre-Columbian gold in Panama has been slow to progress due to the relative scarcity of well-contextualized materials. While the original contexts of many museum objects have been lost, the Smithsonian collections of Panamanian gold were re-evaluated for their potential to answer key questions about gold working in the region. Over 300 objects underwent technical examination and calibrated X-ray fluorescence (XRF) analysis to provide information on fabrication techniques and composition. The results have already begun to contribute to our understanding of gold working in the Isthmian region.

Keywords: Gold, copper, tumbaga, archaeology, Panama, XRF

Introduction

Pre-Columbian goldwork from Panama has been widely collected and admired, but unlike the metalwork of Mexico, Costa Rica, Colombia and the Andes, Panamanian objects have been the focus of relatively few technical studies. Since Lothrop published his comprehensive monograph on the excavations at Sitio Conte (1937), which included analysis of metal objects by W.C. Root, only a handful of researchers have undertaken technical studies specifically addressing Panamanian gold and *tumbaga* (gold-copper alloy) objects (Root 1950, Howe 1986, Fleming 1992, and Scott 1995).

A significant stumbling block is that most Panamanian gold objects housed in museum collections were excavated by grave robbers (*huaqueros*) and amateur archaeologists who rarely recorded location or context. Without contextual information, these objects are of limited scientific value, allowing only broad technological generalizations to be made. Institutional regulations discouraging destructive analysis have also presented another obstacle to the scientific study of this material. The question then remains: Is it possible to gain useful information about the development and regional variations of gold working in Panama from the objects in museum collections?

Researchers at the Smithsonian's Museum Conservation Institute (MCI) have attempted to do so through a large-scale technical study of Panamanian gold and *tumbaga* objects. Begun in 2007, it incorporated technical examination and XRF analysis of several collections in Panama (Beaubien 2008). The second phase of the project, which is the focus of this paper, applies the same analytical and data recording methods to the collections of two Smithsonian museums, comprising 231 catalogued objects from the National Museum of the American Indian (NMAI) and 78 objects from the National Museum of Natural History (NMNH). These objects, which include beads, pendants, bands, plaques, sheathing, bells, rings and tools, were selected based on their Panamanian origin and identification as gold, copper, or an alloy (see Figure 1).

Methodology

The project design comprised three major components: research into object provenience, technical examination and non-destructive instrumental analysis, described briefly below. In order to organize the varied sources of information for each object, a FileMaker Pro database was designed, which allowed active recording during examination, as well as import of data, images and related documents.

Archival Research

As the museum records often contained little provenience information, such as the excavation site, research

Figure 1. Panamanian gold and *tumbaga* objects in the NMAI collection packed for study at MCI (Courtesy, National Museum of the American Indian, Smithsonian Institution, Photo by A.Harrison)

was conducted in the collection archives at NMAI and NMNH, as well as holdings in the University of Pennsylvania Museum of Archaeology and Anthropology, and the American Philosophical Society. From the resulting letters, customs documents and field notebooks, it was possible to more closely assign provenience and site locations to a substantial number of objects, and confirm the reliability of the site and province attributions already in the museum records.

Technical Examination

Visual examination and optical microscopy were carried out on each object included in this study. Description, condition information and notes on fabrication techniques were recorded, including evidence of tool marks, casting traces, joinery, corrosion types, and surface enrichment. The primary production technique (e.g. hammered or cast) was also identified for each object at this time.

XRF Analysis

Every object in this study was analyzed at one or more locations using a portable bench-top ElvaX XRF. The instrument measures elements present at and just below the surface within the beam area (~1cm diam.). The heavy element mode was used for this study, which allows detection of elements from Cl (17) to U (92). Analyses were conducted at 45 keV in count rate stabilization mode, which varies the tube current to achieve a per-sample count rate of 6000-6200 counts per second for

100 seconds live time.

For this study, a set of approximately 35 matrix-matched gold reference standards (Royal Canadian Mint BCR 8079) were analyzed to create a material-specific calibration in the ElvaX software, reporting results in wt%. A selection of these standards was analyzed periodically during testing to adjust the calibration and monitor instrumental precision and accuracy. The limits of detection for each element vary according to the matrix in which they are present. For copper and silver in a gold matrix, they are approximately 0.1-0.2% and ~0.25%, respectively, and for gold in a copper matrix, ~0.25-0.5%.

One or more analyses were made of each object, with condition features recorded and photographs taken of each analysis spot. By noting the presence of bulky corrosion crusts, surface enrichment and variations in surface coloration, it was possible to better evaluate the reliability of the data as representative of original composition.

Results and Discussion

The data set of objects used for further interpretation was refined in two steps. First, only those with reliable provenience information, determined during the archival research phase of the study, were selected; this step reduced the number of objects from 309 to 218. Second, objects with XRF data considered to be unreliable were removed: this further refined the group to 189 objects. Compositional data were eliminated in instances of extensive copper corrosion at the analysis spots or of obvious depletion gilding exhibited by thin gold surface layers on copper-rich (typically heavily corroded) interiors. In general, copper-rich objects are assumed to have undergone some degree of corrosion of those alloy phases in the burial environment, so XRF measurements can only be considered approximations of the original composition. The presence of extensive corrosion signaled that data were even less likely to be representative.

Surface-matrix differences present another issue, as surface enrichment is known to occur frequently on Panamanian objects either as a consequence of annealing and further working or from intentional depletion gilding (Scott 1995, La Niece 1998). Techniques such as surface abrasion and cross-sectional sampling are generally used to increase confidence in results; however, only non-destructive methods were permitted on the Smithsonian objects. Scott (1995) had found experimentally that the elemental variation between surface and substrate was only a few percentage points difference. In addition, depletion gilded layers generally contain some percentage of lower density elements (Ag and Cu), are porous, and typically under 20μm thick. This is well within the characteristic X-ray attenuation depth for Au, calculated to be 49μm using the mass absorption coefficient of Au at 43KeV (from Roy et al. 1997). Our assumption, therefore, is that in cases where surface enrichment is present, the compositional data would be most representative of the matrix. Nonetheless, those objects with obvious depletion gilding were eliminated in this study. Variation in elemental concentration due to segregation was not considered a problem, as the beam diameter of the ElvaX is relatively large (1cm). Despite the issues involved with surface analysis of heterogeneous metal objects, it is believed that many of these problems have been mitigated by the experimental parameters used and removal of potentially misleading data, although the resulting data set under-represents objects with higher copper levels.

The compositional data indicate that all the museum objects contained Au and Ag, with a majority also containing Cu. Many had trace amounts of Fe, noted as an impurity in similar materials (Lothrop 1937) and likely due to traces of soil. No other elements were detected. For interpretation, the Fe data were removed from the compositional calculations, and the Au, Cu, and Ag measurements were normalized to 100% (see Figure 2).

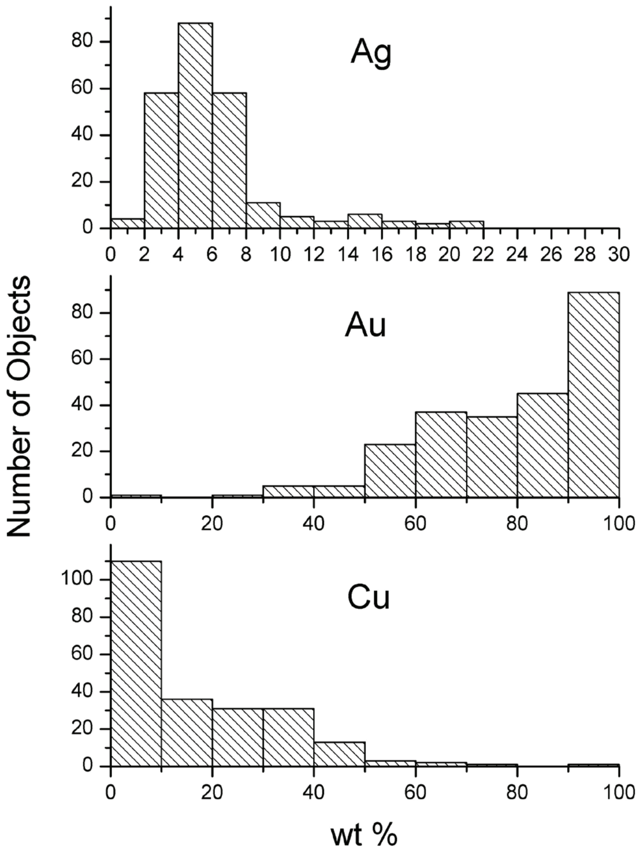


Figure 2. Relative frequency plots of XRF data from Panamanian objects in the NMAI and NMNH collections showing Ag, Au, and Cu content

The Ag content for a majority of objects was 4%- 6%, with the occasional outlier ranging up to 22% (see Figure 2). The plot of Ag to Au content demonstrates two major compositional groupings (see Figure 3). The first group is distinguished by the linear trend extending from near 0 to around 5% (±3%) Ag. The majority of objects fall within this group, which comprises Au and Au-Cu objects with Ag present entirely as an impurity in the Au. The other linear trend with the negative slope from 20% to 0% Ag indicates objects with no Cu component at all.

A silver content of more than 8%, which was measured in a relatively small number of objects, was determined to be beyond the typical Ag content found as an impurity in Panamanian gold.

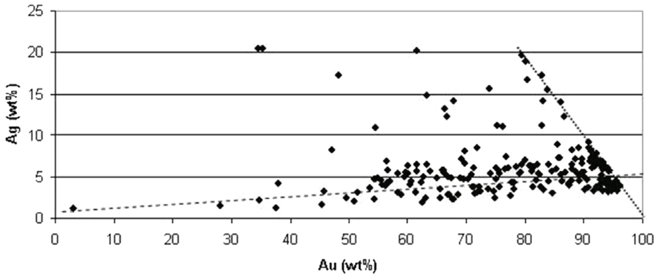
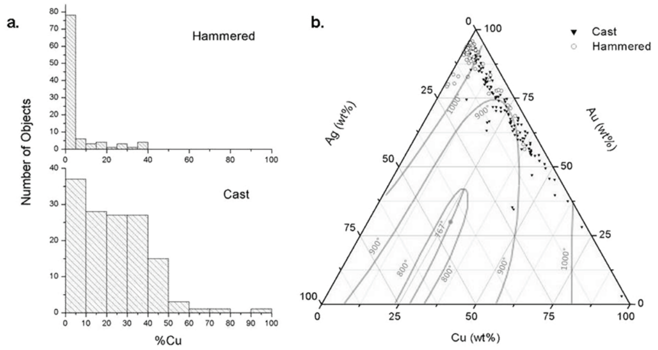


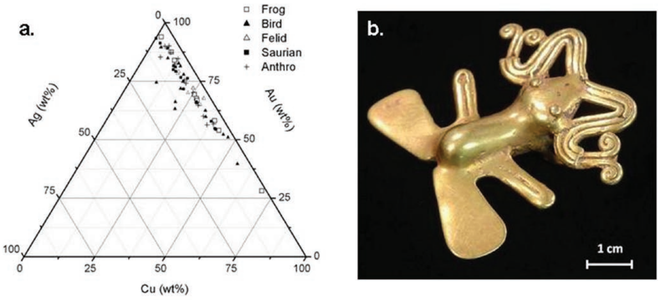
Figure 3. Plot of Ag vs. Au concentration in wt% of Panamanian objects in NMAI and NMNH collections

There is a clear correlation in our results between the cast objects and a higher Cu content (see Figures 4a, 4b). From a practical standpoint, the addition of copper to gold lowers the melting point and increases hardness, which in turn improves the ease of casting. In addition, gold-copper alloys can be depletion gilded, which produces a gold colored surface on a copper-rich substrate. Symbolic meanings of imagery, certain colors, construction methods, tastes and smells have also been suggested as factors in technological choice (Reichel-Dolmatoff 1990, Lechtman 1996). However, the review of the data plotted by object type (pendant, sheathing, bell, bead, etc.) revealed no visible compositional patterns other than that expected from differences in basic fabrication technique.



Figures 4. a) Comparison of Cu content between hammered and cast objects from Panama in the NMAI and NMNH collections. b) Ternary diagram of cast and hammered objects with superimposed Au-Ag-Cu phase diagram

Within the group of cast pendants, which represent a wide range of animal types, some distinctions are suggested. Researchers have proposed a connection between the smell of high-copper alloys and that associated with frogs (Reichel-Dolmatoff 1990), and in a study of Panamanian and Costa Rican pendants, Scott (1995) found a higher copper content in those representing frogs compared with other animal types. Our data reveal only a slight difference between the compositions of frog, saurian, avian, felid and anthropomorphic pendant types (see Figures 5a, b). This finding should be considered in context, however, as data generated from 50% of the frog pendants were removed from consideration – the largest group of pendants eliminated – due to excessive corrosion. This statistic points to a higher overall copper content of the frog pendants.



Figures 5. a) Ternary diagram showing compositional differences by pendant type. b) Frog pendant, from La Vuelta, Panama, A396672 (NMNH, Dept. of Anthropology)

When comparing data from the Panamanian material with adjacent regions, a clear compositional trend emerges (see Figure 6). The data used here for comparison is taken from the published results of SEM-EDS analyses by Rovira (1994) of objects produced by the Calima, Muisca, Quimbaya, Sinú, and Tairona, all pre-Columbian cultures in Colombia. While other elements were reported in minor and trace amounts, only Au, Ag and Cu were used here, normalized to 100%. In addition, several XRF and SEM-EDS analyses reported by La Niece (1998) were included. While the Colombian material has a similar range of Au content to that of the Panamanian objects, there clearly is a higher average Ag content. A greater percentage of the Panamanian material has a lower Cu content and the gap between 5 and 25% Cu in the Colombian material is not at all present in our data. This compositional distinction between Panamanian objects and those produced in neighboring regions provides strong evidence that the vast majority of gold objects were produced locally. While some scholars have suggested that long distance trade was a primary source of the skillfully crafted gold ornaments found in Panama (Helms 1979), the current data contradict these claims.

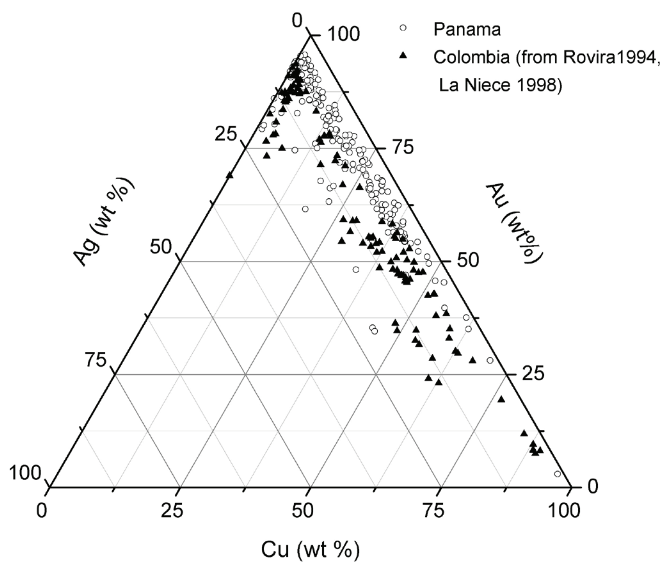


Figure 6. Ternary plot of Cu, Au, and Ag comparing composition of Panamanian and Colombian gold and *tumbaga* objects

Sorting the data by archaeological zones within Panama reveals a slight inter-regional variation in composition (see Figures 7, 8). The group from Veraguas Gran-Chiriquí (VGC) in western Panama includes objects with up to 22% Ag, a trend noted by others (Root 1950, Fleming 1992). Similarly high levels of Ag occur in the group from Panama/Colón, named after the modern provinces in the east. Objects from Gran-Coclé, which includes most of the Azuero Peninsula in central Panama, exhibit a lower average Ag content and no objects with over 9% Ag. A greater percentage of Gran-Coclé objects are also made of very high purity gold. The high Ag content of VGC and Panama/Colón objects may indicate imported objects and materials, or local sources of high-Ag gold ores. This regional pattern may not be so straightforward, however, as Cooke et al. (2003) have presented evidence of high Ag ore sources in central Panama, and elsewhere.

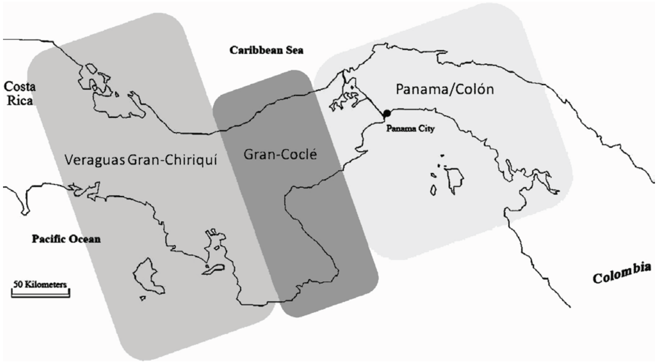


Figure 7. Map showing the three archeological regions discussed in this paper (after Cooke et al. 2003)

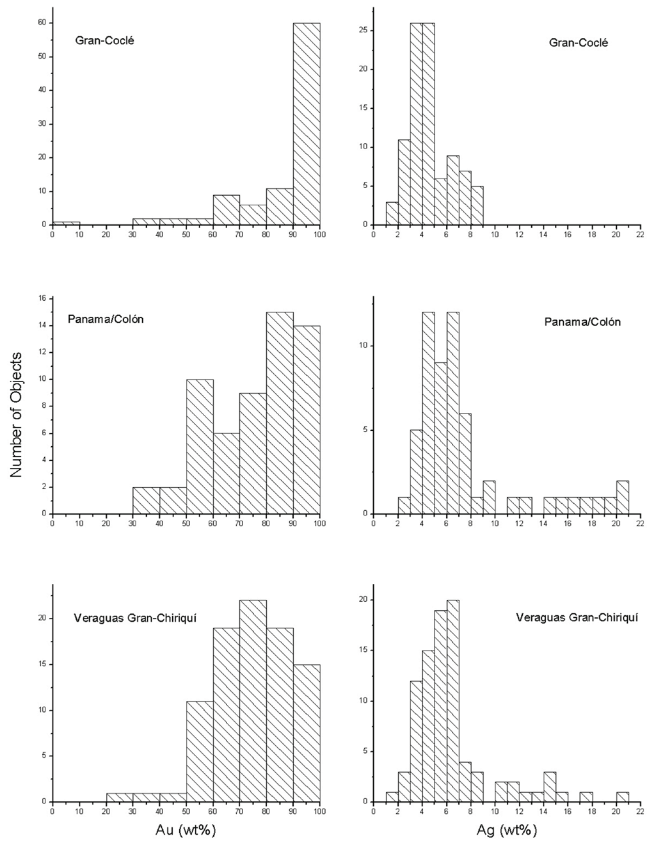


Figure 8. Relative frequency plots of Au and Ag content in Panamanian gold and *tumbaga* by geographical region

Conclusion

Results from this investigation suggest that archaeological metals from museum collections may be fruitfully studied, despite their often limited provenience information and necessity of using only non-destructive analytical techniques. Archival research was found to be useful for refining the final XRF data set to objects with reliable provenience information, and it is also believed that errors in the XRF data were minimized by removing potentially misleading data due to corrosion and enrichment.

The findings to date suggest that the compositions of a majority of the objects used in the final data are the product of using gold ores with impurities, rather than deliberate alloying. The overall percentage of Ag was found to be within a naturally occurring range and characteristically low compared to that of neighboring regions, providing evidence of local production centers in Panama. A large number of objects were also found to have Cu in relatively low quantities, which we believe could have been introduced as an impurity in the ore. However, it is also clear that deliberate alloys with much higher levels of Cu were also being produced, particularly for cast objects, although many of these were eliminated from the data set on the basis of excessive copper corrosion.

This project has added significantly to a growing body of information about an understudied gold working region. Detailed documentation of fabrication techniques, composition and condition, and additional contextual information retrieved from archival sources, are available for each of the 309 objects in the study, which will be of benefit to those researching and conserving the NMAI and NMNH collections. Results also underscore the need for more detailed metallographic study of individual objects, further analytical investigation of ore sources and placer deposits, in addition to well-contextualized scientifically excavated materials to better understand the development and history of gold working in ancient Panama.

Acknowledgments

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References

Beaubien, H., 'MCI 6100: Pre-Columbian goldworking in Panama – Report #1: of Technical Study and Conservation', unpublished report, Museum Conservation Institute, Smithsonian Institution, Suitland, MD (2008).

Cooke, R.G., I. Isaza, J. Griggs, B. Desjardians, and L.A. Sanchez, ‘Who crafted, exchanged, and displayed gold in pre-Columbian Panama’, *Gold and Power in Ancient Costa Rica, Panama, and Colombia*, ed. J. Quilter and J.W. Hoopes, Washington D.C. (2003).

Howe, E. G., ‘Estudio radiográfico de colgantes de oro fundidos al vacío de Sitio Conte’, in *Metalurgía de América Precolombina*, ed. C. Plazas, Banco de la República, Bogotá (1986) 169–200.

Fleming, S., ‘Sitio Conte goldwork: Alloying and the treatment of surfaces’, in *River of Gold: Precolumbian Treasures from the Sitio Conte (Appendix B)*, ed. P. Hearne and R. J. Sharer, University Museum, University of Pennsylvania, Philadelphia (1992) 54–59.

Helms, M., *Ancient Panama: Chiefs in Search of Power*, University of Texas Press, Austin (1979).

La Niece, S., ‘Metallurgical case studies from the British Museum’s collections of pre-Hispanic gold’, *Boletin del Museo del Oro*, 44 (1998).

Lechtman, H., ‘Cloth and metal: The culture of technology’, in *Andean Art at Dumbarton Oaks, Vol.1*, ed. E. H. Boone, Dumbarton Oaks Research Library and Collection, Washington D.C. (1996) 33-43.

Lothrop, S.K., *Coclé: An Archaeological Study of Central Panama vol.1*, Cambridge, MA (1937).

Reichel-Dolmatoff, G., *Orfebrería y chamanismo: Un Estudio Iconográfico del Museo del Oro*, Compañía Litográfica Nacional S.A, Medellín (1990).

Rovira, S., ‘Pre-Hispanic goldwork from the Museo de América, Madrid: a new set of analyses’, in *Archaeometry of pre-Columbian sites and artifacts: proceedings of a symposium organized by the UCLA Institute of Archaeology and the Getty Conservation Institute, Los Angeles, California, March 23-27, 1992*, ed. David A. Scott and Pieter Meyers, Los Angeles (1994) 323-350.

Root, W.C., ‘A report on some metal objects from Veraguas’, in *Archaeology of Southern Veraguas, Panama’*, Memoirs of the Peabody Museum of Archaeology and Ethnology 9 (3), Harvard University, Cambridge, MA (1950) 93–96.

Roy, B., B.K. Chatterjee, S.C. Roy, I. Nanak Bhattacharya, N. Choudhury, ‘Photoelectric cross-sections derived from measured total attenuation coefficient of photons near absorption edges of heavier atoms’, *Applied Radiation and Isotopes*, 48(6) (1997) 785-788.

Scott, D.A., ‘Goldwork of pre-Columbian Costa Rica and Panama: a technical study’, in *Materials issues in art and archaeology IV: symposium held May 16-21, 1994, Cancun, Mexico, Materials Research Society*, 352 (1995) 499-526.

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