Smithsonian
Museum Conservation Institute

TECHNOLOGY OF PRE-COLUMBIAN GOLD IN PANAMA
A Study of Fabrication and Compositional Analysis

RESEARCH REPORT
PART II:
El Caño and Isla Pedro González

MCI 6100.2

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PROJECT DESCRIPTION: Examination and analysis of recently excavated gold and gold-alloy objects in Panama. This research is part of a large scale technical study of the pre-Columbian gold-alloy and related metal objects from Panama in the Smithsonian collections (*MCI 6100.2*) and is also connected with the on-site conservation project at the site of El Caño (*MCI 6256*).

OBJECTS: Gold-alloy and related metal Pre-Columbian objects recently excavated in Panama by archaeologists from the Smithsonian Tropical Research Institute, Panama City, Panama

- 143 registered finds (representing 211 objects or fragments thereof) excavated by the El Caño Archaeological Project, at El Caño in Coclé province
- 6 registered finds (representing 8 objects) excavated by the Proyecto Arqueológico Pedro González at Isla Pedro González in the Pearl Islands (Archipélago de las Perlas)

EQUIPMENT/TECHNIQUES USED:

- Stereo Microscope (Wild Heerbrugg 8)
- Digital Microscope Camera (Leica EC3 with LAS EZ software)
- Digital Camera (Leica D-Lux 3; Nikon D70)
- Benchtop X-Ray Fluorescence (XRF) Analyzer (ElvaX)

CONTRIBUTORS TO THIS REPORT

- Harriet F. (Rae) Beaubien, MCI Head of Conservation/Senior Objects Conservator
- Ainslie C. Harrison, MCI Conservation Fellow at the time of this project, currently NMAI Andrew W. Mellon Conservation Fellow
- Kim Cullen Cobb, NMNH Anchorage Loan Conservator at the time of this project, currently MCI Research Associate

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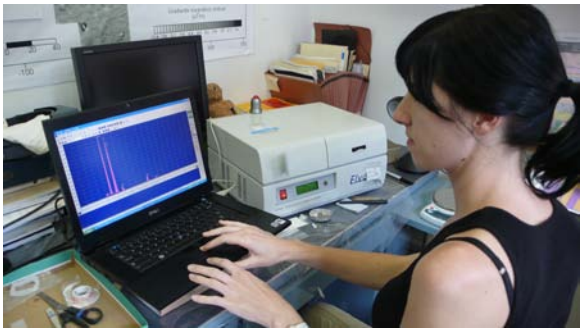
SUMMARY

Over the course of 10 days in September 2009, a team of three conservators from the Smithsonian's Museum Conservation Institute carried out a technical investigated of gold and copper alloy objects recently excavated by archaeologists from the Smithsonian Tropical Research Institute (STRI) in Panama. Over 200 objects from the site of El Caño, and an additional 8 from Isla Pedro González, were studied in a lab space at the Center for Tropical Paleoecology and Archaeology (CTPA), a STRI facility where most of the artifacts are currently stored. All of the objects were analyzed non-destructively by X-ray fluorescence and examined under the microscope. As part of their documentation, overall photographs were taken of each object, with additional photomicrographs taken to document technical features of interest, with all information compiled in a database. In cases where the original packaging did not provide enough protection, objects were re-housed with protective inserts and upgraded archival storage bags. The labeled bags were re-organized in plastic boxes for protection in storage as well as ease of retrieval for further study.



Left: Kim Cullen Cobb and Rae Beaubien, with archaeologist Julia Mayo, during examination of an artifact from El Caño
Right: Ainslie Harrison conducting X-ray fluorescence analysis of an artifact

Study Materials

The objects processed in the course of the study, reported here, are as follows.

- 143 registered items identified as gold- or copper-based alloys, representing 211 objects or fragments thereof, excavated by the El Caño Archaeological Project during the 2008 and 2009 field seasons, curated at STRI-CTPA, Panama City, Panama

- 6 registered items identified as gold-alloys, representing 8 objects, excavated by the Proyecto Arqueológico Pedro González (PAPG) during the 2009 field season, curated at Panamá Viejo, Panama City, Panama

Background Information about the Sites

El Caño (Coclé)

The site of El Caño is situated on the western bank of the Rio Grande, adjacent to the well-known site of Sitio Conte. The two sites are now separated by the river, but may have been part of the same funerary complex, based on comparability of finds and other evidence. The cultural context of the El Caño site is therefore assumed to parallel that of Sitio Conte which, from scientific excavations carried out by Harvard University and University of Pennsylvania projects in the 1930s, has been dated to between 400-900 CE. While parts of the El Caño site were occupied up through Spanish contact, the majority of material found by the current project in mortuary contexts is Conte style (named after Sitio Conte), which falls under the Gran Coclé cultural sphere of Pre-Columbian Panama. In addition to locally manufactured objects from the Gran Coclé region, trade objects from adjacent and distant regions have also been excavated at Sitio Conte and El Caño.

Situated on private land today, the site of El Caño has had a long history of excavation, with past projects from the early 20th century through the 1970s. It was declared an archaeological park by Instituto Nacional de Cultura de Panamá (INAC) in 1979, and includes an array of stone monoliths, a mound (Montículo 3), and a small site museum. The current project, under the direction of archaeologist Dr. Julia Mayo, an archaeologist from the Smithsonian Tropical Research Institute (STRI), began in 2005 with the geophysical survey of the park. In 2008, excavation began on the large circular feature identified in the survey. Excavation continued in 2009 with the discovery of two large burial deposits and associated grave goods. The 2009 season concluded in April, at which point the reconstruction and analysis of the excavated materials continued in the laboratories at STRI in Panama City.

Over the 2008 and 2009 field seasons, 143 registered finds identified as gold- or copper-based alloys, representing 211 objects or fragments thereof, were excavated at El Caño. As the metal objects made up a significant group of artifacts, the analysis of this material was considered a fundamental aspect of the scientific investigations at El Caño. This represented the next phase of a large on-going research project on Pre-Columbian gold alloys from Panama, begun by MCI in 2007, as well as a natural extension of the collaboration between the El Caño Archaeological Project and MCI, which had begun in the form of on-site conservation assistance in 2009 (see the listing in section *Related MCI Reports*).

The 2008 material, transferred during that field season, had not been previously dealt with

by the conservation team. The 2009 material had been processed on site (including cleaning, basic stabilization as needed, and rehousing) by Beaubien and Harrison during a 3-week period on-site (reference *MCI 6256*) and transferred during the course of the season to a safe in Dr. Mayo's office at STRI. Each registered item was uniquely identifiable by the site designation (NA20) and a sequential 4-digit registration number; multiple objects recorded under a single registration number were arbitrarily assigned a point number during this study (e.g., 4650.1).

Isla Pedro González (Pearl Islands)

Isla Pedro González is one of the mountainous islands making up the Pearl Islands (Archipélago de las Perlas), situated approximately 75 km south from Panama City in the Gulf of Panama. The islands are rich in marine resources, and an active pearl fishing industry was recorded from colonial times onward. Current excavations at Isla Pedro González are being carried out by the Proyecto Arqueológico Pedro González (PAPG) overseen by project advisors Dr. Richard Cooke (STRI) and Dr. Juan Guillermo Martín Rincón (chief archaeologist from Panamá Viejo), as part of environmental impact requirements for the future construction of a resort community. In addition to numerous test pits at various locations on the island, two areas were selected for more in-depth excavation, including one that yielded a burial (as of July 2009). Cultural remains recovered from this unit included ceramics, stone nose ornaments, and gold beads. While no directly datable material has been found, the recovered ceramics have been stylistically assigned to the Cubitá period by the archaeologists (200/300 AD-700 CE).

The gold objects, currently curated at the research center of the Panamá Viejo site in Panama City, were included in the study. This material was brought to STRI by project advisor, Dr. Richard Cooke. Each registered item was identified by the site designation (PAPG), context code (H), followed by a sequential number; multiple objects recorded under a single registration number were arbitrarily assigned a point number during this study (e.g., H3.1).

Staffing and Logistics

Harriet (Rae) Beaubien, Ainslie Harrison and Kim Cullen Cobb, a team of conservators from the Smithsonian Institution's Museum Conservation Institute (Beaubien and Cullen Cobb) and National Museum of the American Indian (Harrison) carried out the technical study of gold and related metal items recently excavated at the archaeological sites of El Caño and Isla Pedro González between September 8 and 19, 2009. The staffing combination brought together expertise in archaeological metals, their conservation, instrumental analysis, and goldsmithing practices and tools, as well as familiarity with Panamanian gold through participation in parallel studies (Beaubien, 2004 preliminary project, reference *MCI 6043*; Beaubien and Cobb, 2007 project, reference *MCI 6100*; Beaubien and Harrison, El Caño 2009 fieldwork, reference *MCI 6256*; and Harrison and Beaubien, NMNH and NMAI collections study, reference *MCI 6100.2*).

In Panama, our primary collaborator was Dr. Julia Mayo, director of the El Caño Archaeological Project and a research associate at Smithsonian Tropical Research Institute (STRI). Without her enthusiastic support, logistical assistance and active participation at every step, we would not have been able to carry out this project with such success. In addition to providing complete access to the El Caño collection as well as work space at STRI, she helped us with many local logistical aspects of the project, provided significant archaeological background material about the gold collections, and facilitated our work with the Patrimonio Histórico's

Instituto Nacional de Cultura (INAC) in requesting samples for further analysis. Because of the sensitive nature of the collection and security issues, we coordinated all aspects of our work schedules with her.

The MCI team set up a work area in Dr. Mayo's office, located at STRI-CTPA, a building with tightly controlled access. The office, which is kept locked, has a large safe that houses high-value materials from the El Caño excavations. Tables along the wall were arranged to handle the flow of objects as they were removed from the safe, analyzed, photographed and rehoused. Equipment brought from the US was set up on several tables arranged along the wall, including personal cameras used for general photography, a binocular microscope with a digital camera and a laptop computer for display and image data storage, and the XRF equipment and associated laptop computer for data processing and storage. Equipment and supplies could be left in this area without concern; only the personal cameras and laptop computers were taken back and forth each day.

Funding support for the current phase of the project included grants from the Smithsonian's Scholarly Studies Program (# 142008) and the Samuel H. Kress Foundation (# 501438), with additional funds from a grant awarded to MCI from the Office of the Under Secretary for Science's SI Endowment Fund for the initial phase. Beaubien is the principal investigator for these grants.

Work Flow

We developed our recording procedures to accommodate the work flow, which began with preliminary examination and verification of identification numbers. In cases where a particular registration number represented more than one discrete object, a point number (e.g., xxxx.1) was assigned arbitrarily to each object. XRF analysis was carried out first as this step required the least amount of time and would therefore not be a rate limiting step in the work flow. The instrument was set up on a desk adjacent to the safe, and a small group of objects was removed from the safe for processing at a time. For each object, an appropriate analytical spot was selected (more, if appropriate) and it was photographed in order to record the specific analysis location. (Initially, each object was photographed after analysis with a scale, the artifact tag, and a small paper pointer with a spot number showing the analysis position, and but this was found to be less efficient than photographing the object in position on the XRF instrument window, along with a scale, and tag and spot number.) The objects were rebagged after analysis and collected in a tray.

From there, the objects were moved to the tables set up along the wall of the office, beginning with a photography set up at one end. Each object was photographed from at least two views. Included in the image were the object's identifying number, a centimeter scale and a color bar. The digital photographs, taken at high resolution (without a copy-stand), were transferred to the laptop computer each day by Beaubien, and renamed with the object identifying number, view and date, and the original exposure number; this exposure number was cross-referenced on the photographic log sheets. Photographed objects were rebagged and collected in a tray for the next step.

Microscopic examination and photomicrography took place at the other end of the table. Objects that had undergone photography were chosen from the tray, measured, and examined under the microscope. Observations about technological features and condition were recorded directly in the database either by the operator or an assistant. A photomicrograph was taken of

every bead and specific features of interest on other types of artifact were documented with the microscope camera. After examination and documentation, the objects were cleaned with acetone and rehoused in clean zip-lock bags with cushioning or protective mounts as needed, and returned to storage. Finally, the object bags were sorted by registration number and organized into several hard plastic boxes for easy access.

Examination and Documentation

Microscopic Examination and Database Entry

Visual examination and optical microscopy were carried out on each object followed by entry of descriptive and technical information into the FileMaker Pro database designed by Harrison for the NMNH-NMAI study. This database was designed as an expanded version of the database format used in 2007. (Note: the 2007 database entries will be migrated to this one, to consolidate the data set). Individual object records for each of the artifacts excavated in 2009 were created in advance by Harrison, using a list compiled by Beaubien from field conservation records and registry lists provided by J. Mayo. The 2008 artifacts were added into the database in the course of analysis.

For the examination phase, a Wild Heerbrugg 8 microscope transported to Panama from MCI was used with magnification range of 6-50x. During examination, the object description, condition information, and notes on fabrication techniques were entered into the technical examination layout of the FileMaker Pro database by the examining or assistant team member (see the report for *MCI 6100.2 Part I* for description of the Technical Examination Layout). Each object was measured and the measurements were also entered into the database. Additional notes were entered to indicate objects that would be ideal for further analysis and sampling.

Photography and Photomicrography

Digital photographs were taken of each object and photomicrographs were used to document features indicating fabrication or finishing methods. For overall photos, the Leica or Nikon D70 was used with automatic focus, shutter speed, and aperture. A black background was placed behind the object and all of the photos included a scale and the object's identifying tag, written at the time of excavation. For photomicrography, a Leica EC3 digital microscope camera was used. The camera was connected by cable to a Dell laptop and operated on the computer through the Leica Application Suite EZ software. All of the resulting image files were archived in the project folder on the Museum Conservation Institute's R: drive.

Results

Records for all items in the study were created in the FileMaker Pro database, resulting in 166 files, which included individual files when registered items were made up of more than one object. All were photographed and examined under the stereomicroscope, with an additional 312

photomicrographs taken. The database files include representative photos, as well as context information, observations from the microscopical examination and technical results; the one-page formats of the object reports generated from the database are provided as *Appendix A.* The database, photos and photomicrographs are archived on the R: drive at the Museum Conservation Institute.

X-Ray Fluorescence Analysis (XRF)

XRF Analysis Overview

Every object in this study was analyzed at one or more locations using a benchtop ElvaX X-ray fluorescence spectrometer. XRF measures elements present at and near the surface, where the object falls within the beam area (approximately 1cm diameter), situated at the center of the instrument's circular window (approximately 2cm diameter). Elements that may be detected by this instrument range in Z from 11 (Na) to 92 (U). As heavy metal elements such as Cu (29), Ag (47), and Au (79) were of primary interest, however, the light element mode was not used in this study, thereby limiting detected elements to between Z=17 (Cl) to Z=92 (U). 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.

XRF is a quantitative technique if calibrated with standards encompassing the compositional range of the sample set. A set of approximately 35 matrix-matched gold reference standards (Royal Canadian Mint BCR 8079) were analyzed to create a "product" for the ElvaX software, which calibrates the regression model (labeled "Gold 143") used for quantifying the peak intensity data. These standards were also analyzed periodically during testing to adjust the calibration and monitor the instrumental precision and accuracy. The XRF technique has limits of detection (LOD) for each of the elements, which vary somewhat 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%.

Procedures

After initial training by Jeff Speakman at MCI, analysis was carried out primarily by Harrison, with some also carried out by Beaubien and Cullen Cobb. Each object was individually placed in

the XRF chamber and the area to be analyzed was centered over the window. Photographic documentation of the analysis location (described above) was an important step, as results would eventually need to be evaluated in light of technical aspects, which could vary by location. In cases where the object could not naturally balance over the window, a piece of Ethafoam was used to prop the artifact in the desired orientation. The photos are archived in the project folder on the shared R: drive at the Museum Conservation Institute.

During and immediately after collection of the XRF spectra, data checking and importation of the calculated element concentrations into an Excel spreadsheet was undertaken by the operator. For most objects, only Au, Ag, Cu, and occasionally Fe were detected by the XRF and the corresponding peaks were easily checked.[1] If elements were then found to be erroneously reported by the software, they were removed and calculation of concentration was done using the fundamental parameters algorithm. This method assumes detection of all elements in a sample and normalizes the reported elements to 100%. In these cases, it was found that the concentration of elements was very similar, if not exactly the same as that reported by the regression analysis model using the "Gold 143" calibration. In both cases, the results reported in percentages were immediately imported into the Excel worksheet containing the XRF data of the objects analyzed at STRI. Each spectrum was saved, thereby preserving the raw data that may be re-visited for quantification using different algorithms or calibrations if required.

In addition to copying the element concentrations to the Excel spreadsheet, the operator entered notes for each measurement. This information included the date, operator, object identifying number, any elements removed from the calculation, and the location and condition of the analyzed spot. All of the information was later imported into the FileMaker Pro database along with the element concentrations. Sorting the data by the condition of the spot analyzed helps refine the dataset to measurements with good reliability and accuracy, thereby discounting readings that could be misleading in the interpretation of the results.

Results

The 149 registered items (219 objects or fragments) were analyzed by XRF, some in more than one location, producing 239. See the chart included as *Appendix B* for results from XRF analysis and *Appendix C* for thumbnail images of the XRF analysis locations. XRF data are also presented in the database records, a printout of which is included as *Appendix A*.

Conservation and Rehousing

After the analysis and documentation steps had been carried out, all of the objects were cleaned and rehoused so that they would be protected in storage and easily retrievable for further study. In the process, a very limited amount of reassembly of fragments was carried out when stability of the object would be improved, using conservation-grade adhesives (notably Paraloid B72 in acetone). Gloves were routinely used to prevent possible deterioration of the metal surfaces from sweat and oils transferred from bare hands.

The work, typically carried out in batches, involved cleaning each object or fragment with acetone on a cotton swab and then either returning it its original zip-lock bag if appropriately clean and sturdy. In cases where the original packaging did not provide enough protection,

[1] Including the characteristic sum peaks, escape peaks, and known peaks from the detector.

objects were re-packaged accordingly with protective inserts and upgraded storage bags. Each gold bead with a unique registration number was placed in an individual labeled plastic sample vial, often padded with an Ethafoam ”plug” to reduce movement. Fragile artifacts were either placed in protective sample vials or were cushioned using customized supports made using Ethafoam and Tyvek (such as cavity mounts). Each of these items was put in a zip-lock bag, along with its tag, and the registration number was written on the exterior of the bag with a black permanent marker.

Once all of the objects had been bagged and labeled, they were placed in several large plastic containers, organized by their registration number, and returned to the safe.
The labeled bags were sorted by registration number and placed in hard plastic (polyethylene) storage boxes for protection in storage as well as ease of retrieval for further study.

Selection of Objects for Further Analysis

After the examination and XRF analysis of the El Caño and PAPG objects had been carried out, several research questions arose regarding fabrication methods used in the manufacture of the gold and gold alloy artifacts, particularly beads and tumbaga artifacts. Beads represented a very large percentage of the finds, showing a wide range of compositions and technological variations as well as indications of some level of mass production; multiple examples were available for each technological variety noted in the study. The features of interest included:

- Surface characteristics that reveal specifics of tools used in fabrication
- Compositional variation between interior and exterior of objects indicative of deliberate surface treatment techniques
- Compositional variation across joins that indicate the joining method (e.g. mechanical, solder, diffusion bonding, etc.)
- Unusual surface residues that may shed light on workshop methods such as fluxes used for soldering or annealing
- Microstructural features that reveal specifics of fabrication such as mass-production methods vs. one-of-a kind manufacturing

Tumbaga objects also were of interest because of compositional differences between enriched surfaces and baser bulk composition.

While results from the instrumental techniques used in the study at STRI provided important preliminary information, additional methods such as metallographic sample preparation and study and SEM-EDS were considered necessary to answer these questions. The items listed below from El Caño excavations were selected because they were representative of common types and had clear features of interest. A request was submitted to the Patrimonio Histórico (INAC) for the selected objects to be exported to the Smithsonian Institution for

sampling and analysis. Approval was granted on September 18, 2009, and the following objects were packed for travel and brought back to the Museum Conservation Institute:

NA20-4576: 1 tumbaga fragment (~17 similar fragments found in 2009)
NA20-4829: 1 bead (large collapsed; 2 similar beads found in 2009)
NA20-4853: 1 bead (~50 similar beads found in 2009)
NA20-5101.2: 1 bead selected of 2 (large one; 8 similar beads found in 2009)
NA20-5341: 1 bead (~50 similar beads found in 2009)
NA20-5352: 4 beads selected of 145 (146 similar beads found in 2009)

Upon return to Washington DC, additional documentation was submitted to MCI in order to carry out the analysis of these materials (*MCI 6100.3*).

Related MCI Reports

The MCI reports related to this project include the following:

Beaubien, H. *MCI 6043*: Panamanian Gold: Technical Study Report. Unpublished report (dated 8 May 2007), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD

Beaubien, H. *MCI 6100*: Pre-Columbian Goldworking in Panama – Report #1: Technical Study and Conservation Overview. Unpublished report (dated 26 February 2008), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD.

Beaubien, H. *MCI 6100*: Pre-Columbian Goldworking in Panama – Report #2: Results of the Technical Investigation. Unpublished report (forthcoming), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD

Harrison, A. *MCI 6100.2* Technology of Pre-Columbian Gold in Panama – Research Report Part I: NMAI and NMNH (April 2010), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD

Beaubien, H. and A. Harrison. *MCI 6256* El Caño Archaeological Project, Panama – 2009 Field Season 2009, Conservation Report (March-April 2009), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD

Beaubien, H. and A. Harrison. *MCI 6256* El Caño Archaeological Project, Panama – 2009 Lab Phase, Conservation Report (July-August 2009), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD

Beaubien, H and A. Harrison. *MCI 6100.3* Fabrication Techniques of Pre-Columbian Gold Beads. Analysis Request (April 9, 2010), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD