Smithsonian
Museum Conservation Institute

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

RESEARCH REPORT
PART I: NMAI and NMNH

MCI 6100.2
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DESCRIPTION: A large scale technical study of the pre-Columbian gold-alloy objects from Panama in the Smithsonian collections. Activities included archival research, technical examination, and elemental analysis.

OBJECTS: Gold-alloy and gilded Pre-Columbian objects of Panamanian origin in the Smithsonian Institution collections.

- National Museum of Natural History (NMNH): 78 artifacts originating from Panama, including objects from excavations in Chiriquí, Veraguas, and Herrera Provinces, the Panama Canal zone, and numerous objects with no specific site provenience
- National Museum of the American Indian (NMAI): 221 artifacts originating from Panama, including objects from known excavation sites throughout Panama and those donated without specific provenience.

NOTE: The scope of the original project was expanded to include newly excavated finds from El Caño, curated at the Smithsonian Tropical Research Institute in Panama City, the results from which will be reported separately (Part II).

EQUIPMENT/TECHNIQUES USED:

- Stereo microscopy
- Digital photography (macro and micro)
- Portable X-ray fluorescence (XRF) spectroscopy
- X-ray radiography
- Variable pressure/Environmental scanning electron microscopy with energy dispersive spectroscopy (ESEM-EDS)

STAFFING:
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Introduction/Background

Pre-Columbian gold and tumbaga from Panama has been widely collected and admired, but unlike the metalwork of northern Mesoamerica, Costa Rica, Colombia, and the Andes, Panamanian objects have been the focus of relatively few technical studies. While numerous museums around the world house substantial quantities of Panamanian gold, the majority of this material was excavated by grave robbers (known as *huaqueros*) and amateur archaeologists who rarely recorded location or context. Without contextual information, these objects are of limited scientific value and have therefore only allowed for broad generalizations regarding technology and fabrication of gold and copper-alloy artifacts in the region. The cultural complexity of the Isthmo-Colombian region also adds to the difficulty of producing meaningful data from unprovenienced material as archaeologists are still refining the geographical and chronological limits of these Pre-Columbian cultures in modern day Panama. The research project reported here therefore attempts to address this lack of information through a large scale survey of the pre-Columbian objects from Panama in the Smithsonian collections, combining archival research with technical examination and compositional analysis.

The original project, on which this research builds, was carried out by Rae Beaubien and a team of MCI researchers and collaborators in 2007.[1] Their project involved the analysis and conservation of a large number of gold and tumbaga objects in Panama at the Smithsonian Tropical Research Institute (STRI) and the Museo Antropológico Reina Torres de Araúz [MARTA] (MCI # 6100.1 Reports 1 and 2, 2009). In the current study[2], similar examination and analytical techniques were adapted for the NMAI and NMNH collections in Washington DC.

Technical examination was carried out under the microscope to document fabrication techniques, finishing methods, toolmarks, and condition. In addition, each object was analyzed by calibrated portable XRF to obtain approximate compositional information. To facilitate data collection and analysis, a database was designed that could incorporate the results from both examination and compositional analysis.

In order to produce meaningful results from the museum material, the current project also included a phase of background research into each object. Because museum records showed that only limited information about provenience was typically conveyed at the time of accession, background research was expanded to include archival resources related to the collection items. Documentation from the museum records, archives, and relevant literature were compiled, digitized, and entered into the database where possible. In addition to the technical examination and analysis already described, selected objects underwent x-radiography, scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS), and Fourier transform infrared spectroscopy (FTIR) at MCI to answer more specific questions on fabrication, structure, and composition.

A range of questions may be answered by the data collected in this project. While future work includes the analysis and interpretation of this information, specific topics that will be addressed include: Methods of bead fabrication, compositional indicators of provenience (e.g. Ag concentration, PGE inclusions, and As), the origin of resins used in composite objects, identification of modern vs. ancient solder, and the comparison of instrumental techniques in the analysis of objects with enriched surfaces. The findings from these lines of inquiry will be disseminated in talks and professional publications, which will be placed on file at MCI.

[1] Supported in part by grants from the Smithsonian's Charles D. and Mary V. Walcott Endowment Fund and the Samuel H. Kress Foundation.

[2] Supported by grants from the Smithsonian's Scholarly Studies Program and the Samuel H. Kress Foundation

Study Materials

The objects examined in this study are part of the collections of the National Museum of the American Indian and the National Museum of Natural History, which are housed in Suitland, MD at the Museum Support Center (MSC) and the Cultural Resource Center (CRC). All of these objects originated from Panama and contain gold and/or copper in some quantity. To begin locating the relevant objects at the NMAI and NMNH, Collection Managers Pat Nietfeld (NMAI) and Dave Rosenthal (NMNH) had conducted searches of the digital catalogues of their respective museums. While "Panama" was always included as the geographical area in the search criteria, several material types were included in the search, including "metal", "gold", "copper", and "tumbaga." The resulting list of objects included 221 catalogue numbers at NMAI and 84 catalogue numbers at NMNH. In September 2008 Beaubien submitted a list of these objects with the examination and non-destructive analysis requests to the NMAI and NMNH curatorial councils. These requests were approved by November 2008, allowing work to begin on the collections immediately afterwards by the report author.

The collections management staff at NMNH retrieved all of the Panamanian material from the safe in storage at the MSC, which produced 78 of the 84 catalogued objects. The NMAI material required more intense sorting as the material was organized in the vault at the CRC by object type (nose rings, pendants, etc.) rather than geographical location or catalogue number. After the objects were re-organized by geographical location by the author and collections staff, the Panamanian material included 231 objects representing 159 individual catalogue numbers where necklaces with multiple strung beads are recorded as single objects. If based on the object count of each NMAI catalogue number, the total number of objects included in this study would number 2248. For objects with hundreds of individual beads, however, only a representative sample was examined and analyzed in this study due to time constraints.

While a large number of objects included in this study have no site information, the province in which the majority of objects were retrieved is documented. Seven provinces are represented by the study material, including: Bocas del Toro, Chiriquí, Veraguas, Coclé, Herrera, Panamá, and Darién provinces. These provinces can be combined to form four main geographical zones, Veraguas Gran-Chiriquí, the Gran-Darién, Gran-Coclé, and the Colon/Panama region in central Panama. The distribution of the study material into these categories is as follows:

- Veraguas Gran-Chiriquí: 150 objects
- Gran-Coclé: 90 objects
- Panamá/Colón: 55 objects
- Darién: 2 objects

In addition, there are 8 sites from which a portion of the objects in this study originate, while about 100 objects have no known site at all. The sites and number of objects excavated at those locations are listed below:

- El Caño: 4
- El Hatillo: 54
- Lago Alajuelo: 30
- La Vuelta (near El Hato): 2
- La Pita: 1

- Las Palmas: 8
- Area around Soná, Roja: 24
- Venado Beach: 27

Database

While a FileMaker Pro database had been created for entry of data during the previous project in Panama, it was determined that a new database would be required for the current study. The decision to make a new database rather than alter the original one was made both because it could not be easily edited and because there were major changes to the basic design and layouts required. Rae Beaubien, who had used the original database in 2007, was consulted on what improvements could be made before the new database was designed. While some of the same fields from the original database were included in the new design, a large number of fields were combined, eliminated, and added.

The new database was designed by the author around the three-phase structure of the current project: archival research, technical examination, and analysis. An individual layout was created for each of these phases as the entry of information would fall into these three different categories. Each of these layouts is discussed in the sections below. While most of the fields in each of the layouts are unique to that layout, the unifying information visible in all three is the object number, class, subclass, owner, country, province, and site.

Several layouts were also designed for printing the records in different report formats and a layout for conservation was added towards the end of the project to accommodate the information from the 2009 field activity at El Caño and import of data from the 2007 project. While the design of the database shaped the collection of archival, technical, and analytical data throughout this project, changes were continuously made as potential improvements were identified. The database will continue to be edited as its function and use changes over time with new data and users.

Museum Information Layout

The museum information page was designed to include all of the data from the museum database, catalogue cards, and archival documents (fig.1). A photograph of the object is also included in this layout. Due to the different levels of detail provided in the documentation of each institution, there is some overlap between the fields. The object catalogue number and accession number, for example, are considered to be the same identifying number for the NMAI objects, while at NMNH the accession number is a batch or group number that differs from the unique catalogue number given to each object.

The idea of object class and sub-class was developed as a way to distinguish between the general category of the object and its more specific features. The object class is defined as the most general category of object type, such as bell, disk, pendant, tool or ornament etc. The object sub-class relates more precisely the object's appearance or function, which would include descriptions such as zoomorphic pendant, earring, chisel, etc. Including both the broader category of object and more specific description facilitates subsequent searching and sorting of data.

The geographical or provenience information was included in five separate fields: country, province, area, site, and geographic zone. While most of these are self-explanatory, it should be mentioned that the "area" category was included because many of the museum records

include geographical information that does not strictly fall into any of the other more traditional field types such as “Country,” “Site” or “Province.” The geographic zone field was created as a category based upon the division of Panama into several archaeological zones: Veraguas Gran-Chiriquí (VGC), the Darién (Gran-Darien), Gran-Coclé, and the Colón/Panamá region in central Panama. One of these geographic zones was assigned to each object based on the known provenience information.

The provenience documentation field was also included as a means of indicating the reliability of the location information. Some of the objects, for example, were identified as originating from a certain region based on style, which is not an entirely reliable method for determining provenience. Other objects, however, are documented in excavation notebooks and published reports, which provides much greater confidence in the ascribed provenience.

Under the category of “Museum Info:” are the fields with information on the collector, donor, accession date, etc. This information is most often provided in the catalogue cards or database of the museum, and was therefore easily imported from those records into the database. The museum records multimedia container fields were also added so that a digital image of the catalogue card or accession documents, where available, could be added to each record. The fields for research notes and references were also included for annotations and associated publications to be entered during the archival research phase of the project.

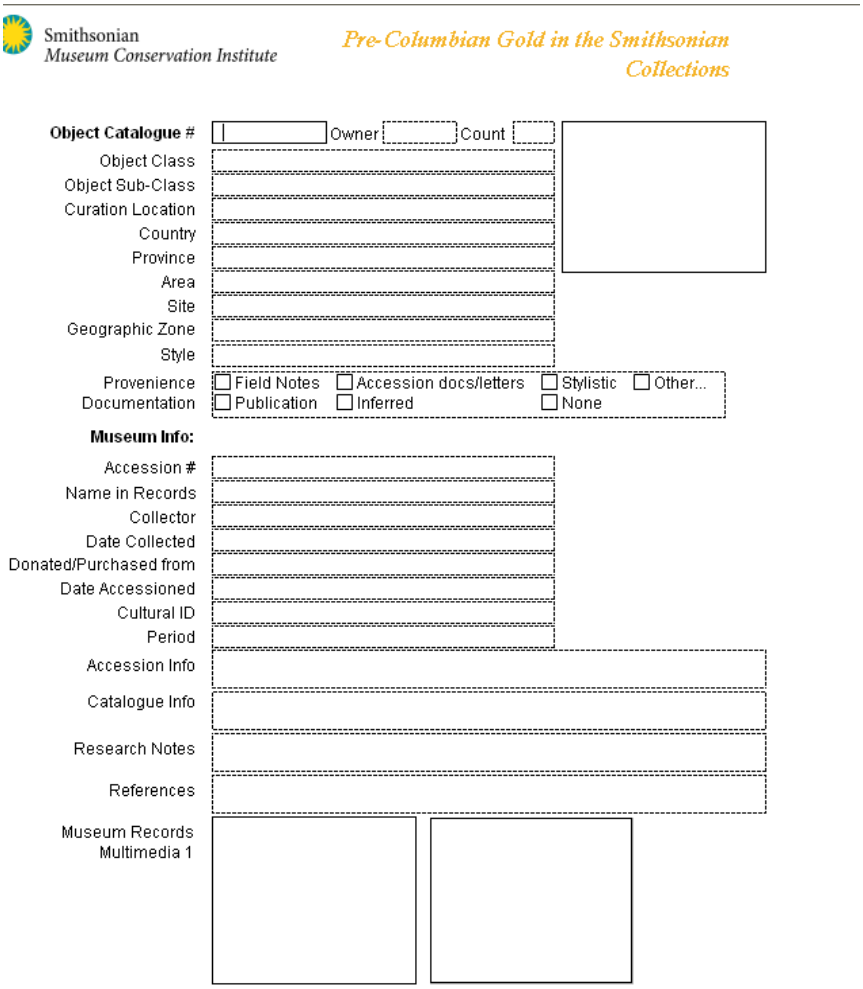

Figure 1. Museum information layout in the FileMaker Pro Database

Technical Examination Layout

The layout for technical examination was designed to allow for easy entry of notes during examination of the objects under the microscope. As examination proceeded, improvements were made to this layout and several additional fields were added. Initially it was determined from consultation with Rae Beaubien that fields for entering narrative-style descriptions would be useful as this facilitated the communal working method used in the 2007 project. During the past project, verbal observations about each object were made by multiple conservators and then recorded in the database by one person typing. The "notes" fields were therefore included under each technical category to allow for this method of data entry and for unique details about each object to be easily recorded (fig.2). In order for the database to be easily searchable by specific technical aspects of the objects, however, check boxes were added to each main technical category. In this way, the same language would be used for each object, and this critical information could be entered quickly.

The "Description" and "Condition" fields were designed for entry of the most general information about each object (fig.2). What the object is and its specific features can be entered into the description field. For example, a zoomorphic pendant may have the description: "Small open back cast armadillo pendant with two suspension loops for forearms." The dimensions may then be entered into the "measurements" fields below the description. The condition field was originally included so that information on losses, corrosion, damage, and past conservation measures could be recorded. A typical entry under condition may therefore be: "Surface is partially corroded revealing some black corrosion underneath. There is an adhesive residue and black fibers adhering to the two front and two back feet, likely from previous display. No losses. Accretions and fibers in crevices." Further information on the amount and color of corrosion may then be entered under the corrosion section just below.

The technical details about the objects follow below the more narrative descriptions at the top. Each category includes a set of check boxes with pre-determined choices and a field for notes, in which the specific details can be written out to support the choice of check box. The last such category is designated for recommended analyses. In this section, the operator can check which techniques are suggested and the reason can be written out below.

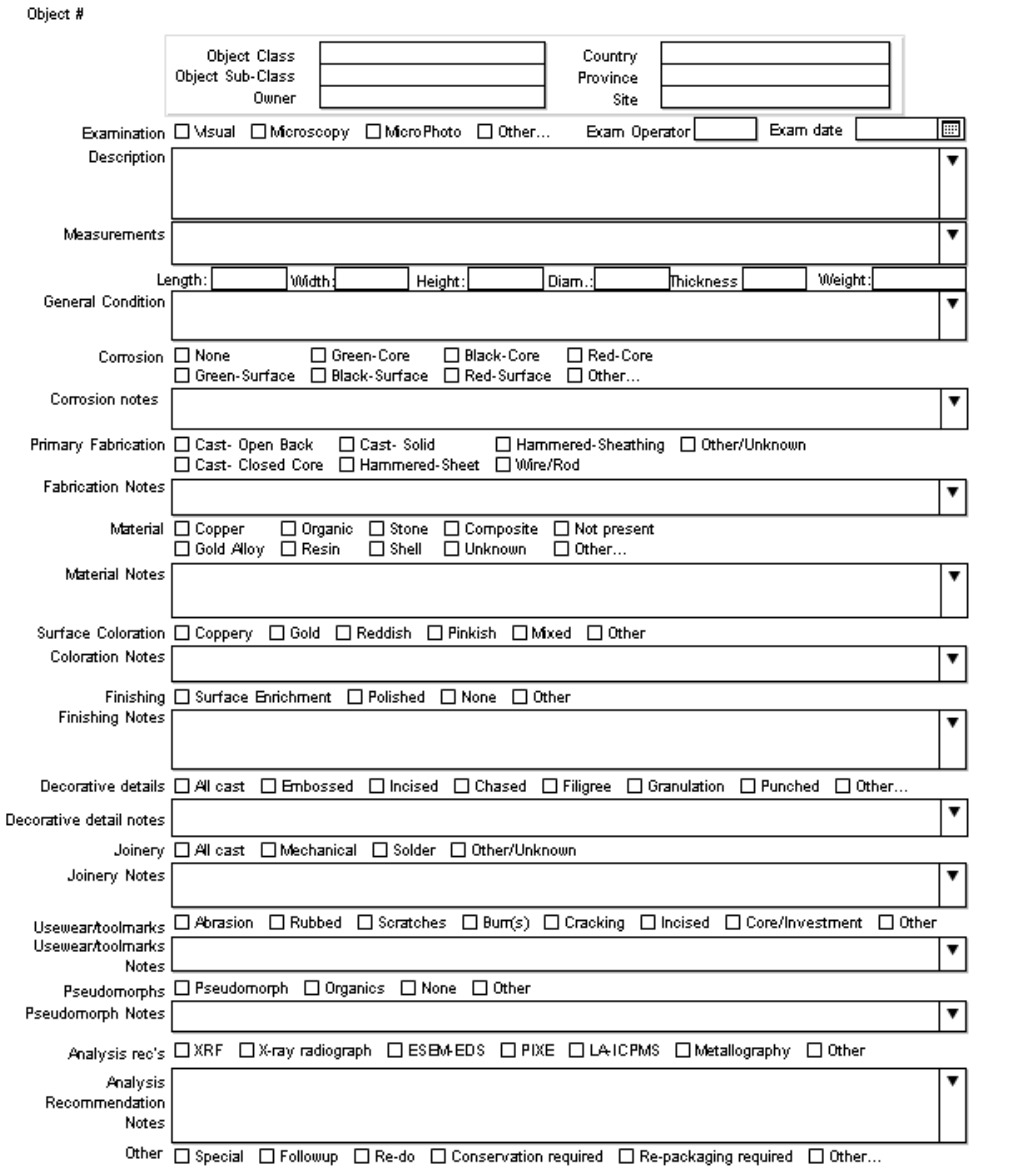

Fig.2 Technical Examination layout in the FileMaker Pro Database

Analysis Layout

The analysis page was designed to incorporate results from elemental analysis, mainly XRF and SEM-EDS (fig.3). Boxes for three separate analyses were included in this layout in order for multiple spots on one object to be recorded as well as multiple types of analyses (e.g. XRF *and* SEM-EDS). While a field is provided in which to describe the location of analysis, the accompanying notes field can be used to explain the condition of the analysis location. For example, if the object has bulky corrosion at the analysis spot, this can be documented and a note can be made in the reliability field to indicate that the data is most likely not representative of the bulk composition. In addition, a container field was provided for each analysis to display a photo of the analysis location.

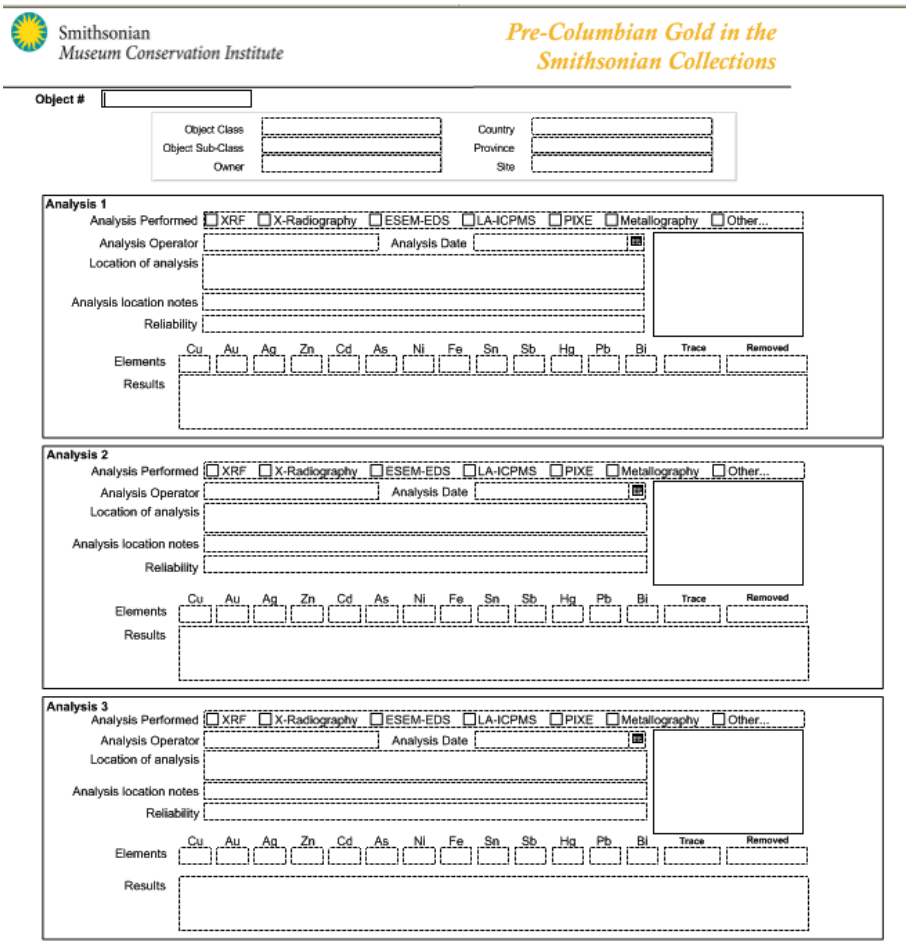

Fig.3 Analysis layout in the FileMaker Pro Database

Museum/Archival Research

After initial design of the database, information from the museum records and archives was collected for entry into the database by the author. Excel spreadsheets were generated from the museum database records provided by the NMAI and NMNH collections managers. The data from these spreadsheets was then imported into the FileMaker Pro database, thereby creating a record for each object in the study with the basic catalogue and accession information already included.

National Museum of Natural History (NMNH)

Additional research into the objects from NMNH was conducted in the card catalogue in the Anthropology Collections Management Laboratory office at MSC with initial assistance of Deborah Hull-Walski and Dave Rosenthal. The catalogue card for each object was photocopied and digitized. The hard copy files and microfilm of accession information for each object were also consulted and photocopies were made of all relevant documents, followed by digitization. These records were then imported into the museum multimedia fields in the museum info layout of the database.

The information provided by the museum records generally included a photo, the catalogue number, accession number, name of object, object count, curation location code,

collector and/or donor, country, and province. Some of the records also included a collection date and general site location. Rarely was the specific site of excavation noted in the catalogue card or accession documents and in no case was the stratigraphy or dating information provided. The lack of specific provenience and contextual information may be ascribed to the method by which the objects were obtained by the museum, namely through massive regional collecting expeditions, professional *huaqueros*, and purchases from private citizens.

While a number of different individuals collected and purchased objects for the NMNH, previously called the US National Museum up until 1957, it is clear from the accession documents that the majority of these were purchased from professional tomb looters in Panama (see table 1 for a list of collectors and donors). One of the most prolific of these grave robbers was Señor Juan Gratacós, who sold at least 28 documented objects to the museum through intermediaries such as J. Alden Mason and Karl P. Curtis. A letter from Gratacós to Mason dated February 14, 1941 (UPMAA Gratacós-Mason letters) states:

> "I send you a box of 29 objects of plated charcoal (carbon banados) including many fragments; all the broken ones including the eagles are to be melted up so that they may serve as study material for the technique & materials, if that interests you. I have melted up many that give me 4 to 8 carats of gold…"

Mason also organized the sale of a large number of objects from Gratacós to a variety of museums including his own University of Pennsylvania Museum. In a letter to the UPenn museum director Horace Jayne dated April 27, 1940 (UPMA Gratacós-Mason letters), Mason refers to Gratacós saying:

> "Sr Gratacós makes a business of excavating and selling gold objects. For several years he has sold a large part of his finds to Sam Lothrop for the Peabody Museum of Harvard. The ornaments are of art types different from those of Coclé, and more like those of Chiriquí. The technique is very interesting, being a plating of thin gold on a base surface… I am not sure whether we have any examples of it in the museum. Sr. Gratacós asks only $150 for this collection, which seems to me a bargain that should not be missed. When the specimens are cleaned and repaired they are almost as beautiful as pure gold ornaments."

Samuel Lothrop also acknowledges the purchase of objects from Gratacós and Curtis in his volume on the archaeology of Veraguas (1950, p.vii), saying:

> "In criticism of the collection in this Museum, it is fair to say that it is not very large but it is fairly well documented. The exact location of excavated specimens is, of course, a matter of record. The provenience of most purchase specimens is also known and, in some cases, also the grave associations. For this we must thank Mr.Karl P. Curtis and Don Juan Gratacós for the interest they have taken in forwarding all possible field data with the actual specimens. Don Juan is a huaquero through whose hands has passed a large part of the archaeological remains discovered by casual digging for many years past. Mr.Curtis, formerly employed in the Canal Zone, was the first to recognize that the Provinces of Veraguas, as well as Coclé, produced archaeological remains unlike those of Chiriquí. I am indebted to both these gentlemen for practical help and advice while in the field."

Lothrop here states that Curtis and Gratacós provided him with detailed field documentation indicating the provenience of objects they excavated, which could potentially elucidate the origins of similar objects at NMNH. Upon contacting the archives at Harvard's Peabody Museum, however, it was discovered that almost nothing approaching provenience documents for the Gratacós and Curtis objects currently exist. Archivists at the Peabody Museum, Susan Haskell and Pat Kervick, looked through the Lothrop Archives in addition to

20+ accession files and their catalog cards in order to find the provenience documents provided by Curtis and Gratacós. This produced a few letters from Curtis to Lothrop discussing "his Spaniard" bringing in gold from his diggings (presumably Don Juan Gratacós) and location information for about 50 Panamanian gold objects in the Peabody collection, which originate from one of several locations in Veraguas listed simply as: "Bubé," "25 miles beyond Soná-Bubé," "Near Las Palmas," "Carazas grave," "Bube near Viedal River," and "Below Montijo Arenas Grave." Several of these location descriptions are duplicated in the object records at the NMNH, including Las Palmas, and near Soná, however, no additional details were provided from investigation into the Peabody objects.

While the search for provenience information of the Curtis and Gratacós collections at the NMNH has revealed no additional location or contextual information, it has confirmed that the objects in the NMNH collection identified as originating from Veraguas were indeed excavated by individuals known to have worked extensively in this region. The credibility of those individuals, however, may be a matter of contention, particularly as several catalogue entries of these objects in the Peabody collection were annotated with the word "FRAUD," perhaps indicating that these objects were later identified as forgeries.

With regards to the other collectors, only James A. McNiel and M.W. Stirling contributed significant numbers of objects to the NMNH from extended periods of excavation. The earliest collection of Panamanian objects at the US National Museum was gathered by McNiel, who was present in Panama during the 1859 "Gold Rush" in Chiriquí when the discovery of gold in graves caused a flurry of grave robbing (Wood and Shelton 1996). William Henry Holmes, who studied the McNiel collection at the US National Museum described their lack of excavation records in an article on the subject, saying: "Mr. McNiel acknowledges that with all his experience in the work of excavation no single piece has been taken from the ground with his own hands, and he cannot say that he ever witnessed the exhumation by others, although he has been present when they were brought up from the pits. Generally, the workmen secrete them and afterwards offer them for sale. He has, however, no shadow of a doubt that all the pieces procured by him came from the graves as reported by his collectors" (Holmes 1887, Pg. 13). Once again, the records here indicate the province in which the objects were excavated but nothing regarding exact site, contextual information, or stratigraphy.

While Stirling and G.R.Willey excavated several sites throughout Panama, the only material subsequently published in full originated from the Parita sites in Central Panama (Willey and McGimsey 1954, Willey and Stoddard 1954, Ladd 1964). Most of the Panamanian gold in the NMNH collection, however, is documented as originating from Veraguas, which they visited after excavating at Barriles in Chiriquí in 1949 (Wood and Shelton 1996). They first worked at the site of La Pita in Veraguas and later at three other funerary sites in the region. Juan Gratacós assisted the excavation at La Pita (Wood and Shelton 1996) and may therefore have been the source of the objects Stirling purchased in Veraguas.

Accession #	Collector (date)	Sold/Donated by (date)	Accession Information in Museum Records	Province	Site	# of Objects
013654	J.A.Mcniel (1883)	Agents J.S. Lamson & Bros. Lamson	Collected by McNiel by 1883	Chiriquí	No info	13
019931	Rau, C (pre-1859)	Rau, C 1887	Found on one of the "Huacas" of Chiriquí, N. Granada, Panama. Brought to New York in 1859	Chiriquí	North Granada, Huaca	1
058333	C.H.Soar	C.H.Soar (1915)	3 metal objects (one of gold and two of copper gilt) from Chiriquí, province of Panama, South of boundary of Costa Rica. Purchased from C.H. Soar Order # 57337. $55.00. The above were forwarded from San Francisco by the Dr. Walter Hough, and are excellent examples of the metal work of the ancient peoples	Chiriquí	No info	3
159473	Sr.Juan Gratacós	Mason, J Alden (1941)	Gold plated figurine ornaments from Prov. of Veraguas, Panama, collected y Sr. Juan Gratacós, Panama, and from him purchased (Order no.10987) through Dr.J.A Mason. No data on exact site or conditions of finding. All cast in molds and thinly plated	Veraguas	No info	15
181391	Sr.Juan Gratacós	Curtis, Karl P (1948)	Two part gold ornaments of Veraguas culture from Panama; Purchased by Karl Curtis in Panama	Veraguas	Near Soná	2
181570	Sr.Juan Gratacós	Curtis, Karl P (1949)	Gold-plated ornaments from shaft tombs in vicinity of Sona, Veraguas Panama. Presented to the US national Museum by Mr.Karl P. Curtis. Some were collected by the donor but a majority were acquired from Juan Gratacós "a professional tomb looter of Sona"	Veraguas	Near Soná	11
184319	?	Mrs.Stirling (1949)	Four gold ornaments from Chiriquí Province, Panama, Purchased through Mrs. M.W. Stirling by the Old World Archeological Fund and Presented to the National Collections.....	Veraguas	Near Soná	5
188488	?	Edward Chapin (1950)	Fragment of gold ornament said to have been found in Panama; presented to the national collections by Dr. E.A. Chapin, Curator of insects	No info	No Info	1
188983	Purchased by M.W. Stirling in Panama	M.W. Stirling (1953)	"Ornaments from Veraguas, Panama tombs purchased by M.W. Stirling in Panama" Accession docs	Veraguas	No info	10
202030	Collected by M.W. Stirling in Panama (1951)	Bureau of American Ethnology (1954)	"Collected in 1951 by M.W. Stirling at site on the Rio San Pablo, 4 miles above Sona" Accession docs	Veraguas	Rio San Pablo, Near Soná	6
219603	M.W. Stirling and Willey (1948) (?)	BAE (1964)	This material may either be a donation from the National Museum of Panama, or material collected by M.W.Stirling and Willey (1948)	Herrera (?)	El Hatillo, Site He-4 (?)	6
254765		Marjo Stevens (1964)		No Info	No info	1
265536	Dr.C.L.G. Anderson (~1906)	Swackhamer, Donald A (1966)	Said by nephew to be excavated by Anderson ~1906 in Panama Canal Zone	Panama	No Info	1
268732	Purchased by George Barrett (1966)		No accession docs at NMNH (hardcopy or microfilm)	Bocas del Toro	No info	1
361220	BAE	Department of Anthropology (No records prior to 1976)	Accessioned in 1976 when the object was taken out of the display case and no previous accession/catalogue information on objects found	Veraguas	La Pita	1

Table 1. List of Collectors and Donors of Panamanian gold to the NMNH

National Museum of the American Indian

As the catalogue cards of all NMAI objects are digitized and available in the museum database, no additional photocopying or digitization of the museum records was required. The

records imported into the FileMaker Pro database from the museum database generally provided information on the catalogue number, object name, country, province, area, site, collector, donor, and accession date. In addition, a photo of the object and image of the catalogue card was included.

While the museum records provided some basic background information, attribution of provenience and collector was in some cases suspect or else completely missing. In order to fill in the missing provenience information and determine the reliability of the information provided, an archival and literature search was undertaken. The relevant documents retrieved from this phase of research were photocopied and digitized. Where exact objects were mentioned in these sources, the file of the digitized document was inserted into the object's record in the database under the museum multimedia field.

The NMAI archives provided a majority of the archival information for the objects in the collection. A search of donor's names produced nine boxes containing correspondence, field notes, invoices, etc. (see table 2). The documents in each of these boxes were examined for reference to the acquisition of the gold and tumbaga objects in the NMAI collection. All relevant documents were then noted, photocopied, and digitized.

Box	Contents	Notes
Box FD#2	Folders: Dade, Philip 1957-1963 and Dade, Philip 1964-1974	(Contains informal correspondence between Dockstader and Dade including descriptions of the objects sent to Dockstader and the general location of their excavation
Box FD#5	Correspondence between Dockstader and Mr and Mrs Harte (1960-1974)	Invoice of Gold Huacas from Panama with weights and descriptions
Box OC132, Folder #3	Neville Harte's excavation notebook for Venado Beach	References to "disks" and a gold necklace with 46 beads. No specific description or drawings of gold artifacts
Box OC132, Folder #4	Neville Harte's excavation notebook for Guacamaya, Rio Grande Valley, and Madden Lake	Went through book. Images of every burial excavated (Drawing of section and artifacts) but no gold mentioned.
Box OC132, Folder #5	Harte's journal containing short narrative of Sona trip	No reference to finds.
Box OC 137 Folder #30	Correspondence between Dr.William Lannick and Dockstader	A letter from Dockstader lists the "gold specimens" from the Parita sie, Azuero Peninsula, Panama
Box OC 141 Folder #19	Receipts for objects obtained by Sackler	To Walter Randall, $400 Two headed animal, $400 Puma with snake, killed. Dec.3, 1964
Box OC 142 #2	A few documents/lists of objects given/donated to museum by Ernest Schernikow, New York, Cable address: Epitome New York	No reference to gold anthropomorphic figure, Panama now in OP exhibit
Box OC 32, #10	Correspondence between Hyatt Verrill and George Heye	Heye hires Verrill in 1924 to "conduct an ethnological expedition in Panama, first going to the region of the Colombia border on the west coast, and afterwards taking in the tribes of the central part of Panama south of Costa Rica…."
		In 1925, Verrill begins excavation in Cocle, sending 4 crates back to the museum (sent list of objects but this is not in file)
		Verrill mentions in letter of Jan.4, 1925 that there are no gold artifacts at so-called "temple" site even though natives spent several months digging.
Box OC 32, #13	Verrill's packing lists of specimens	1924, shipped per S/S Santa Luisa: Men's gold earrings (#8864) from Teguala tribe, Samgandi and Tubugandi Rivers, Darien. Ethnographic specimen
Box OC 138 # 17	Early documents regarding Lothrops work with MAI	No reference to Panama
Box V-O #9	Contains Lothrop's hand written manuscript on Peruvian Gold	

Table 2. Location of documents in the NMAI archives related to their collection of gold from Panama

The earliest Panamanian gold and tumbaga objects in the NMAI collection were gathered during trips headed by employees of George Gustave Heye, the founder of the Museum of the American Indian (MAI), which in 1989 became the NMAI. George Dissette, Frank Utley, and Marshall Saville were the earliest collectors for Heye in Panama at the beginning of the 20th

century, shipping back a total of 55 gold and tumbaga objects, none of which currently have extant documentation in the NMAI archives detailing their provenience. In 1924, Hyatt Verrill was commissioned to go to Panama specifically to collect ethnographic and archaeological objects for Heye. Verrill began excavation in 1925 at El Caño in Coclé, sending the excavated material back to the MAI. The only object in this study collected by Verrill is a greenstone nose ring with gold sheathing indicated as originating from Coclé, which may have been excavated at El Caño, although this is not recorded in any extant documentation.

While a few of the Panamanian gold objects housed at the NMAI were donated or purchased from private individuals, the majority of the objects in this study at the NMAI were obtained from three main collectors, Philip Dade and the husband and wife team Eva and Neville Harte (see table 3 for a list of collectors and donors). These collectors were amateur archaeologist ex-patriots who sold finds from their excavations to individuals and museums to fund their ongoing expeditions.

Early correspondence between Frederick Dockstader and the Hartes mentions a few items sold to the museum; however, the Hartes were not inclined to sell their gold collection until much later. Due to personal and financial reasons, the majority of objects in the Harte collection were sold to the MAI in one batch in 1967 and an invoice with a list of the objects is present in the archives. Unfortunately no documentation regarding provenience of these materials was found in the NMAI archives. The gold listed in the invoice is labeled only "Gold Huacas-Panama." The correspondence, however, mentions the field notes, etc. indicating the provenience of their objects.

During the 1950's and 1960's, Philip Dade sold a massive collection of Panamanian ceramics, metals, and other artifacts to the MAI. The close relationship that developed between Dade and the director of the museum at the time, Frederick Dockstader, is evidenced in the collection of their correspondence in the NMAI archives spanning the years 1957 to 1974. In the letters between Dade and Dockstader, Dade often refers to the location of his excavations and the provenience of objects sold to Dockstader. For example, in reference to the Parita material, Dade writes to Dockstader on November 7, 1966: "You know, Fred, confidentially, that Mound 6 grave 1-2 I guess was the richest and most important Pre-Colombian burial ever discovered and that includes Stirling's La Venta and Lothrops Grave 26 Cocle. You have a major part of Mound 6. I still have about 260 grams…." And Dade goes on to list the objects in his possession from this site, including: "Two alligators each with a bell in its claws…1 ring, exquisite wide gold with frames for 3 inserts…5 pairs of alligators with inserts (missing-see above)… Two Parita chisels- not too easy to come by" (Box FD#2, Dade 1966). Based on his descriptions, these objects can be identified as catalogue numbers 237895, 237887, 237891, 237898, and 237899 respectively. All of the objects in the NMAI collection identified in Dade's letters were annotated in the database to indicate any additional provenience information provided in the Dade-Dockstader correspondence.

Collector (date)	Sold/Donated by (date)	Province	Site	# Objects
Dissette, George C. (1906)	Dissette, George C. (1906)	Bocas del Toro Province	No Info	32
Utley, Frank D. (1906)	Utley, Frank D. (1906)	Chiriquí Province	Bugaba	4
		Chiriquí Province	Divalá	3
		Chiriquí Province	VolCaño Mountain	1
		Chiriquí Province	Santa Feles	1
		Chiriquí Province	Bugabita Arriba	13
Saville, Mr. Marshall H.	Saville, Mr. Marshall H. (1906)	Darién Province	Darién Province	1
Verrill, A. Hyatt (1924)	Verrill, A. Hyatt (1924)	Coclé Province	Coclé Province (El Caño?)	1
No Info	Museum Purchase (1929)	Coclé Province	Río Grande	15
Lothrop, Samuel Kirkland (1929)	Lothrop, Samuel Kirkland (1929)	No Info	No Info	1
No Info	Heye, Mrs. Thea (1933)	Chiriquí Province	David	1
Harte, Eva and Neville A. (1951)	Stendahl, Earl	Panamá Province	Venado beach between Veracruz and Palo Santo	4
Dade, Philip (?)	Dade, Philip (1961)	Panamá Province	Venado Beach	11
	Stephenson, Alexander (1963)	Herrera Province	El Hatillo, Site He-4	24
	Dade, Philip (1964)	Veraguas Province	Santa Fe	3
	Dade, Philip (1964)	Veraguas Province	Santiago	2
	Sackler, Dr. Arthur M. purchased from Philip L Dade (1966)	Veraguas	No Info	3
		Darien	No Info	1
		Herrera Province	El Hatillo, Site He-4	8
Dade, Philip (1968)	Lannik, Dr. William M. (1968)	Herrera Province	El Hatillo, Site He-4	20
Harte, Neville (Excavated 1963)	Randel, Walter (1964)	Herrera Province	Las Palmas	1
purchased from Walter Randall		Veraguas Province	Santiago	1
No Info	Ford, Mrs. D. (1966)	No Info	No Info	1
Harte, Eva and Neville A.	Sackler, Dr. and Mrs. Arthur M. (1967)	Veraguas Province	Veraguas	2
		Coclé Province	Penonomé District	5
		Veraguas Province	Rojas	8
		Panamá Province	Venado Beach	7
		Chiriquí Province	Chiriquí Viejo	6
		Colón/Panamá Province	Lago Alajuelo (Madden Lake)	22
		Veraguas Province	Las Palmas	6
		Veraguas Province	Saddle, Rio Grande	1
		Coclé Province	El Caño	4
Garcelon, Helen	Garcelon, Helen C. (1969)	Herrera Province	Península de Azuero	11

Table 3. List of Collectors and Donors of Panamanian gold to the NMAI

Examination and Documentation

Photography

Digital photography was undertaken in order to fully document each object included in this study. The resulting photographs could then be consulted or annotated during subsequent phases of the project and added to the database where photos were missing. Each museum provided a setup for photography, which included a copy stand in the NMNH Anthropology Collections Management Laboratory at MSC and a full scale photo studio in the conservation lab of NMAI. A black background was used for most of the photos; however, a gray background was used in a few cases to provide better contrast for a few types of objects. All of the photos included a scale and label identifying the object number; however, a variety of scales and label types were used due to the changing location and conditions. All of the resulting JPEG files were archived in the project folder on the Museum Conservation Institute's R: drive.

Microscopic Examination/Photomicrography

Visual examination and optical microscopy were carried out on each object included in this study. Work was carried out in the Conservation Laboratory of the NMAI and in the NMNH Collections Management Laboratory. For the examination phase, a Wild Heerbrugg 8 microscope was used with magnification ranging from 6-50x. A Leica digital camera attachment and LAS EZ software on a laptop

connected by cable allowed photo-documentation of the microscope images (fig.4). Only features indicating fabrication or finishing methods were documented; however, some overviews and details of objects were also photographed for documentation purposes and to allow for subsequent measurements to be taken.

During examination under the microscope, the operator entered information concurrently on the lap top connected to the microscope. The resulting object description, condition information, and notes on fabrication techniques were entered into the technical examination layout of the FileMaker Pro database described above. As described under the database section, check boxes and edit boxes were filled out with information regarding the artifact material, structure, condition, and visible evidence of fabrication methods such as tool marks, casting traces, joinery, and surface enrichment. In addition, objects were noted that would be ideal for subsequent analysis and sampling.

Figure 4. Setup for photomicrography

Objects Examined:

- 77 Objects from NMNH were photographed and examined under the stereomicroscope with 115 photomicrographs taken.
- 231objects (159 catalogue numbers) from NMAI were photographed and examined under the stereomicroscope with 276 photomicrographs taken.

Results

See database in Appendices A and B. Photomicrographs are archives on the R: drive at the Museum Conservation Institute.

X-Ray Fluorescence Analysis (XRF)

Technique

Every object in this study was analyzed at one or more locations using a bench top 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. For analysis of the pre-Columbian gold, 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%. Sub-surface penetration of x-rays also varies according to the sample matrix; however, the characteristic x-ray attenuation depth for Au, was calculated to be 49μm using the mass absorption coefficient of Au at 43KeV (from Roy et al. 1997).

Procedures

For analysis, each object was individually placed in the XRF chamber and the area to be analyzed was centered over the window (fig.5). Photographs were taken of the analysis location afterwards; however, objects analyzed in Panama were photographed in place over the XRF window. 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. After initial training by Jeff Speakman, analyses were carried out in the NMAI and NMNH Conservation Laboratories by the author.

Figure 5. Placement of object over window

During and immediately after collection of the XRF spectra, data checking and importation of the calculated element concentrations into an Excel Speadsheet were carried out 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.[3] 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 all of the XRF data for this study. 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 the element concentrations copied to excel, the operator entered notes for each measurement. This information included the date, operator, owner of the object, any elements removed from the calculation, and the location and condition of the analyzed spot. Digital photographs were also taken with the location of the analysis spot indicated. 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.

Limitations

Although XRF can provide a great deal of compositional information, limited inferences about the base alloys can be made using this approach if the composition of an object varies greatly between the surface and interior. While the depth of x-ray penetration may be calculated

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

using the density of the sample matrix, sample composition, and energy of the emitting x-ray source, the first variable can only be approximated for complex objects such as those included in this study.

While the limited depth of analysis using XRF may cause no problems for largely homogenous metal objects, problems arise when the surface chemistry differs from the base alloy. As surface enrichment is a common feature found on pre-Columbian gold-copper alloy objects, interpretation of data from XRF analysis must account for this possibility. For this reason, XRF analysis was coupled with technical examination and all objects with possible surface enrichment or bulky corrosion were noted. These objects underwent analysis at multiple spots and at break edges where possible to determine whether a variation in composition could be detected. A representative sample of objects with surface enrichment and visible break edges were also selected to undergo further analysis with SEM-EDS to quantify the difference in interior and exterior composition.

Another shortcoming of this method is peak overlap of certain elements. The relatively low peak resolution of this portable XRF can be problematic when peak energies of elements are close enough to cover one another. For these materials, where Au, Ag, and Cu are abundant, detection and quantification of elements with similar peak energies may be hindered, including Os, Pt, Hg, and Zn. In cases where detection of these elements was considered essential, analysis by other methods such as SEM-EDS was recommended.

Objects Analyzed

- 229 objects from NMAI were analyzed (289 spots), representing 158 catalogue numbers.
- 78 objects from the NMNH collection were analyzed with XRF (127 spots)

Results

See Appendix C for results from XRF analysis. XRF data are also presented in the database, a printout of which is included as Appendices A and B.

Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS)

Technique

Environmental (or low vacuum/variable pressure) scanning electron microscopy-energy dispersive spectroscopy (ESEM-EDS) was performed on selected objects. This technique measures elemental composition and permits high-magnification imaging of objects or samples that fit within the instrument's chamber (30cm diameter x 8cm height). Analyses may be carried out in normal environmental conditions, without need for coating or sampling. ESEM-EDS provides semi-quantitative information on surface elemental composition, similar to that provided by XRF analysis but with much finer spatial resolution and higher magnification. This technique also allows imaging using secondary electrons for detailed surface morphology, and backscattered electrons to provide elemental mapping based on the relative atomic mass of the elements present at and near the object surface.

Instrumentation

The instrument used in this study was MCI's Hitachi S-3700N Variable Pressure Scanning Electron Microscope w/Bruker XFlash EDS with Quantax 400 software (fig.6). Whole objects were placed in the SEM chamber and analyses took place under vacuum at 15 kV accelerating voltage, and at 10mm working distance where possible (fig.7). Analysis was undertaken by the author after initial training by Judy Watson. Working distance for some analyses, however, varied between 10-20+ mm due to the large or complex shape of some objects and the necessity of placing several objects in the sample chamber at one time due to time constraints.

Figure 6. Hitachi S-3700N SEM-EDS

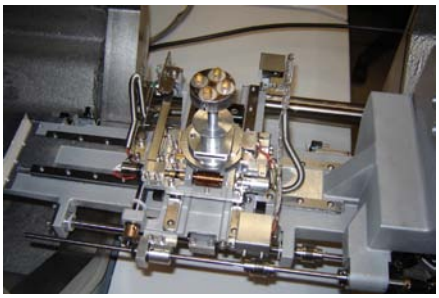

Figure 7. Sample holder with beads

A variety of data collection features were used for imaging and elemental analysis of the NMAI and NMNH objects. Imaging was undertaken in both secondary electron and backscattered electron modes depending on the features being highlighted. For elemental information, hypermap mode was used with a 15 minute average collection time of spectra. This method was used in cases where a variety of elemental and spatial information was desired for subsequent analysis. In other instances, where elemental information from a specific area was desired, spectra mode was used with a collection time of 200 seconds. Additionally, elemental mapping (collected for 2-3min) was used in cases where spatially correlated compositional information was desired for relatively quick assessment of specific questions. In these cases, further analysis is not possible and the maps of the relevant elements were therefore saved immediately.

Research Questions

Several specific research questions directed the sample selection for ESEM-EDS. This analysis was performed in cases where the method of fabrication remained ambiguous after microscopic examination and XRF analysis. Gold beads comprised the largest category of artifact falling into this group as the location and method of joinery is often difficult to determine through simple examination. In addition, SEM-EDS imaging of toolmarks and features from forming can help clarify the techniques and steps used to make these objects.

ESEM-EDS was also performed on objects that exhibited soldered repairs in order to determine the solder composition. By detecting the presence of modern impurities in the solder, it is possible to differentiate between modern and possible ancient repairs. Objects with visible break edges were analyzed by ESEM-EDS to determine variations in elemental composition between areas not differentiable with XRF, such as an enriched surface layer and interior metal. In addition, several composite objects with components made from unknown materials were analyzed by SEM-EDS to give some clue as to the types of materials present.

Objects Analyzed

- 22 objects from NMNH were analyzed with SEM-EDS representing 9 catalogue numbers

- 44 objects from NMAI were analyzed with SEM-EDS (345 separate images and analyses)

Results

SEM images and EDS analyses are currently archived on the SEM-EDS computer and on the R drive at the Museum Conservation Institute. A list of the SEM-EDS images and analyses is included here as Appendix D and a contact sheet of the SEM images is included as Appendix E.

X-Radiography

Technique

Imaging of objects was performed using digital x-radiography. This technique is similar to traditional x-radiography in that an x-ray source was used to produce x-rays that pass through the object, reaching the sensor in variable quantities depending on the thickness and density of material between the source and sensor. In digital x-radiography, a phosphor plate replaces the film as x-ray sensor. Rather than undergoing chemical developing processes, the plate is placed in a special scanner where the latent x-ray image is digitized using laser light scanning.

X-radiography was undertaken by Ron Cunningham, Senior Paintings Conservator at MCI, to clarify the structure of selected objects. X-radiography can indicate the presence and type of joins as well as some details of manufacture such facets and varying thicknesses from hammering. In addition, x-radiography may indicate locations of varying composition, such as from solder that may not be visible to the eye.

Objects Analyzed

- 38 objects from the NMNH collection have undergone X-radiography
- To date 42 objects from the NMAI collection have undergone X-radiography

Results

See Appendix F of x-radiograph images. Original TIFFs are archived on the R drive and on the computer in the radiography lab at the Museum Conservation Institute.

Future Work and Dissemination of Data

- Continue SEM analysis of NMAI material on loan to MCI until June 2010.
- Analysis and interpretation of data from XRF, SEM-EDS, and x-radiography.
- Present paper on this project at ICOM-Metals 2010 in Charleston, SC.
- Continue analysis and interpretation of data with the aim to publish additional findings.

REFERENCES

Holmes, W. H. 1887. *The use of gold and other metals among ancient inhabitants of Chiriquí, Isthmus of Darien*. Bureau of American Ethnology Bulletin, 3. Washington DC.

Ladd, J. 1964. *Archaeological Investigations in the Parita and Santa Maria Zones of Panama*. Washington DC: Smithsonian Institution.

Lothrop, S. K. 1937. *Cocle: An Archaeological Study of Central Panama pt.1*. Cambridge, Mass: Harvard University.

———. 1942. *Cocle: An Archaeological Study of Central Panama pt.2*. Cambridge, Mass: Harvard University.

———. 1950. *Archaeology of Southern Veraguas, Panama*. Cambridge: Harvard.

National Museum of the American Indian Archives. Boxes: FD, OC 32, OC132, OC137, OC138, OC141, OC142 , V-O.

Roy, B., Chatterjee, B.K., Roy, S.C., Nanak Bhattacharya, I., Choudhury, N., 'Photoelectric cross-sections derived from measured total attenuation coefficient of photons near absorption edges of heavier atoms' in *Appl. Radiat. lsot.* 48(6) (1997) 785-788.

Scott, D. A. 1995. 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*, edited by P. B. D. Vandiver, James R.; Galván Madrid, José Luis; Freestone, Ian C.; Wheeler, George Segan Materials Research Society 499-526.

University of Pennsylvania Museum Archives, Admin Records, Curatorial American Section, Collectors &Collections (Gratactós-Mason Correspondence regarding Panama gold, 1940)

Willey, G.R. and C.R. McGimsey. 1954. The Monagrillo Culture of Panama. *Peabody Museum Papers.* 49 (2). Cambridge: Harvard University.

Willey, G.R. and T.L. Stoddard. 1954. Cultural Stratigraphy in Panama: A Preliminary Report on the Giron Site. *American Antiquity.* 19:332-342.

Wood, D., and C. N. Shelton. 1996. New data from old collections: The 1949 Stirling collection from Panama in the National Museum of Natural History. *Museum Anthropology* 20 (1):3-20.

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 (April 2009), archived at the Smithsonian's Museum Conservation Institute, Suitland, MD