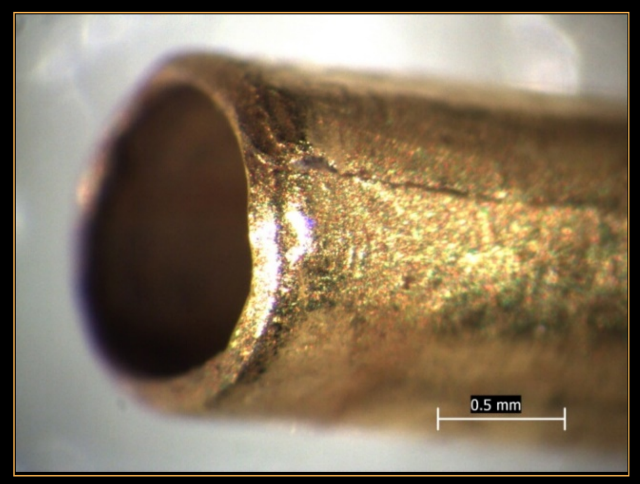
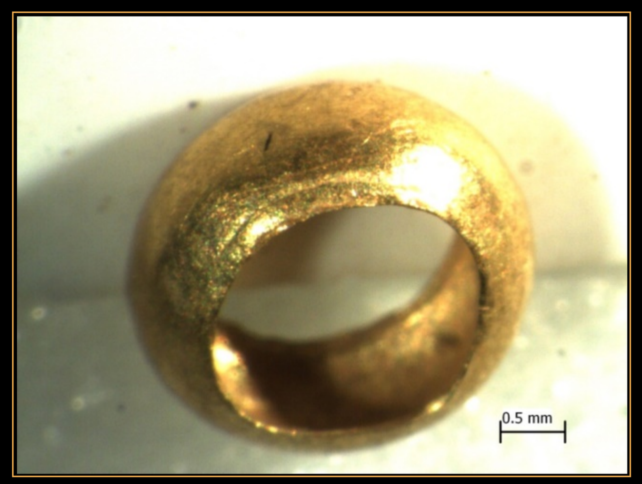
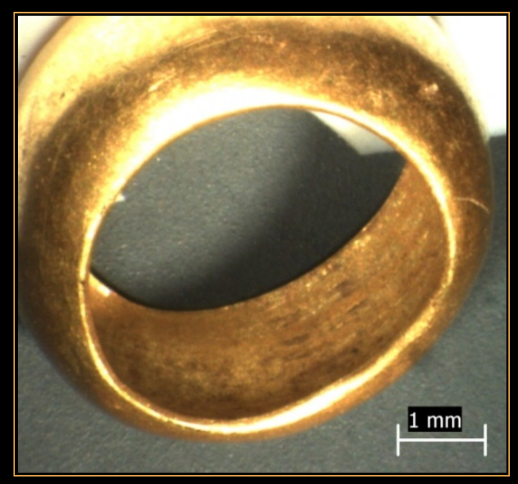
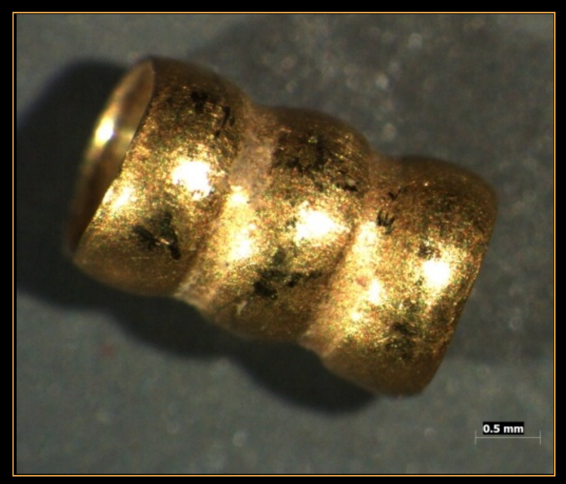
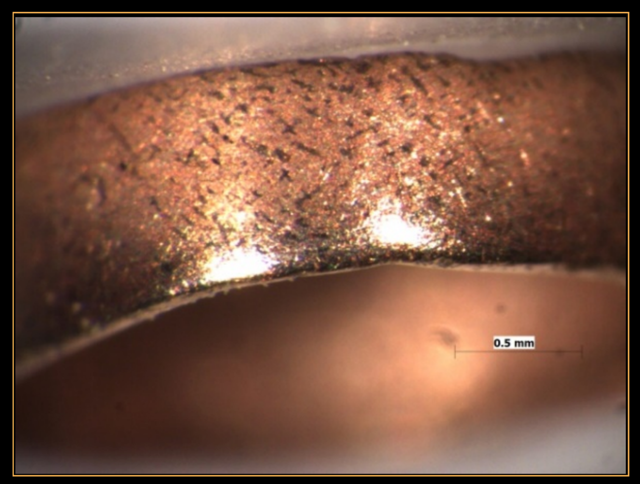








UNDERSTANDING BEAD MANUFACTURING METHODS IN PANAMA

A study of roughly 2100 archaeological gold beads from Panama was conducted to better understand the technology used in their manufacture. The work undertaken at the Smithsonian's Museum Conservation Institute included examination, technical analysis and replication studies. In the first phase of the study the beads were divided into compositional, formal and technological categories. The most common type of bead, a rolled bead fabricated from sheet metal with an overlap, was chosen for more in-depth study in order to determine how the join in the bead was accomplished. No elemental variation was detected along the exterior surfaces or over cross-sections of the join regions suggesting that neither a solder nor a eutectic system was used as a bonding method for this type of bead. Initial results from experimental reproduction indicate that the shared micro-features on these beads may be due to the way in which the beads were rolled and cut during mass-production.

STUDY GROUP

- 1,700 beads from the Smithsonian's National Museum of the American Indian
- 60 beads from the Smithsonian's National Museum of Natural History
- 223 beads from the site of El Caño
- 8 beads from Isla Pedro González in the Pearl Islands

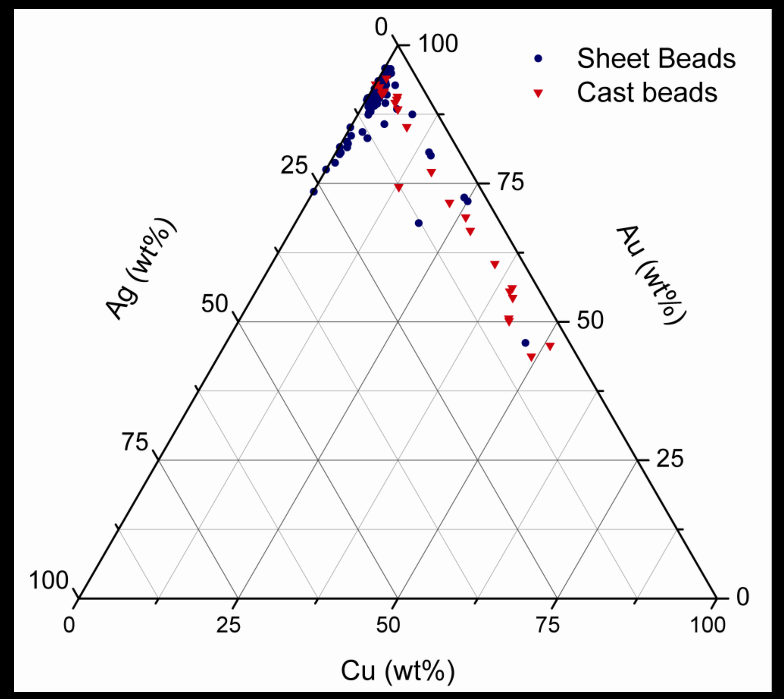
ANALYTICAL TOOLS

- Microscopy to view physical features
- Metallography to study physical structure & metal components
- X-ray fluorescence spectroscopy (XRF) for compositional analysis
- Scanning electron microscopy/energy dispersive spectroscopy (SEM-EDS) for elemental mapping

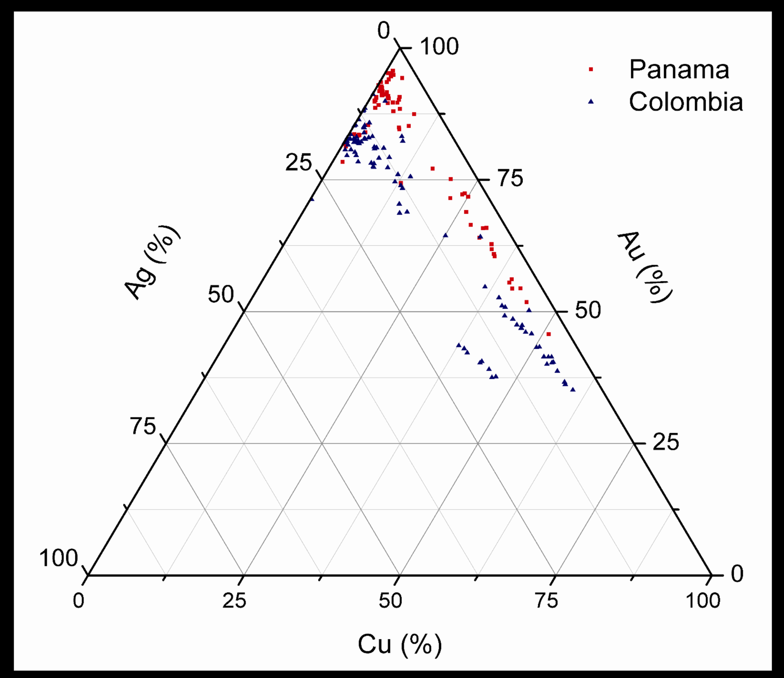
RESULTS

- 1.3% = Cast beads
- 98.7% = Sheet metal beads. 88.91% fabricated by rolling or burnishing sheet over a temporary core and overlapping or joining ends mechanically. Shared micro-features may be from bead rolling and cutting process.

XRF ANALYSIS



CAST vs. HAMMERED BEADS, PANAMA
Ternary plot of 113 beads from Panama indicate hammered sheet metal beads are often higher in gold, and cast beads are higher in copper.



COLOMBIAN vs. PANAMANIAN BEADS
Ternary plot of 101 beads from Colombia and 113 beads from Panama show a pattern of lower silver concentration in the Panamanian beads. See also , Harrison and Beaubien 2010.

FABRICATION TECHNIQUES CONSIDERED

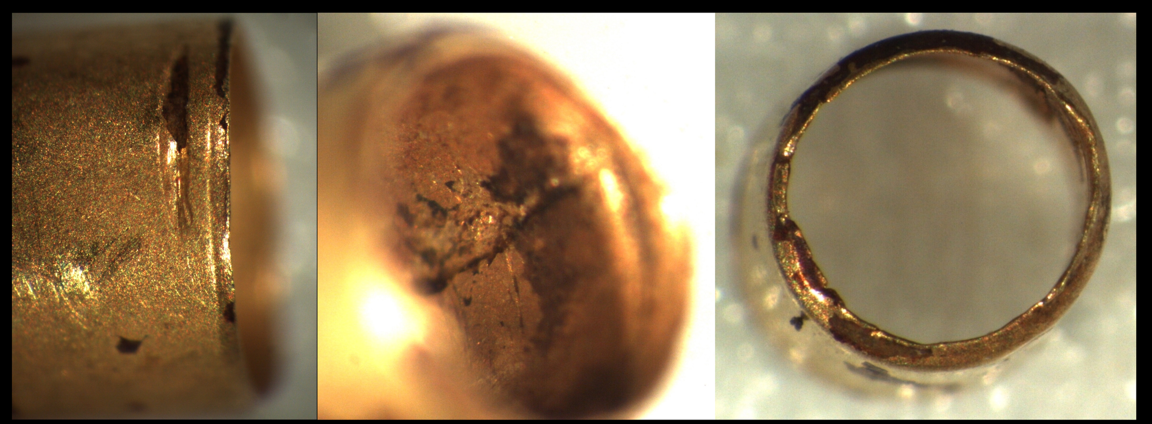
MECHANICAL

- Crimping - pleating metal to form a bead. Depending on the force applied the metal surfaces may come into close contact along most of the pleat. Crimping is visible to the naked eye. Regions of work hardening may be visible in cross-sectional analysis.
- Burnishing - plastic deformation of a surface due to sliding contact with another object, such as a polished stone. The combination of pressure and friction can compact overlapping metal surfaces together. Visually, burnishing smears the texture of a rough surface and makes it shinier. Burnished seams may not be visible to the naked eye although they may be visible under magnification, and regions of work hardening may be visible in cross-sectional analysis.

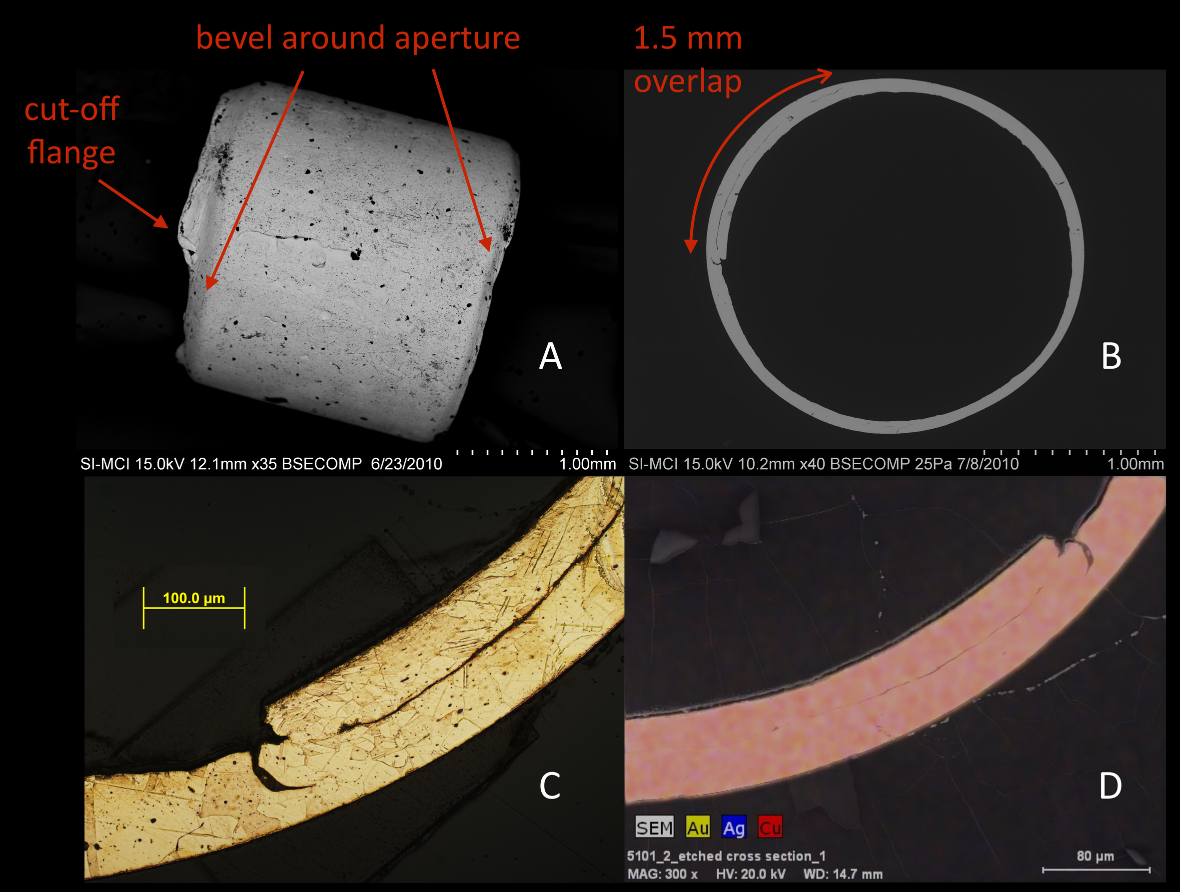
THERMAL

- Fusing two homogeneous metals - adjacent surfaces are heated until they become fluid and diffuse into each other. This process takes place at the liquidus or melting temperature of the metal and the lack of variation in the metallic bond may make detection difficult.
- Soldering (Hard Soldering) - using heat to flow an alloy of a lower melting temperature metal between the two surfaces of a metal with a higher melting temperature. For our purposes, the solder would likely be formulated of Au, Cu and Ag in a ratio that reduces the melting temperature below that of the original alloy. The solder may not be visible under magnification. However the compositional variation between the solder and original alloy may be measured by a variety of analytical techniques including SEM-EDS.
- Diffusion bonding/Eutectic formation - gold alloys with a low percentage of copper will form a eutectic when copper salts in an organic adhesive are applied between the surfaces to be joined, followed by heating. Carbonization of the adhesive occurs at 600°C reducing the salt to metallic copper, which forms an alloy with the original metal. The localized reduction in melting temperature results in bonding at the points of contact. The slight change in composition of the eutectic system has been identified in several previous studies using both surface analysis with SEM-EDS and analysis of cross-sections.

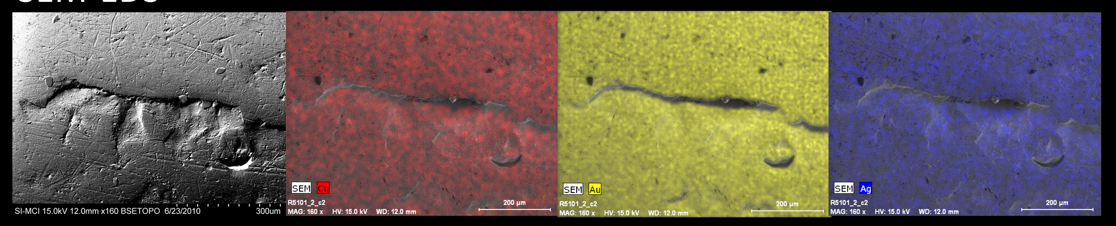
CASE STUDY: Bead R5101.2, El Caño, Panama



- 2mm long X 2mm diameter
- overlap approximately 1.5mm edge to edge
- inner surface of bead is coarse in texture
- exterior has polished surface
- beveled edges visible around both apertures with a cut-off flange of metal around the inside of the apertures.
- etched metallographic samples show evidence of cold working (Figure C) followed by annealing, with additional localized deformation after the final annealing.
- the zone directly between the two layers at the very end of the overlap is tightly aligned across the grain boundary.
- metallographic samples show no variation in microstructure or color in the region of the overlap, suggesting no addition of solder or other material.
- SEM-EDS confirms no difference in composition in the overlap

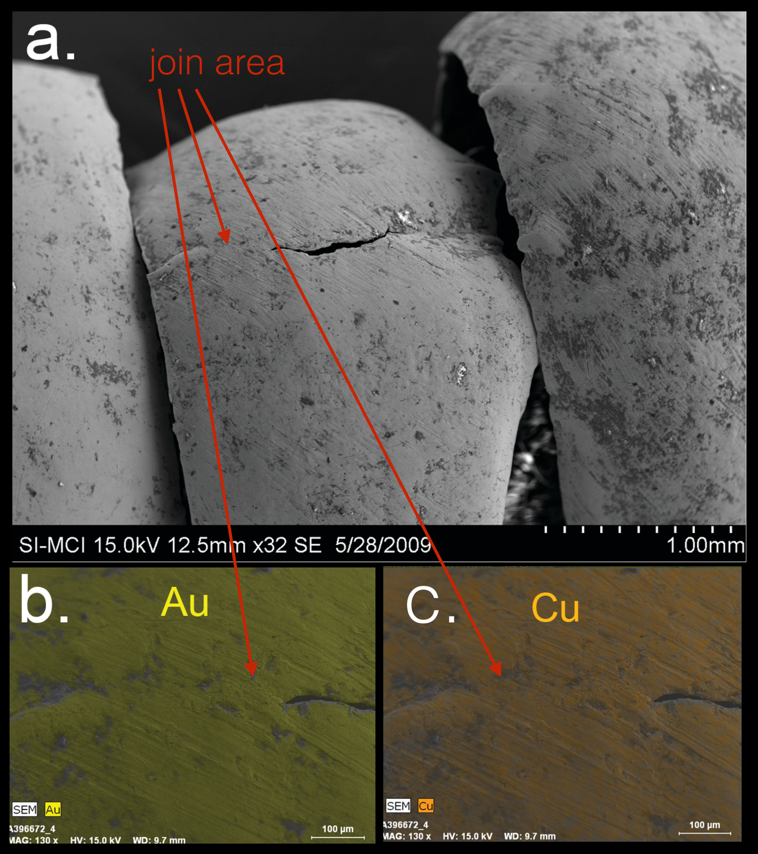


SEM-EDS



SEM-EDS ANALYSIS

28 beads from the NMAI and NMNH collections, and four rolled and joined beads from El Caño - all with obvious overlapping or visible seams - were selected for SEM-EDS analysis. All were manufactured from hammered sheet with an overlap or seam visible on either the interior, exterior, or on both sides. The analysis was focused primarily on the overlapping regions. Bevels, burrs, chisel marks, or a combination of these features was noted on the bead openings, or apertures. Three of the four beads also had evidence of abrasion in the form of a rough texture on the interior surfaces. Below is an SEM of bead A396672, from NMNH, showing no difference in composition across the join



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