ABSTRACT

INDIGENOUS GOLD FROM ST. JOHN, U.S. VIRGIN ISLANDS: A MATERIALS-BASED ANALYSIS

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The purpose of this research is to examine the origin, manufacturing technique, function, and meaning of metals used during the twelfth and thirteenth centuries on the island of St. John, United States Virgin Islands. This project focuses on two metal artifacts recovered during National Park Service excavations conducted between 1998 and 2001 at a shoreline indigenous site located on Cinnamon Bay. These objects currently represent two of only three metal artifacts reported from the entire ancient Lesser Antilles. Chemical and physical analyses of the objects were completed with nondestructive techniques including binocular stereomicroscopy, scanning electron microscopy, portable X-ray fluorescence spectrometry, and particle-induced X-ray emission spectrometry with assistance from laboratories located at Northern Illinois University, Beloit College, Hope College and The Field Museum. This data will be combined with contextual site data and compared to other metal objects recovered throughout the ancient Caribbean.

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INDIGENOUS GOLD FROM ST. JOHN, U.S. VIRGIN ISLANDS:

A MATERIALS-BASED ANALYSIS

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CHAPTER 1

INTRODUCTION

Until recently, discussions concerning metal and metallurgical traditions in the ancient Caribbean were uncommon (see Oliver, 2000; Martinón-Torres et al., 2007, 2012; Valcárcel Rojas & Martinón-Torres, 2013). The limited amount of metal recovered from archaeological contexts in the Caribbean, less than 50 artifacts predating European contact reported, has lead to the scarcity of research on this topic (Martinón-Torres et al., 2012; Valcárcel Rojas & Martinón-Torres, 2013). In addition, there is zero archaeological and ethnohistoric data that support localized smelting or casting occurring prior to the arrival of Europeans (Valcárcel Rojas & Martinón-Torres, 2013:515). Despite this lack of evidence, metal has a long historical tradition in the region dating its first known occurrence sometime between the first and fourth centuries CE (Siegel & Severin, 1993).

Recent discussions that have focused on the composition, functional and symbolic meaning of metals have been heavily informed by ethnohistoric data (Oliver, 2000; Martinón-Torres et al., 2007, 2012; Valcárcel Rojas & Martinón-Torres, 2013). This data has been recently supplemented by the ongoing chemical and physical study being conducted by Marcos Martinón-Torres, Roberto Valcárcel Rojas and María Filomena Guerra on Cuban metals (Valcárcel Rojas & Martinón-Torres, 2013:516; see also Martinón-Torres et al., 2007; 2012). Their research has offered new insight into the supply, use and value of the metal “to a level of detail that could not have been achieved without the application of scientific techniques” (Cooper et al., 2008:35).

This research project examines the two metal artifacts recovered during National Park Service excavations conducted between 1998 and 2001 at a shoreline indigenous site located on Cinnamon Bay, St. John, U.S. Virgin Islands. The analytical methods used to investigate the chemical and physical compositions of each object parallel the nondestructive chemical and physical techniques employed by past studies in order to produce complimentary and comparable data sets. This research will also examine these following questions:

1. ***Origin:*** What is the chemical composition of the Cinnamon Bay metals and can this help determine their origin?
2. ***Technology***: What manufacturing techniques were employed to produce the Cinnamon Bay metals? How do these techniques compare to those employed on other objects in the Caribbean region?
3. ***Meaning***: Can the chemical and physical data be combined with contextual site data to help determine the function and role the Cinnamon Bay metals served at the local level? Will these observations reflect or contradict regional patterns already observed?

Macroscopic (visual) analysis previously completed by Ken Wild has identified the two Cinnamon Bay metal artifacts as (1) a perforated gold disc that served as an inlay “for carved wooden and beaded idols” (Wild, 2013:926; see also Wild, 1999) and (2) a “small perforated gold/copper mixed square pendant” (Wild, 2013:928). The perforated gold disc will be referred to as *Metal Object A* and the gold/copper mixed square pendant will be referred to as *Metal Object B* in this project (See Figure 1). Associated calibrated 2-sigma radiocarbon dates have yielded a date range of 1100-1200 CE for Metal Object B and a date range of 1180-1280 CE for

Metal Object A (Wild, 2013:941). Wild's compositional and functional hypotheses will also be thoroughly assessed and expanded upon.

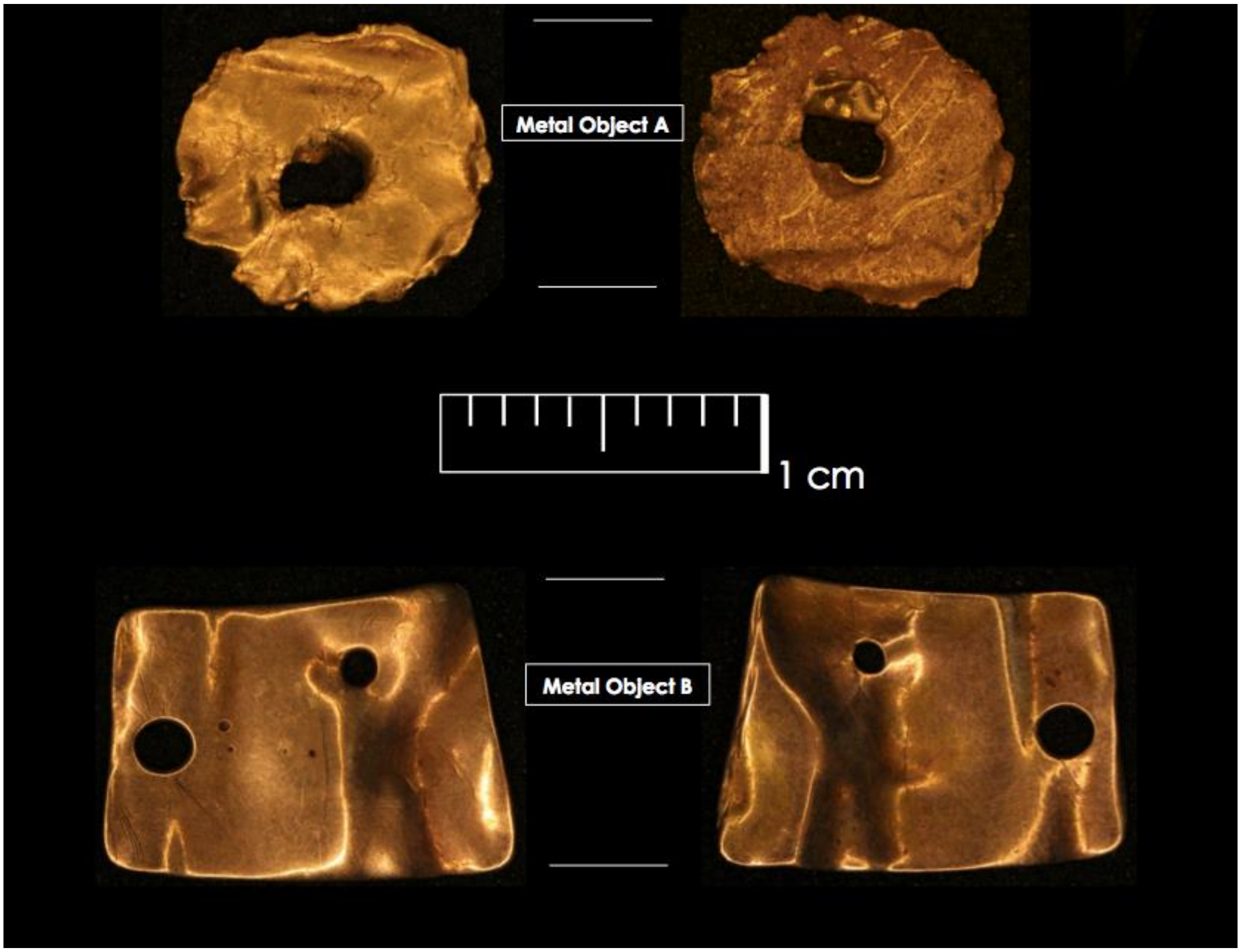

Figure 1. Photographs of Cinnamon Bay metals from the Olympus SZX12 mounted with a Canon digital single-lens reflex DS126311 camera.

Chapter 2 contains brief background information on the natural setting of the Caribbean region, the Virgin Islands and the project area. Chapter 3 outlines the theoretical framework that will be used to make interpretations about the acquired data sets. Chapter 4 briefly outlines the history of research in the region, the Virgin Islands and project area while acknowledging recent trends in research approaches. Chapter 5 summarizes the types of known indigenous metal artifacts throughout the Caribbean region and describes their morphology. Chapter 6 discusses the analytical methods used to complete the chemical and physical analysis of the Cinnamon Bay metals. Chapter 7 presents the results of these analyses. Chapter 8 discusses the results with reference to the research questions outlined previously in this chapter. Finally, Chapter 9 offers conclusions and suggestions concerning how this project and future research can be improved.

In the Caribbean, metal is arguably one of the least studied types of material culture. I recognize the sample size for this project is small, but given the limited formal excavation completed on St. John this concentration of metal is unusual. Interestingly, the Cinnamon Bay site is just the fourth indigenous site in the entire Caribbean region to have multiple pieces of metal recovered. This count includes the cemetery at El Chorro de Maíta whose pre-Columbian origin is “somewhat ambiguous” (Rojas et al., 2011:231). In addition, the pristine preservation at the site enhances the metal’s interpretative value while facilitating a better understanding of these objects at a local level (see Wild, 1999, 2013). With less than 50 indigenous metal artifacts reported in the whole Caribbean region, and only three reported in the entire Lesser Antilles, this analysis of the Cinnamon Bay metals will undoubtedly provide new insight into the function and meaning behind indigenous metal practices within the Caribbean.

CHAPTER 2

NATURAL SETTING

The Region

The islands that comprise what is considered the Caribbean region today extend along a chain heading north and northwest from Trinidad and Tobago originating near the mouth of the Orinoco River in South America (Figure 2). This chain eventually splits into two distinct directions near Hispaniola (the island including Haiti and the Dominican Republic). One chain extends west to Cuba near the Yucatán Peninsula in southeastern Mexico, while the other veers north and terminates near Florida in the United States. The Atlantic Ocean borders the islands to the east and northeast, while the Gulf of Mexico bounds the region in the northwest. Lastly, the Caribbean Sea forms the western and southern boundaries of the region dividing the islands from the mainland of Middle and South America.

The Caribbean region is often further organized into three smaller groupings: the Greater Antilles, the Lesser Antilles and the Bahama (or Lucayan) Archipelago (Rouse, 1992:3). However, Keegan et al. (2013) identify five distinct archipelagoes (or island groups) (Figure 3). These authors identify two additional distinct regions based on the “geographical proximity, island size, and maximum elevation” between the various islands (Keegan et al., 2013:3). The two additional regions are labeled the “Southern Caribbean Region” and “Trinidad and Tobago”

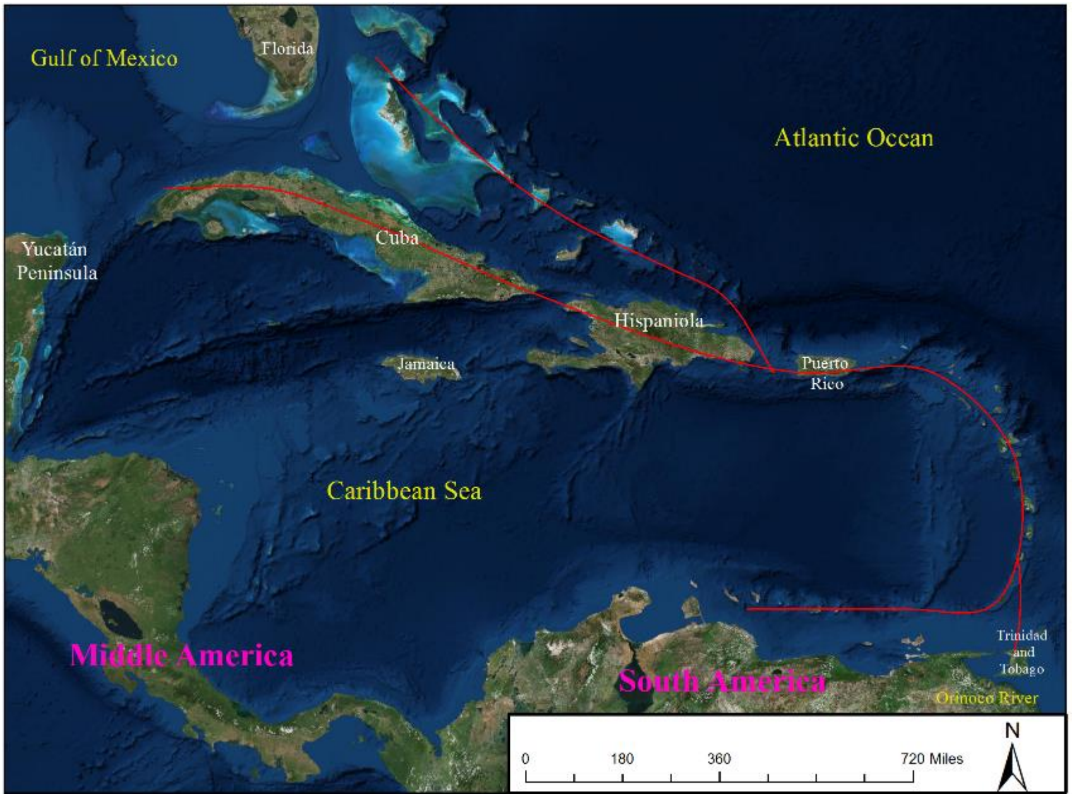

Figure 2. Map of the Caribbean region

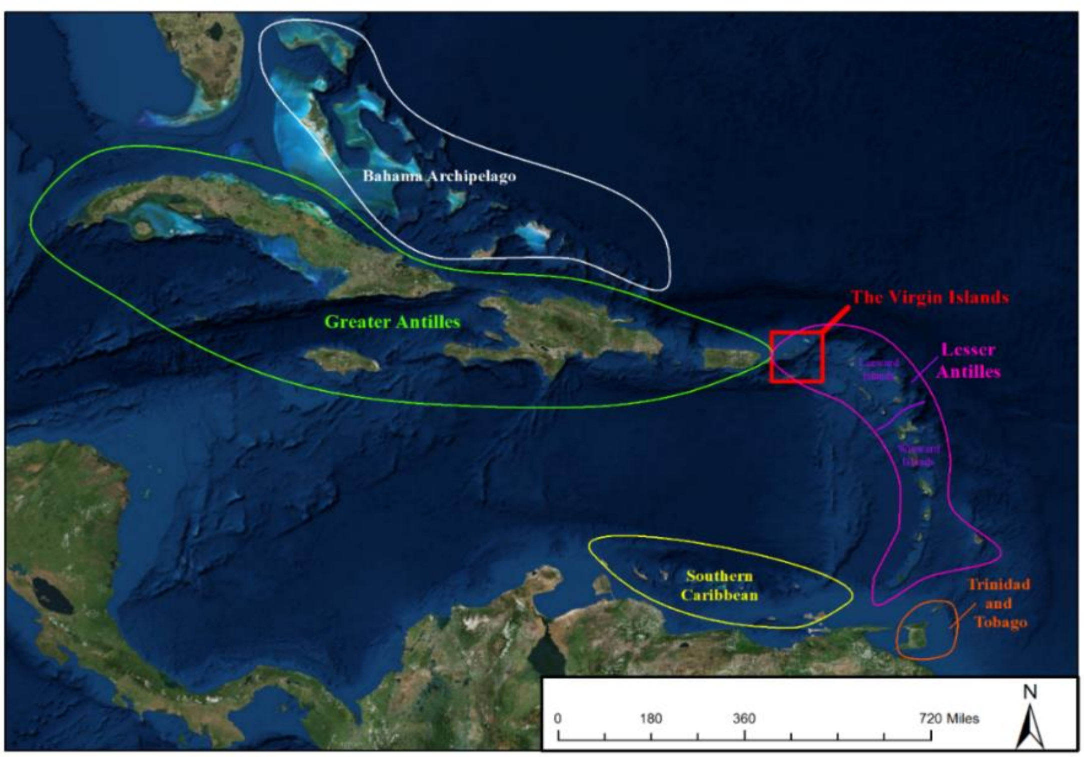

Figure 3. Map of the five subgroups

(Keegan et al., 2013:5).

The Greater Antilles is located in the northern section of the Caribbean and defined by the islands stretching from Cuba to Puerto Rico (Figure 3). These islands are composed of geologically related mountain ranges that crosscut the various islands in this region (Keegan et al., 2013:4-6). All four of the main islands (Cuba, Jamaica, Hispaniola and Puerto Rico) are relatively large compared to the rest of the Caribbean and have surfaces dominated by sedimentary and metamorphic rocks (Keegan et al., 2013:8). All four main islands contain a high level of environmental diversity including areas with an abundance of fertile soil capable of supporting large populations (Rouse, 1992:3).

The Lesser Antilles extends from the Virgin Islands in the north down to Grenada in the south (Figure 3). The region is further divided into two groups: the Leeward Islands and the Windward Islands. The Leeward Islands are located in the northern section of the Lesser Antilles and are generally smaller than all of the islands in the Windward group. The Leeward group contains a combination of high volcanic and low limestone islands (Keegan et al., 2013:4).

The Windward Islands are located in the southern section of the Lesser Antilles and contain distinctly larger islands of volcanic origin (Keegan et al., 2013:4). Interestingly, the Leeward/Windward distinction also parallels Irving Rouse's protohistoric cultural distributions defining the boundary between the "Eastern Tainos" in the north and the "Island Caribs" to the south (Rouse, 1992:8).

The Lucayan (or Bahamian) Archipelago borders the northeastern part of the Caribbean in the Atlantic Ocean and extends from the eastern edge of Florida down to Haiti and Cuba (Figure 3). The islands consist of calcareous rocks, typically limestone with high levels of calcium carbonate (Keegan et al., 2013:8). Technically, the island's shores do not border the

Caribbean Sea, but they do share “a common history, similar climate, and have flora and fauna that is predominately Caribbean” (Keegan et al., 2013:9) and are included within the Caribbean cultural schema.

The Southern Caribbean Region is composed of the small island chain that runs between Aruba and Margarita parallel to the coast of Venezuela (Figure 3). The islands are volcanic in origin and archaeological evidence indicates people living in this region were more closely related culturally to people in the South American mainland versus the Caribbean (Keegan et al., 2013:4).

The final fifth region, comprised of Trinidad and Tobago, is marked by distinct geologic and geographic phenomena that separate these islands from the rest of the Caribbean (Figure 3). Trinidad is the largest island in the immediate area and was connected to the mainland as recently ~6,000 BP (Keegan et al., 2013:4). Thus, the island contains a greater amount of continental flora and fauna compared to other islands in the Caribbean. Trinidad and Tobago are in close proximity to the South American mainland and this has likely contributed to the archaeological data that suggests these islands contain some of the earliest evidence of peopling migrations into the Caribbean region (Keegan et al., 2013:4).

The Virgin Islands

The United States Virgin Islands, the group of islands that is the central focus of this research project, is located near the center of the Caribbean region and consists of three primary islands: St. Thomas, St. Croix, and St. John (Figure 4). Neighboring smaller islands, cays and rocks fill the rest of the group (Sleight, 1962:3). St. John is the smallest of the three principal

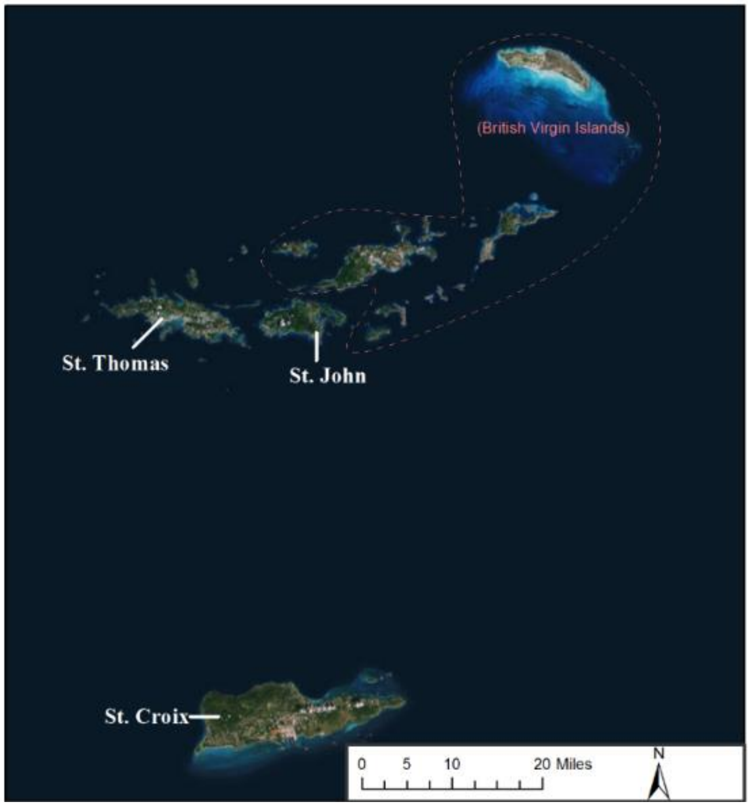

Figure 4. Map of the United States Virgin Islands (USVI)

islands and has an area of approximately nineteen square miles. St. John measures approximately eight miles along its east-west axis and four miles along its north-south axis (Sleight, 1962:3). Technically, the Virgin Islands are geologically related to the Greater Antilles (Rankin, 2002:2). However, the islands themselves are more comparable in size and geographic location to the Lesser Antilles and typically grouped within this sub-region.

Geologically, St. John can be considered an exposed mountainous peak rising sharply from the sea with a majority of its land at angular and steep slopes (Sleight, 1962:13). The coast consists of a series or “rocky headlands with enclosed bays and crescent beaches” (Sleight, 1962:13). The interior areas of these beaches often contain limited semi-level valley mouths. These areas are “sometimes dry and sandy, sometimes characterized by mangrove swamps in various stages of transition” (Sleight, 1962:14). The bay-valleys are relatively broad and consist of long beaches with short depths (Sleight, 1962:14). In addition, the mountains tend to rise at steep angles along their sides and headlands (Sleight, 1962:14). There are exceptions to this topographic description, but the above characterization provides a general sense of St. John's surficial setting.

Early historic records indicate St. John was covered with a mix of wet and dry forests (Sleight, 1962:7). The dry forests cover most of the island and vegetation in these areas tend to be thorny and "essentially impenetrable" (Rankin, 2002:1). The water drainages (or guts) are largely vegetation free due to flash flood events (Rankin, 2002:1). It is important to note that most of the island was cleared for sugar plantation during colonial times and much of the island contains second-growth forests (Rankin, 2002:1-2).

The physical geographic locations and distances between each island facilitate travel. Once the main island chain is entered, each island is essentially in sight from one another (Rouse, 1992:3). Strong currents flow through almost every passage and can be traversed during cooperating weather (Rouse, 1992:3). Accordingly, the sea should not be understood as an isolating barrier between, but instead a "highway that unites them" (Keegan, 2013:1). The Caribbean region is positioned to the southwest of the Azores High (a subtropical semi-permanent high atmospheric pressure zone in the Atlantic Ocean) and as a result trade winds move through the region from the northeast throughout most of the year (Sleight, 1962:10). This system also reinforces westward-moving sea currents (Rouse, 1992:4). Generally, the pressure system brings northeasterly winds in the fall and winter, while easterly winds dominate the spring and summer months (Sleight, 1962:10). However, St. John and the immediate surrounding islands tend to experience a prevailing easterly wind based on annually recorded wind averages (Sleight, 1962:10).

The Project Area

Cinnamon Bay, the specific valley mouth and beach that yielded the archaeological material discussed in this project, is situated along the north coast of St. John (Figure 5). The valley is formed by a complex of drainages that flow during runoff events from slopes adjacent to the south (Sleight, 1962:19). The valley floor is marked by alluvial deposits the have fanned northwestward creating a triangular valley floor (Sleight, 1962:19). The floor is higher in the eastern half compared to a western half that shows evidence of frequent flooding caused by events from land and sea (Sleight, 1962:19). The sand dune bar, typical of most bay environments, runs parallel to the shoreline and likely formed from a combination of wind and fluvial processes. The structure of this feature indicates it has "moved, broken, and reformed many times" (Sleight, 1962:19).

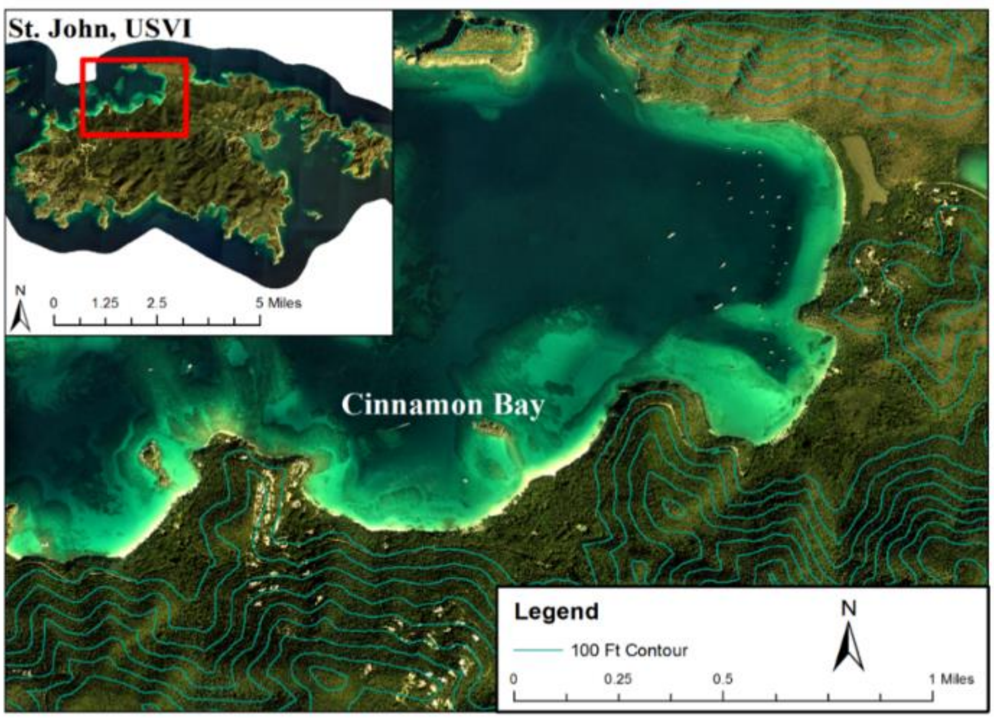

Figure 5: Map of St. John and Cinnamon Bay

CHAPTER 3

THEORY

"The material qualities of material culture are central to how they are used and made meaningful" (Jones, 2004:330).

The materials-based theoretical framework applied in this study provides a better understanding of the range of human behaviors associated with the Cinnamon Bay metals. To begin, it is important to remember this study is primarily archaeometric in nature. It uses analytical instruments and techniques to characterize the chemical, physical and mechanical properties of the metal artifacts under review. Jones (2004) demonstrates how the concept and approaches to *materiality* are relevant to archaeometric studies. Jones (2004) states, "In essence, the notion of materiality encompasses the view that material or physical components of the environment and the social practices enacted in the environment are mutually reinforcing" (Jones, 2004:330). In other words, artifacts are not simply byproducts of the past, but are instead direct products, with the inverse ability to influence past human behavior. In fundamental terms, artifacts are culturally constructed and therefore, "*material qualities*" of artifacts influence their "*use and perception*" (Jones, 2004:331).

Past metallurgic archaeometric studies in the surrounding regions have demonstrated how issues of materiality cannot only be discussed, but advanced by archaeometric methods (see Holser, 1995; Lechtman et al., 1975). In one notable study, Holser (1995) investigated metal use in ancient West Mexico and used archaeometric techniques to add quantitative data to discussions about the ritual significance of alloying metal to obtain a particular color (Hosler, 1995:100). She demonstrates analytically that bronze artifacts containing the alloying element, tin or arsenic, show concentration levels higher than what is deemed necessary for improving artifact design and mechanical function (Hosler, 1995:100-101). This data supports the hypothesis that the tin and arsenic are only added to obtain a particular color. By focusing on the chemical content of the metals, Hosler (1995) demonstrated color to be an important component of the materiality of these metals and consequently its use within ancient West Mexican communities.

Other studies in the Caribbean and Circum-Caribbean region have relied less on archaeometric techniques and focused more on the comparative aspects of materiality. One early example of this type of study, presented by Helms (1987), suggests a level of interaction between the Caribbean and Central America based on the shared shiny character of black polished wood items used typically by the elite. A recent trend has been to replicate these types of comparative materiality studies to draw further connections outside the insular Caribbean region to adjacent communities living in Central and South America (an area commonly referred to as the Circum-Caribbean).

Recent discussion on Circum-Caribbean interaction has advocated for the application of a pan-Caribbean perspective (see Hoffman et al., 2010). Hoffman et al. (2010) advocates for a research framework that "need[s] to view the wider Caribbean or Circum-Caribbean region as potentially one large arena within which Amerindians could have established and maintained local and regional circuits of mobility and exchange" (Hofman et al., 2010:4). The authors clearly note this perspective does not downplay the importance of "synchronic developments at the local scale of the community" (Hofman et al., 2010:4). In this scheme, Helm's (1993) seminal work, *Craft and the Kingly Ideal: Art, Trade and Power,* provides numerous perspectives on the interpretation of long-distance goods and the relationship between acquisition and political authority. Geurds (2011) and Curet (2014) argues however, that these ideas should be applied with caution in the Caribbean.

Geurds (2011) critiques the pan-Caribbean frameworks by mentioning they are typically "not based on samples of a particular data-set…[and] predominantly built around comparisons of resemblance" (Geurds, 2011:52). He further argues, these efforts need to be "accompanied by follow-up research taking a regional and site level perspective" (Geurds, 2011:52). He advocates for the study of how these exchanged objects were used at a local level arguing, "material things are routinely drawn upon and applied to different agents in different situations" (Geurds, 2011:52). Curet (2014) offers a similar critique in regards to long-distance trade models and advocates for increased attention towards objects within more localized context. Curet (2014) states, "arguments go from the level of the evidence of objects (low level) to a macro-regional model without considering the social context at lower levels where the artifacts were found, especially the community and localized regions" (Curet, 2014:53). Curet (2014) furthers this critique by suggesting this method of application of data is "unrigorous" and tends to rely on minimal quantitative and statistical analysis (Curet, 2014:53).

Guerds (2011) attempts to solve this issue and provides an alternative perspective where research into the pan-Caribbean could target specific artifact types that contain "highly specific materiality" (Guerds, 2011:53). In this model, the targeted object "could not simply be replaced by some other arbitrary 'symbolic object' to which the same 'meaning' is ascribed" (Guerds, 2011:53). While difficult, especially in regards to the metal objects under investigation (see Chapter 8), this framework offers at least one avenue to apply materials-based approaches within pan-regional perspectives while simultaneously highlighting the importance of multi-scalar perspectives.

Fully understanding the context of each object, rather than comparing various styles and categories in isolation, offer an improved opportunity to reveal the significance and meaning of objects at various scales. Lechtman (2000) advocates for this type of contextual study by arguing metals should be understood within a range of co-existing materials or “suites” (6). This approach “lessens the burden of having to determine meaning for any one subset of materials alone” (Lechtman, 2000:6) and allows for the characterization of assemblages. These identified associations between specific objects will in turn facilitate questions about individual categories of objects (Lechtman, 2000:5-6).

In sum, applying a framework based on aspects of materiality allows the material properties (chemical and physical) of an object to become the principal point of inquiry. Thus, this study uses the material properties of the Cinnamon Bay metals as the starting point to explore the interwoven behaviors of the people who produced and used these artifacts. Combining this approach within a unit of analysis at the local level (or site level) facilitates an approach that prioritizes contextual meanings and has the ability to reveal patterns of behavior actually occurring in the past.

CHAPTER 4

HISTORY OF RESEARCH

The Region

Caribbean archaeology has largely occurred within the epistemological, ontological, and methodological confines of the cultural-historic approach championed in the region by Irving Rouse beginning in the early 1930s (Pestle et al., 2013:244). Rouse conducted a multitude of small excavations across various islands including mainland South America using a research framework that focused primarily on pottery typology (Rouse, 1992). Rouse built a cultural-chronology based on styles, subseries, or series for the entire Caribbean region that was continuously refined over many years (Pestle et al., 2013:247). Rouse's main research goal aimed to further understand cultural evolution and migration patterns into the region (Rouse, 1986, 1992).

Cultural-historical theoretical frameworks dictated research in the region well into the 1990s and even govern over approaches in some islands today (Pestle et al., 2013:245). Theoretical critiques of Rouse's approach first appeared in the early 2000s when social-political organization at local site-levels became a central focus (Keegan, 2001; Curet, 2005). However, a "lack of a clean break between the new and old theoretical frameworks led Caribbeanists to continue to use the categories of culture history without adequate questioning of their veracity"

(Pestle et al., 2013:245). Furthermore, “attacks against [Rouse’s] position normally encountered strong resistance” (Pestle et al., 2013:245). Research in the region frequently occurs under Rouse’s categories (styles, subseries, series) without critically acknowledging that these categories are not natural units with the ability for application within other frameworks (Pestle et al., 2013:246). Basically, the issue is the continued acceptance by researchers that the chronological, cultural, and social units are viewed as equivalents (Pestle et al., 2013:246).

The persisted influence of the cultural-historical approach has left even modern Caribbeanists in the routine to label the presence of specific “cultures” at sites solely based on changes in ceramic decoration. Rodríguez Ramos (2010) provides a concrete example of why future research needs to critically question this continued practice. Rodríguez Ramos (2010) assembled a large database of radiocarbon dates in Puerto Rico and provides instances where Rouse’s “cultures” overlapped, especially lacking an ability to explain the occurrence of mixed archaeological deposits. Pestle et al. (2013) furthers this critique by demonstrating the category of “Cuevas” *style*, as developed by Rouse (see Rouse, 1992), to be invalid based on recent chronometric data that contradicts the temporal and geographic distribution of this cultural unit (Pestle et al., 2013). Pestle et al. (2013) suggest future studies should be undertaken in association with absolute chronology and with the acceptance that multiple pottery traditions and mechanisms for cultural change can exist simultaneously across space and time.

The Virgin Islands

The Rousean chronological classification system, nomenclature and framework have dominated archaeological research conducted in the Virgin Islands. While critiques of Rouse’s chronology have been made (Lundberg & Wild, 2006; Lundberg, 2007; Wild, 2013), these attempts have simply refined the Cultural Historical perspective and do not reject the general tenants of this paradigm. My project does not claim to provide a “new” groundbreaking perspective completely reinterpreting previous lifeways on St. John. However, I move beyond Rousean nomenclature and its inherent limitations when possible. Fortunately, Wild (2013) collected and recently analyzed nine radiocarbon samples taken from charcoal within undisturbed stratigraphic contexts at the indigenous shoreline site on Cinnamon Bay. These calibrated 2-sigma radiocarbon dates establish the temporal reference points used while discussing the metal artifacts of particular focus in this project.

The archaeological record indicates people first settled St. John by 770 BCE (Wild, 1989:88) and St. Thomas as early as 900 BCE (Lundberg, 1989:84). However, habitation sites dating to 4,000 BCE have been located on Puerto Rico suggesting people could have been living or visiting the Virgin Islands much earlier (Rodríguez Ramos, 2010:50). A site along the south shore of St. John in Lameshur Bay yielded flaked and ground stone tools (Wild, 1989). The lithic assemblage showed small degrees of utilization and wear patterns consistent with cutting, grinding and hammering (Wild, 1989:100). The lithic material was mixed in a context with a high number of potentially processed gastropods (Wild, 1989:106). These observations support the interpretation that food processing and tool production were carried out at the site (Wild, 1989:100). The Lameshur Bay site remains the only indigenous site identified on St. John with a cultural component that contains lithic tools without the presence of ceramics.

The second phase of occupation on St. John occurs during what Rouse identifies as the beginning of the Ceramic age (Rouse, 1992:71). This period (believed to begin sometime around 200 BCE in the region) was originally considered to mark the introduction of agriculture and ceramics into the region with the first major repeopling event (Rouse, 1992:71). However, other islands in the region, including Puerto Rico, have reported evidence of pottery and limited gardening being implemented as early as 660 BCE (Rodríguez Ramos, 2010:71). Although small-scale agricultural practices existed during this early period, archaeological data suggests people did not begin to organize themselves into semi-permanent villages until the Ceramic period. Finely made pottery (white-on-red and zic ware (see Rouse, 1992) was also introduced along with stone adzes, and various ornaments carved from stone, bone, shell and wood that were strikingly different from earlier assemblages (Rouse, 1992:77-85). Coastal sites on St. John in Coral Bay, Cinnamon Bay, and Cruz Bay contain ceramics that likely date to this early period based on typological comparisons to other islands in the region (Donahue, 2014:22). However, radiocarbon dates from these sites have not produced absolute date ranges to properly confirm this association (Donahue, 2014:22).

St. John experiences a substantial increase in sites following 800 CE (Lundberg et al., 1992:7). Areas along the north shore are heavily occupied represented by large, dense cultural deposits located at Trunk Bay and Cinnamon Bay (Wild, 1999, 2013; Donahue, 2014). Unfortunately, only limited test excavations have been conducted at these sites so their size and layouts are not well understood. Ceramic assemblages from the sites of Calabash Boom and Trunk Bay have been studied in great detail by Lundberg (2005), and Lundberg and Wild (2006), and linked to similar ceramic developments in eastern Puerto Rico (see also Lundberg et al., 1992). Most notably, widespread and stark changes in ceramics biased towards plain finishes occur during this time. Rouse links these apparently abrupt changes in ceramic technology to insular cultural changes in the Greater Antilles as opposed to a second large-scale repeopling event (Rouse, 1992:105-109). Rouse also feels the origins of the contact-period chiefdoms (commonly referred to in the literature as "Taínos") encountered by the Spanish date to this localized transitional period (Rouse, 1992:109-123). Other artifacts from these assemblages include flaked stone tools, conch shell celts, coral reamers, small shell beads and clay spindle whorls (Lundberg & Wild, 2006).

Material culture on St. John changes dramatically again around 1000 CE based on the results of excavations at the shoreline sites along Trunk Bay (800 CE – 1200 CE), Cinnamon Bay (1050 CE – 1440 CE), Cannel Bay (possibly 1300 – 1440 CE) and an upland site overlooking Cinnamon Bay called Rustenberg North Prehistoric (985 CE – 1020 CE) (Wild, 1999, 2013; Donahue, 2014). Unfortunately, these sites have not received detailed attention and limited excavations occurred largely under salvage-type scenarios by the National Park Service. In general, site layout and size has been largely understudied. The data that comes from this period indicate significant shifts in ceramic design elements that include the introduction and proliferation of anthropomorphic/zoomorphic adornos and incised decoration (Wild, 1999, 2013). Also, elaborate items from the sites differ markedly from previous centuries. The assemblage includes stone and shell three-pointer zemis, nose plugs, stone and shell beads, shell pendants and inlays, potential stone collar fragments, and the metal artifacts under current investigation for this project (see Wild, 2013). It is important to note that Cinnamon Bay is the only indigenous site on St. John containing radiocarbon samples that post-date 1300 CE. However, ceramic data from an indigenous site located in Caneel Bay suggest a contemporaneous occupation (Donahue, 2014:24). Occupation at these sites appears to end around 1440 CE (Wild, 2013; Donahue, 2014). These final centuries, based largely on comparisons of artifact assemblages and radiocarbon dates to neighboring islands, are typically associated with the contact-period hierarchical chiefdom societies, known commonly as "Tainos," encountered and recorded by European chroniclers (see Rouse, 1992).

The Project Area

The shoreline indigenous located on Cinnamon Bay was first recognized by Danish archeologist Gudmund Hatt (see Hatt, 1924). It appears Hatt did not excavate at the site (Hatt, 1924). However Bullen (1962:42) mentions "two groups of specimens" are cataloged in the Danish National Museum from Cinnamon Bay, suggesting that these objects could have been collected form the surface.

Ripley P. Bullen and Frederick W. Sleight completed an archaeology survey of the entire island of St. John in 1960 and a surface survey and test excavation at Cinnamon Bay (Sleight, 1962:19). They noted an abundance of ceramic artifacts exposed near the eastern area of the Cinnamon Bay shoreline indicating "a relatively heavy occupation in prehistoric times…near a natural location for settlement" (Sleight, 1962:19-20). Their test excavation revealed further intense occupation producing an artifact lens that was "thicker than any we found elsewhere" (Bullen, 1962:42). Bullen's ceramic analysis indicated occupation at the site between 900 CE and 1500 CE (Bullen, 1962:42). Interestingly, Bullen (1962) also notes stylistic attributes of a ceramic modeled human-head handle recovered from Cinnamon Bay strongly resembled similar specimen from the Lesser Antilles and that this possibly represented trade with southern groups of people (46). It is also important to note, Bullen's approach to ceramic typology received heavy criticism by later researchers at Cinnamon Bay (see Rutsch, 1970:64-65).

During 1969 and 1970, salvage archaeological excavations were conducted at Cinnamon Bay prior to proposed construction in the Cinnamon Bay campground. These investigations were led by Edward S. Rutsch and accompanied by a group of his students. Rutsch completed 14 five foot by five foot excavation test squares in six inch arbitrary levels (Rutsch, 1970:34; Stoutamire et al., 1980:9). Three of these tested areas received further investigation and were labeled excavation units by Rutsch. One of these units was located very close to where the metal under review for this project was recovered. Rutsch notes in this particular unit that they “discovered a midden 31 inches deep, without apparent stratigraphy but rich in aboriginal artifacts and food remains, including ceramics, stone tools, worked shell, food shell and bones of mammals, birds, fish and turtles” (Rutsch, 1970:34). Rutsch reports in detail the number of each artifact type recovered and includes a preliminary analysis for the recovered ceramics (see Rutsch, 1970).

Stoutamire et al. (1980) completed a reanalysis of the cultural material recovered by Rutsch. Haviser analyzed and wrote the ceramic, lithic, and shell analysis portion of this report. Haviser found rim profiles (Stoutamire et al., 1980:14-16) and design elements (Stoutamire et al., 1980:34) to be similar to Eastern Puerto Rican assemblages. The conclusions of Stoutamire et al. (1980) lack interpretation and are primarily concerned with developing a chronology for the Cinnamon Bay site and St. John. The developed chronology is based on particular design elements found in the ceramics and compared to typologies developed on neighboring islands. Stoutamire et al. (1980) suggested a date range beginning in the first century CE and lasting until about 1500 CE (or contact) (44-48).

Between 1987 and 1989 the National Parks Service’s Southeast Archaeological Center (SEAC) completed archaeological investigations at Cinnamon Bay ahead of proposed construction. Numerous shovel tests and two one meter by half a meter excavation units were placed in the south and west ends of the valley near North Shore road (Wild, 1991:46). This area of the valley had not received the same level of attention compared to the eastern shoreline zones discussed previously. Prehistoric ceramic sherds were discovered farther west than any of the previous excavations (Wild, 1992:68). The excavations did not identify any prehistoric features and ceramics were the dominant prehistoric artifact type recovered, followed by lithic and shell material. The ceramics received the most analytical attention and were primarily categorized by temper and surface finish (Wild, 1992:71). Two ceramic sherds contained decoration that were deemed temporally diagnostic suggesting an indigenous occupational date range of 300 CE to 1000 CE for this area of Cinnamon Bay (Wild, 1992:73).

In 1992, SEAC excavated one two by two meter test unit in the shoreline site at Cinnamon Bay where the metal objects analyzed in this project was recovered. The shoreline site, constantly being threatened by wave action that destroys and buries sediments, required immediate attention and made it necessary to determine the integrity of subsurface deposits. The test unit revealed a pristine context with sequential in situ deposits of decorative ceramics, litchis, faunal, and paleobotanical material (Wild, 1999:305). The original alignment of the colonial period North Shore road appears to have functioned to protect the site from disturbance from agricultural activity (Wild, 2013:925). At the base of the test unit, a posthole feature was identified extending into a culturally sterile soil horizon providing evidence for a prehistoric structure (Wild, 1999:305). Decorative ceramics also indicated close association to eastern Puerto Rican assemblages (Wild, 1999:305). Three carbon samples suggest a preliminary 2-sigma date range of 1000 CE to 1490 CE for this portion of the shoreline indigenous site (Wild, 1999:305).

In 1995, hurricane Marilyn hit St. John and further impacted the integrity of the Cinnamon Bay shoreline indigenous site investigated by SEAC in 1992. In response, The Virgin Islands National Park, with funding provided by the non-profit organization Friends of the Virgin Islands National Park, spent almost four years between 1998 and 2001 recovering additional archaeological data focusing on areas immediately threatened by erosion (Wild, 1999:304). The National Park Service designated the shoreline indigenous site as VIIS-191 (see Figure 6).

Figure 6: Map of Cinnamon Bay and location of VIIS-191

The 1998 excavations were comprised of three adjacent four by four meter units positioned directly next to the location of the 1992 SEAC excavation (see Figure 7). The test units were excavated in arbitrary ten-centimeter levels. The entire excavation fill was dry screened through quarter inch metal screens immediately followed by wet screening through sixteenth inch metal screens (K. Wild, personal communication, 2015). These excavations yielded an extraordinary amount and range of cultural material including patterns consistent with ceremonial behavior (see Wild, 1999, 2013). Most importantly, the metal artifacts under review for this project were recovered during these excavations. A more detailed examination of the material remains from these excavations at Cinnamon Bay framed within a discussion of the symbolic meaning of the metal objects will follow in Chapter 8.

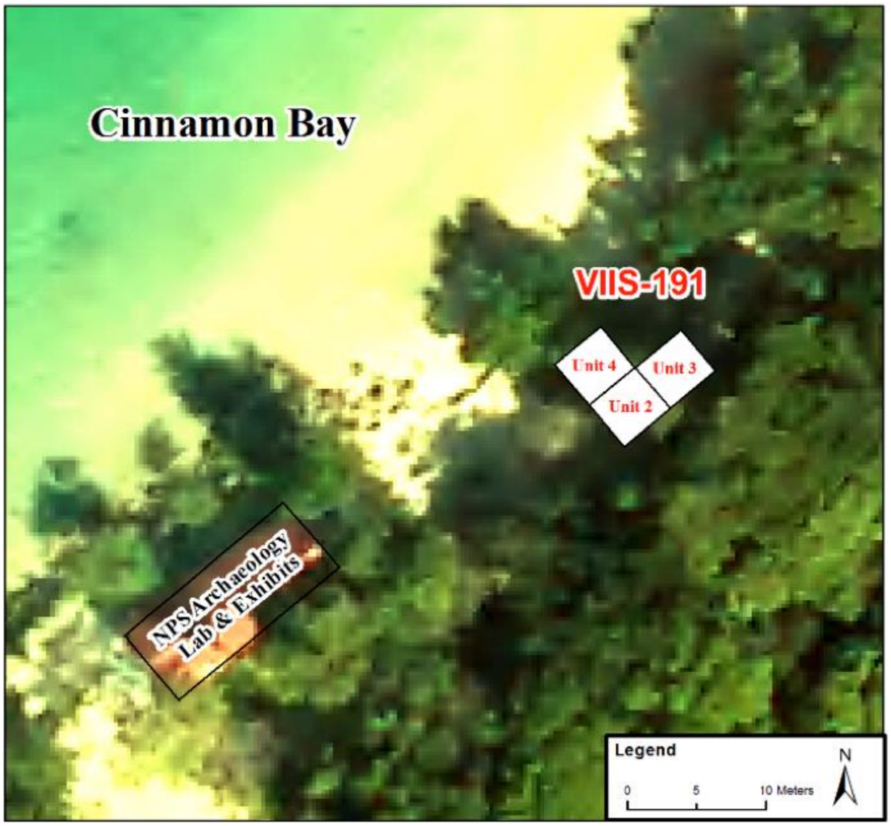

Figure 7. Map of NPS 1998-2001 test excavation units

CHAPTER 5

MATERIALS

Types of Metal

Archaeological evidence for the presence of metals in the Caribbean is scarce (Oliver, 2000; Martinón-Torres et al., 2007, 2012; Valcárcel Rojas & Martinón-Torres, 2013). Multiple factors likely contribute to the skewed data including the common practice of Spanish pillaging and ethnohistoric records that describe the indigenous burial practice of metal removal from corpses prior to internment (Oliver, 2000; Valcárcel Rojas & Martinón-Torres, 2013). The earliest evidence for metals to date first appear in the Caribbean archaeological record during the first through fourth centuries CE and are present during European contact (Siegel and Severin, 1993). Two types of metal dominate the landscape: (1) natural (or alluvial) unalloyed *gold*, and (2) an artificial gold-silver-copper alloy know ethnohistorically as *guanín,* or more commonly known in Latin America as *tumbaga*. Interestingly, ethnohistoric records indicate indigenous groups placed higher value on the artificial metal alloys compared to locally available pure gold in both real (pure gold was typically traded to the Spanish for gold-copper alloy) and symbolic terms (Oliver, 2000:203). Oliver (2000:203) suggests the distance from the gold-copper alloy source origin enhanced not only the exoticism, but also the symbolic value of this material type.

Overall, the data suggests metal use was dramatically higher in the Greater Antilles than in the Lesser Antilles (see Table 1). Table 1 (modified from Valcárcel Rojas and Martinón-Torres (2013)), details the accurately reported indigenous metal objects recovered from archaeological sites in the Caribbean.

Table 1. Accurately Reported Metal Artifacts Recovered from Indigenous Archaeological Sites in the Caribbean

From Valcárcel Rojas and Martinón-Torres (2013). *Note: x indicates the unquantified presence of a given element. Chemical compositions reported in weight percent (wt%). X-Ray Fluorescence (XRF), Scanning Electron Microscopy-Energy Dispersive Spectrometry (SEM-EDS). Interior (I). Surface (S).*

Object	Length/ diameter (mm)	Max. width (mm)	Possible Metal	Metal Identified	Type of Analysis	Cu %	Ag %	Au %	Country/ island	Site/ region	Biblio-graphic reference
Nose Ring	22			gold				x	Puerto Rico	Tecla I	Chanlatte Baik 1977
Sheet			gold						Puerto Rico	Monserrate	Chanlatte Baik 1977
Sheet	10	7		guanín	SEM-EDS	55	5	40	Puerto Rico	Maisabel	Siegel and Severin 1993
Sheet with several perfor-ations			guanín						Vieques, Puerto Rico	Sorcé	Chanlatte Baik 1984; Siegel and Severin 1993:77; Oliver 2000:200
Sheet with perfor-ation	10			gold	PIXE	0.3	9.5	88.8	St. John, U.S. Virgin Islands	Cinnamon Bay	Wild 1999; Wild 2013
Sheet with two perfor-ations	12	8		guanín	PIXE	52.0	10.3	33.2	St. John, U.S. Virgin Islands	Cinnamon Bay	Wild 2013
Sheet Frag-ment	107	75		guanín	SEM-EDS & PIXE	70-*I* 50-*S*	4-*I* 4-*S*	25-*I* 45-*S*	Marie-Galante	Anse du Coq	Honoré et al., 2013
Two sheets with perfor-ation			gold						Haiti	Cadet	Chanlatte Baik 1977
Sheet	20		gold						Haiti	Limonade	Vega 1987
Sheet				gold				x	Dominican Republic	Montecristi	Vega 1987
Sheet	18		gold						Dominican Republic	La Cucama	Vega 1987

(Continued on following page)

Table 1. (Continued)

Object	Length/ diameter (mm)	Max. width (mm)	Possible Metal	Metal Identified	Type of Analysis	Cu %	Ag %	Au %	Country/ island	Site/ region	Biblio-graphic reference
Sheet	50	15	gold						Dominican Republic	La Cucama	Vega 1987
Sheet with perfor-ation	100			gold				99	Domini-can Republic	Montecristi	Vega 1987
Sheet	23			gold				99	Dominican Republic	Montecristi	Vega 1987
Sheet	27	13	gold						Dominican Republic	La Cucama	Vega 1987
Sheet	13	5	gold						Dominican Republic	La Cucama	Vega 1987
Sheet	18	5	gold						Dominican Republic	La Cucama	Vega 1987
Sheet	21	16		gold			7.2	92.5	Jamaica	Bellevue-White River	Lee 1985
Sheet	14		gold						Cuba	Potrero de El Mango	Rouse 1942:144, plate 8
Sheet with perfor-ation	24	6	guanín						Cuba	La Rosa de Los Chinos	Mesa 1989
Sheet with perfor-ation	12	10		gold	SEM-EDS		5.6	94.4	Cuba	Toma del Agua	Torres Etayo 2006:58
Sheet	35	7	gold						Cuba	El Martillo	Yero Masdeu et al. 2003:24
Sheet	13			gold	XRF	1.5	20.1	78.4	Cuba	Esterito	Valcárcel Rojas et al. 2007
Sheet with perfor-ation	14	7	gold						Cuba	El Paraiso	Ulloa Hung 2000
Sheet	20	16		gold	XRF	0.1	8.5	91.4	Cuba	Laguna de Limones	Valcárcel Rojas et al. 2007
Human figure	48		guanín						Cuba	Santana Sarmiento	Miguel Alonso 1951
Sheet with perfor-ation	21	9		guanín	XRF	49.5	13.9	36.5	Cuba	El Boniato	Valcárcel Rojas et al. 2007

(Continued on following page)

Table 1. (Continued)

Object	Length/ diameter (mm)	Max. width (mm)	Possible Metal	Metal Identified	Type of Analysis	Cu %	Ag %	Au %	Country/ island	Site/ region	Biblio-graphic reference
Sheet with perfor-ation	13	9		gold	XRF	0.1	3.8	96.0	Cuba	El Morrillo	Valcárcel Rojas et al. 2007
Sheet with perfor-ation	20			gold	XRF		6.5	93.5	Cuba	Loma del Aíte	Valcárcel Rojas et al. 2007
Sheet with perfor-ation	13	17		guanín	SEM-EDS	47.9	12.6	39.5	Cuba	El Chorro de Maíta	Martinón-Torres et al. 2007
Sheet with perfor-ation	19	15		guanín	SEM-EDS	55.1	10.0	34.9	Cuba	El Chorro de Maíta	Martinón-Torres et al. 2007
Sheet with perfor-ation	16	15		guanín	XRF	41.7	12.9	45.4	Cuba	El Chorro de Maíta	Valcárcel Rojas et al. 2007
Sheet with perfor-ation	23	24		guanín	SEM-EDS	x	x	x	Cuba	El Chorro de Maíta	Guarch Delmonte 1996
Bell	13			guanín	XRF	26.8	30.0	43.1	Cuba	El Chorro de Maíta	Valcárcel Rojas et al. 2007
Sphere	3			guanín	XRF	x	x	x	Cuba	El Chorro de Maíta	Guarch Delmonte 1996
Bead	2			gold	SEM-EDS	1.3	5.2	93.4	Cuba	El Chorro de Maíta	Martinón-Torres et al. 2007
Bead	2			gold	XRF	1.8	8.1	90.1	Cuba	El Chorro de Maíta	Valcárcel Rojas et al. 2007
Bird figure	23			guanín	SEM-EDS	x	x	x	Cuba	El Chorro de Maíta	Guarch Delmonte 1996
Sheet	21			guanín	SEM-EDS	57.0	6.4	36.6	Cuba	Alcalá	Martinón-Torres et al. 2007
Sheet with perfor-ation	22	9		guanín	XRF	53.0	8.6	38.4	Cuba	Vega de Labañino	Valcárcel Rojas et al. 2007

Table 1 includes a recent find made at the site of Anse du Coq on the island of Marie-Galante located near the island of Guadeloupe (Honoré et al., 2013). This object is the only metal object recovered archaeologically in the ancient Lesser Antilles other than the two from

Cinnamon Bay and will be discussed in further detail (see Table 2). Table 2 provides a brief summary of the total (accurate and less descript) reported metal artifacts distributed throughout the ancient Caribbean.

Table 2. Distribution of Metal Artifacts in the Ancient Caribbean

	Island	**Gold**	**Guanín**	**Total**
Greater Antilles	Cuba	10	12	22
	Hispaniola (Haiti/Dominican Republic)	17	0	17
	Puerto Rico	2	1	3
	Vieques, Puerto Rico	0	1	1
	Jamaica	1	0	1
	Total	**30**	**14**	**44**
Lesser Antilles	St. John, USVI	1	1	2
	Marie-Galante	0	1	1
	Total	**1**	**2**	**3**
	Regional Total	**31**	**16**	**47**

The Anse du Coq metal object likely dates to 1290 CE – 1450 CE (Honoré et al., 2013:2-6). The object is triangular and measures 107 mm by 75 mm and has a thickness that does not exceed a millimeter (Honoré et al., 2013:3). The object appears fragmentary and thus likely from a larger object. Interestingly, a side of the object that appears broken reveals layering and coloration variation between the surface and the interior. This is possibly related to enriching or depleting gilding techniques used to obtain a particular surface color. Consequently, the surface and interior areas were chemically tested separately using PIXE and SEM-EDS. Both methods produced similar results and the compositional data was reported as average weight percent. The interior was composed of approximately 70 percent copper, 25 percent gold and four percent silver (Honoré et al., 2013:5). The surface contained higher levels of gold reaching approximately 45 percent, and a reduction in copper content to about 50 percent (Honoré et al., 2013:5). The silver values stayed relatively identical (Honoré et al., 2013:5). The PIXE analysis also detected trace amounts of palladium and tin which Honoré et al. linked to alluvial gold (Honoré et al., 2013:5).

Less accurate reports of metal in the Caribbean include inlays on a wooden stool (or duho) (Oliver, 2000:204) and a bone figure (Channlatte Baik, 1977:61). Both objects are considered to be from the Dominican Republic and contain laminar incrustations that appear to be of gold. These objects combined provide an additional seven metal objects in total bringing the reported total to 47 (including the Anse du Coq guanín) (Valcárcel Rojas & Martinón-Torres, 2013). There are even more gold fragments reported from the Dominican Republic, Haiti and Puerto Rico, but their descriptions are too vague to include them in this study (Valcárcel Rojas & Martinón-Torres, 2013).

Morphology

The predominant form of metal objects from the Caribbean is laminar (flat) sheets thinner than one millimeter (Valcárcel Rojas & Martinón-Torres, 2013:514). These sheets are commonly formed into simple subcircular, oval or trapezoidal shapes and typically include perforations (Valcárcel Rojas & Martinón-Torres, 2013:514). Rarely, objects are decorated with embossed lines. If this type of decoration occurs it is typically found on guanín (Valcárcel Rojas & Martinón-Torres, 2013:514). These objects are usually smaller than three centimeters in maximum length. The size “may be related to the limitations imposed by the small size of the natural gold nuggets" for metal objects created from alluvial gold (Valcárcel Rojas & Martinón-Torres, 2013:514).

Only seven known metal objects are not in the typical laminar form (Valcárcel Rojas & Martinón-Torres, 2013:514). These include a nose ring, beads, a bell, a single anthropomorphic figurine, and a potential bird-head pectoral fragment (Valcárcel Rojas & Martinón-Torres, 2013:514).

CHAPTER 6

ANALYTICAL METHODS

The chemical and physical compositions of the two metal objects from Cinnamon Bay were analyzed using non-destructive techniques due to the rare nature of the objects. The techniques are: binocular stereomicroscopy, scanning electron microscopy (SEM), portable X-ray fluorescence spectrometry (pXRF), and particle-induced X-ray emission spectrometry (PIXE). Assisting laboratories are located at Northern Illinois University, Beloit College, Hope College and The Field Museum.

The goal of the physical analysis is to obtain data that can be used to reconstruct the production techniques applied during the manufacture of the Cinnamon Bay metals. This includes the identification of: striation patterns that are consistent with certain polishing techniques, surface finishes obtained with various abrasives, perforating, cutting and punching techniques, finishing techniques used around the perforations and edges of each object, evidence of failed cut or perforation marks, and finally, cracks and stresses consistent with cold hammering.

The goal of the chemical analysis is to determine the elemental composition of the Cinnamon Bay metals. This data will help in determining the origin of each object. For instance, investigating potential levels of the copper, silver and gold can demonstrate if the metal is of natural (or alluvial) unalloyed origin, or an artificially produced alloy. Gold-alloys with copper contents higher than 25 percent typically do not occur in nature (Martinón-Torres et al., 2012:447). Silver levels in alluvial gold deposits, and even gold-copper alloys, can aid with determining the mineral source of the object as well. If exact source locations cannot be identified, variation in elemental composition can also indicate the use of multiple source locations. In addition, PIXE allows for the additional acquisition of reliable trace elemental data. This data typically helps identify inclusions or small trace amounts of elements in each object that are characteristic of a particular source. Unfortunately, there is a current lack of trace elemental data available in the Caribbean to draw comparisons, but this dataset will be accessible for future studies (M. Martinón-Torres, personal communication, 2015).

Optical Microscopy

Optical microscopic techniques included the application of binocular stereomicroscopy using an Olympus SZX12 mounted with a Canon digital single-lens reflex DS126311 camera. The Olympus SZX2 has a zoom ration of 1:12.86, a zoom range of 0.7× - 9×, a field diameters of 31.43 millimeters achieved with a 1× objective (Cell and Molecular, 1997:4). The zoom body has an integrated aperture diaphragm allowing for increased depth of focus control during high magnification (Cell and Molecular, 1997:4) (see Figure 1). This analysis was carried out at Professor Karen E. Samond’s lab located on the Northern Illinois University campus with the assistance of Brandon Semel (Northern Illinois University graduate student).

Scanning Electron Microscopy

Scanning electron microscopy was employed using a JEOL JSM 5900LV to investigate the physical properties of each object. This particular SEM has an optimized resolution of ~5 nanometers and a maximum beam energy of 30 kiloelectron volts (keV) (Associated Colleges, 2012). For each analysis, the entire object was place directly in the SEM chamber under high vacuum and secondary electron images were obtained at various distances using the secondary electron detector at a beam energy of 20 keV. The exact specifications and distances for each image are indicated on each SEM photo presented in this paper. It is important to note all SEM images presented in this paper are from this instrument. This analysis was performed at the SEM lab located on the Beloit College campus under the direction of Steve Ballou (Geology Technician at Beloit College).

Portable X-ray Fluorescence Spectrometry

The metal artifacts were analyzed with two separate portable (or handheld) x-ray fluorescence spectrometry (pXRF) units in order to determine their chemical composition. One laboratory is located at The Field Museum in Chicago, Illinois and the other pXRF lab is located at Beloit College in Beloit, Wisconsin.

Dr. Laure Dussubieux, research scientist at the Elemental Analysis Facility at The Field Museum supervised the first pXRF analysis. Dr. Dussubieux wrote the following parameters for The Field Museum's pXRF:

> XRF analyses were conducted using an Innov-X Alpha Series portable instrument. The excitation source is an X-ray tube with a tungsten anode. The Si PiN diode detector has an energy resolution of less than 230 eV FWHM at 5.95 keV Mn Kα line. The analytical mode was selected. An aluminum filter is used. The voltage is 35 kV and the current 8 mA. Total acquisition time is 60 seconds. Quantitative results are calculated using

> fundamental parameters, by the software provided with the instrument. The aperture of the instrument is approximately 1 cm^2 and ideally should be totally covered by the sample presenting a flat and polished surface. The samples were not subject to any preparation. (L. Dussubieux, personal communication, 2014)

Dussubieux also performed repeated analyzes of three reference materials containing comparable compositions to the Cinnamon Bay metals to obtain precision and accuracy data for The Field Museum's pXRF (see Beck, 1991). Precision was found to always be better than two percent relative for gold (Au), three percent relative for copper (Cu), and three percent relative for silver (Ag) when detected (see Appendix A). Accuracy was always better than six percent relative for gold. When small amounts of copper and silver were present, less than 0.5 weight percent, accuracy was very poor (over 195 percent relative) (see Appendix A). When copper was present above three weight percent, accuracy was always better than 24 percent relative. When silver was present above three weight percent, accuracy was always better than 43 percent relative.

Steve Ballou facilitated the pXRF analysis at Beloit College. Ballou networked with Tony Osborn, representative of Thermo Scientific Portable Analytical Instruments at Alpha Solutions, Inc., to help define the pXRF parameters used during the Beloit College analysis. The parameters were as follows:

> XRF analyses were conducted using a Thermo Scientific Niton XL3t GOLDD+ portable instrument. The excitation source is an X-ray tube with an Ag anode. The silicon drift detector has an energy resolution of less than 185 eV @ 60,000 cps @ 4µ sec shaping time (peaks are measured at full width half maximum). The analytical mode selected was general metals. The maximum voltage is 50 keV and maximum current is 0.2_ mA. The voltage is 40 keV and current is 0.1 mA on the main filter and 6-10 keV and 0.2 mA on the light filter. Total acquisition time was 60 seconds. Quantitative results are calculated using fundamental parameters. The aperture of the instrument is 8 mm and ideally should be totally covered by the sample presenting a flat and contamination free surface. The

samples were not subject to any preparation. (S. Ballou & T. Osborn, personal communications, 2016)

Particle Induced X-ray Emission Spectroscopy

Particle Induced X-ray Emission (PIXE) was employed to gather additional chemical compositional data. PIXE analysis was performed at the Hope College Ion Beam Analysis Laboratory (5SDH Pelletron® Accelerator, National Electrostatics Corp, Middleton, WI) under the direction of Professor Graham F. Peaslee and Hope College student Nicholas Hubley. Dr. Peaslee wrote the following parameters for the PIXE setup:

> Each sample was irradiated with approximately 0.3 nA of 3.4 MeV protons for 300 sec in a high-vacuum scattering chamber. These measurements were replicated in five different locations on each sample and the x-ray yields recorded to measure sample homogeneity. Characteristic elemental X-rays emitted from each sample were detected by a Si(Li) detector (Ortec, model SLP-10180-ST) located at 135º with respect to the beam axis. There was a 0.002" Mylar filter placed between the target and the X-ray detector to suppress low-energy X-rays. The effective detection threshold allowed silicon Ka X-rays to be recorded, but only semi-quantitative concentrations of each element lighter than sulfur could be obtained. Representative x-ray spectra for Samples A and B are shown in (Figure 8). The axes are semi-logarithmic to help highlight the minor elements in a matrix that is heavily gold (Metal Object A) or heavily gold and copper (Metal Object B). (G. Peaslee, personal communication, 2016)
>
> The Si(Li) detector is regularly energy calibrated with sealed sources, and in order to obtain quantitative results from the x-ray yields, a NIST standard reference material (SRM-2586) with known concentrations of transition metals was used to standardize results with a commercial fitting program: GUPIXWin® (Maxwell et al., 1995:407). The matrix was assumed to be predominantly gold for Metal Object A, and predominantly gold and copper mix for Metal Object B. The beam intensity used for these measurements was measured by an independent faraday measurement before and after each sample irradiation. Concentrations reported by GUPIXWin from these runs are estimated to have precision on the order of ±10% using this beam intensity measurement technique. This has been confirmed by replicate measurements of the standards. (G. Peaslee, personal communication, 2016)

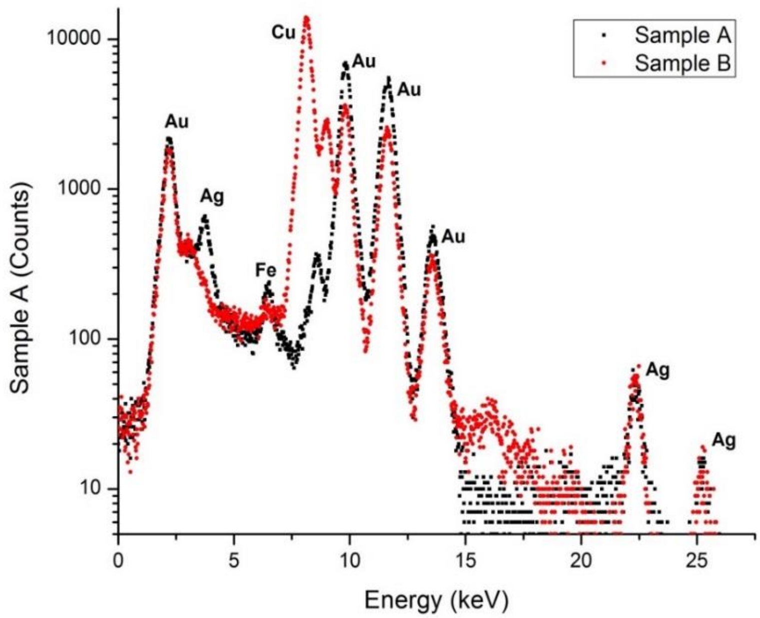

Figure 8: Representative X-ray spectra obtained from a 300s irradiation on each sample

CHAPTER 7

Results

Physical Analysis

Figure 9 and Figure 10 were created using binocular stereomicroscopy to detail the dimensions and basic morphology (including color) of Cinnamon Bay Metal Object A and Metal Object B respectively. These figures also include the weight of each metal object in grams (g). The thicknesses of both objects are less than one hundred microns.

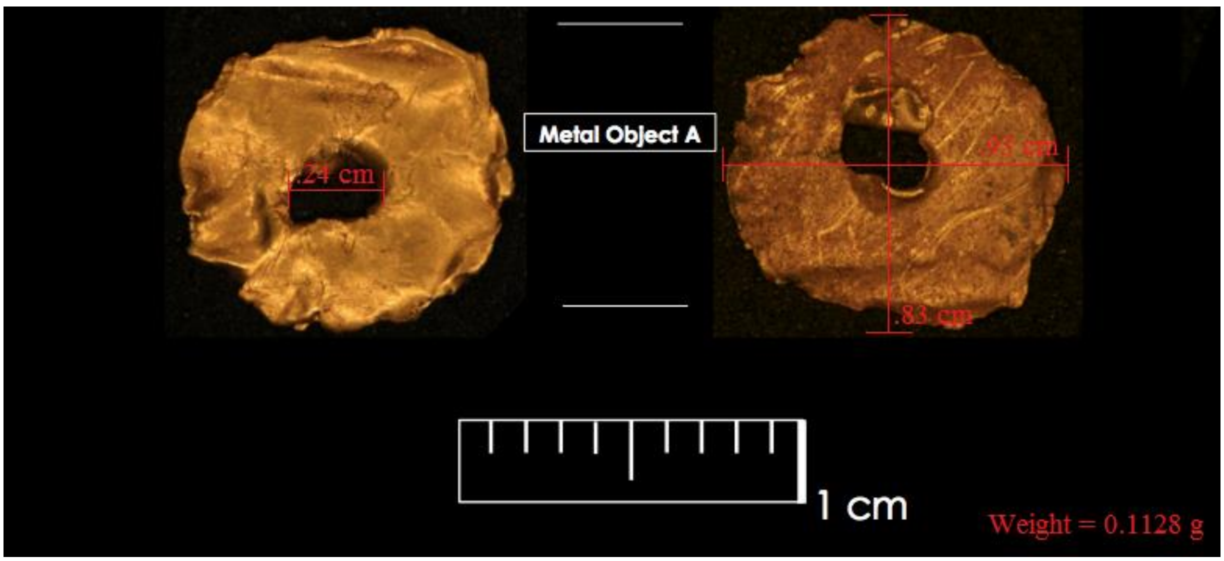

Figure 9. Metal Object A with dimensions and weight

Chapter 8 includes only the SEM images necessary for the discussion of the analytical results. Additional images can be found in Appendices B and C. Each SEM image is accompanied by a photograph of the whole object with the area under microscopic view boxed in red (see Figure 11 for example).

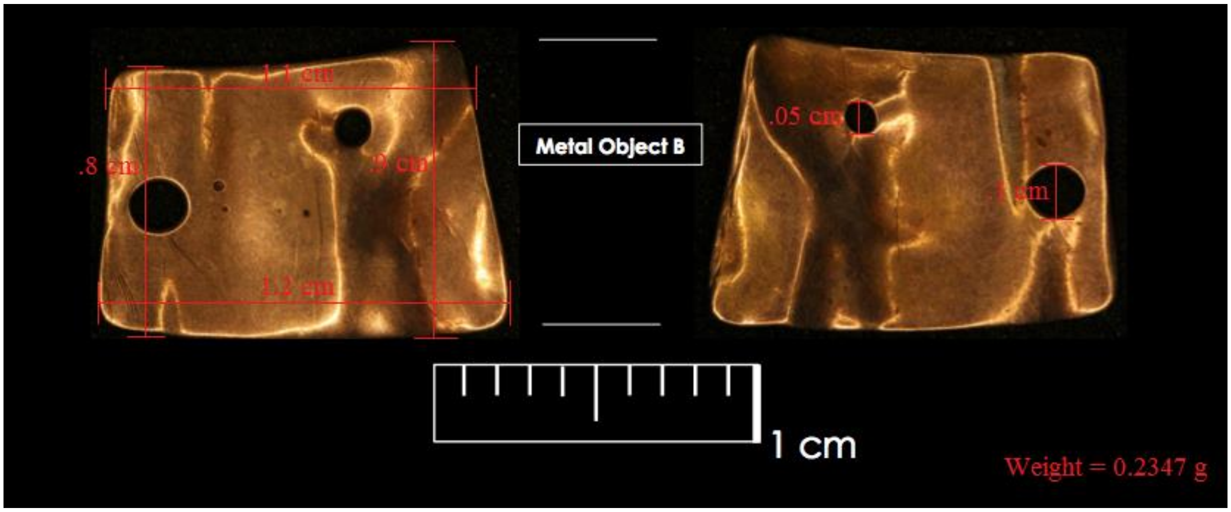

Figure 10. Metal Object B with dimensions and weight

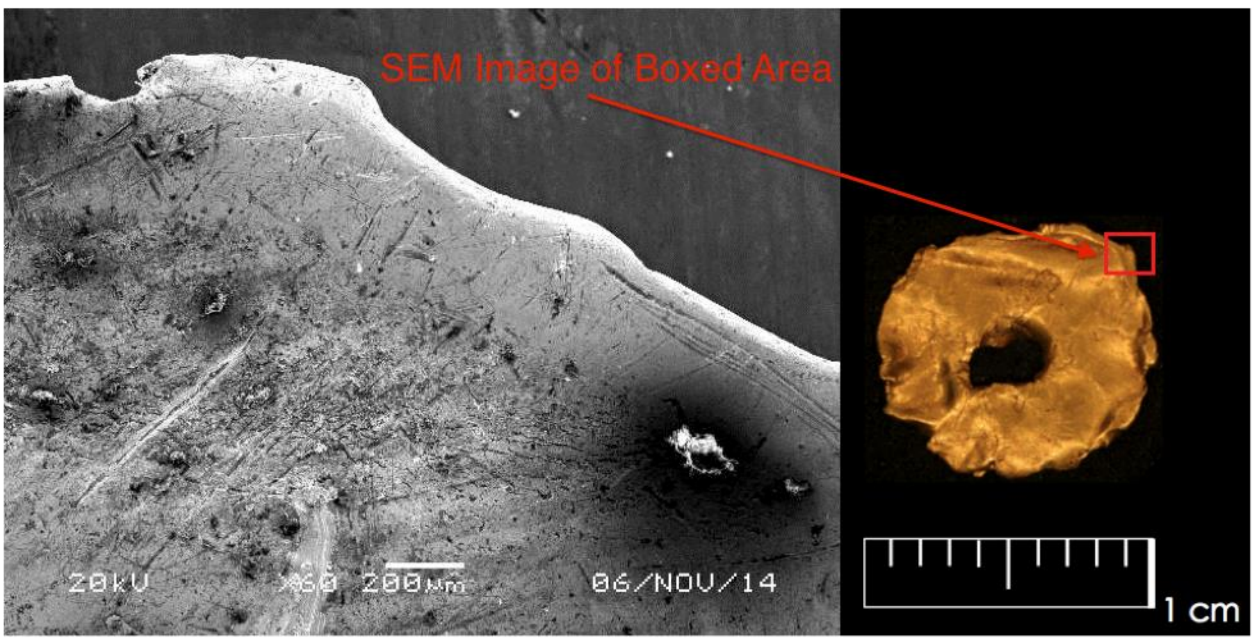

Figure 11. SEM image of Cinnamon Bay Metal Object A used to demonstrate layout

Chemical Analysis

The chemical compositions of each metal object were examined through the use of non-destructive techniques that included portable X-ray fluorescence (pXRF) and particle-induced X-ray emission spectrometry (PIXE) (see Tables 3, 4 and 5). Both metal objects were analyzed at least three times for each method. The pXRF analysis included tests for both sides of the object. All of the reported values are calculated into either weight percent (wt%) or parts per million (ppm) and detailed within each Table. It is also important to note, trace elemental concentrations (typically less than 0.1 weight percent or 1000 ppm) reported within the pXRF results are not reliable based on limitations imposed by the detectors for this type of material (M. Martinón-Torres, personal communication, 2015).

Previous regional research (see Martinón-Torres, 2007, 2012) has primarily focused discussions on concentrations and relative weight percentages of copper (Cu), silver (Ag) and gold (Au). The average values for these three elements were calculated and are reported separately in Table 6 to facilitate later discussion.

Table 3. Field Museum pXRF Results

Blank cells denote results that fell below detection limits for this instrument. 0 values were inserted into blank cells for an element that was detected in at least one scan in order to calculate mean and standard deviation.

pXRF Field Museum												
	Ti (wt%)	Cr (wt%)	Mn (wt%)	Fe (wt%)	Co (wt%)	Ni (wt%)	**Cu** (wt%)	Zn (wt%)	**Ag** (wt%)	In (wt%)	Sn (wt%)	**Au** (wt%)
Object A, Run 1	0			0	0.18	0	0.38		6.88	0.16	0.34	92.07
Object A, Run 2	0.61			0.54	0.17	0.10	0.51		6.54	0	0	91.52
Object A, Run 3	0			0.22	0.15	0	0.45		6.78	0	0	92.39
Mean (Average)	0.37			0.25	0.17	0.03	**0.45**		**6.73**	0.05	0.11	**91.99**
Standard Deviation	0.35			0.27	0.02	0.06	0.07		0.17	0.09	0.20	0.44
Object B, Run 1	0.54	0	0		0.16	0	47.34	0.61	9.29		0	42.07
Object B, Run 2	0.51	0.19	0		0.11	0.12	51.28	0.73	9.04		0.22	37.79
Object B, Run 3	0.56	0.12	0.09		0.11	0	47.31	0.68	9.06		0.27	41.80
Object B, Run 4	0.33	0.15	0		0	0.08	51.54	0.79	9.43		0	37.69
Mean (Average)	0.49	0.12	0.02		0.10	0.05	**49.37**	0.70	**9.21**		0.12	**39.84**
Standard Deviation	0.11	0.08	0.05		0.07	0.06	2.36	0.08	0.19		0.14	2.42

Table 4. Beloit College pXRF Results

Blank cells denote results that fell below detection limits for this instrument. 0 values were inserted into blank cells for an element that was detected in at least one scan in order to calculate mean and standard deviation.

pXRF Beloit College												
	Sb (wt%)	Sn (wt%)	Cd (wt%)	**Ag** (wt%)	Bi (wt%)	Pb (wt%)	**Au** (wt%)	Zn (wt%)	**Cu** (wt%)	Fe (wt%)	V (wt%)	Ti (wt%)
Object A, Run 1	0	0.05		4.72	0.03	0.00	94.65		0.07	0.46		0.00
Object A, Run 2	0.01	0.02		4.70	0.02	0.00	94.65		0.07	0.44		0.10
Object A, Run 3	0.01	0.04		4.71	0.03	0.02	95.06		0.08	0.06		0.00
Object A, Run 4	0	0.03		4.71	0.00	0.04	95.07		0.07	0.06		0.00
Mean (Average)	0.01	0.03		**4.71**	0.02	0.01	**94.86**		**0.07**	0.25		0.02
Standard Deviation	0.01	0.01		0.01	0.01	0.02	0.24		0.00	0.22		0.05
Object B, Run 1	0.03	0.08	0	5.95	0.15	0	39.06	0.48	54.07	0.03	0.14	
Object B, Run 2	0.03	0.08	0.03	5.94	0.15	0.00	39.08	0.47	54.09	0.00	0.13	
Object B, Run 3	0.04	0.07	0	5.87	0.14	0.06	44.52	0.44	48.71	0.00	0.13	
Object B, Run 4	0.03	0.07	0	5.88	0.14	0.06	44.64	0.47	48.56	0.00	0.13	
Mean (Average)	0.03	0.07	0.01	**5.91**	0.14	0.03	**41.83**	0.47	**51.36**	0.01	0.13	
Standard Deviation	0.00	0.00	0.01	0.04	0.00	0.03	3.18	0.02	3.14	0.02	0.01	

Table 5. Hope College PIXE Results

Numerical values represent elemental concentrations reported in parts per million (ppm). Weight Percentages do not including K, Ca – considered a surface contamination. Blank cells denote results fell below detection limits for this instrument

PIXE Hope College	**Concentrations in ppm (parts per million)**						
	Fe K	**Ni K**	**Cu K**	**Zn K**	**Ag K**	**Sn L**	**Au L**
Object A, Run 1	292	85	462		17910	0	208569
	0.1%	**0.0%**	**0.2%**		**8.6%**	**0.0%**	**91.0%**
Object A, Run 2	1139	257	1477		56922	0	575583
	0.2%	**0.0%**	**0.3%**		**9.9%**	**0.0%**	**89.6%**
Object A, Run 3	1262	50	414		14465	9252	140674
	0.9%	**0.0%**	**0.3%**		**10.3%**	**6.6%**	**81.9%**
Object A, Rerun 3	966	209	669		31676	0	337936
	0.3%	**0.1%**	**0.2%**		**9.4%**	**0.0%**	**90.1%**
Object A, Run 4	1551	592	2177		63136	0	651430
	0.2%	**0.1%**	**0.3%**		**9.7%**	**0.0%**	**89.6%**
Object A, Run 5	932	376	1450		52389	0	572619
	0.2%	**0.1%**	**0.3%**		**9.1%**	**0.0%**	**90.4%**
Mean (Average)	**0.3%**	**0.1%**	**0.3%**		**9.5%**	**1.1%**	**88.8%**
Object B, Run 1	0	15774	400699	23397	79244		183648
	0.0%	**2.2%**	**56.9%**	**3.3%**	**11.2%**		**26.1%**
Object B, Run 2	0	7725	236280	9931	54161		303453
	0.0%	**1.3%**	**38.6%**	**1.6%**	**8.9%**		**49.6%**
Object B, Run 3	0	11935	375679	19443	63383		189006
	0.0%	**1.8%**	**57.0%**	**2.9%**	**9.6%**		**28.7%**
Object B, Run 4	0	12366	348200	17912	68024		253689
	0.0%	**1.8%**	**49.7%**	**2.6%**	**9.7%**		**36.2%**
Object B, Run 5	380	10120	324864	17075	67950		141752
	0.1%	**1.8%**	**57.8%**	**3.0%**	**12.1%**		**25.2%**
Mean (Average)	**0.0%**	**1.8%**	**52.0%**	**2.7%**	**10.3%**		**33.2%**

Table 6. Chemical Analysis Summary

	Location and Type of Analysis	Cu (Avg wt%)	Ag (Avg wt%)	Au (Avg wt%)	Total (Avg wt%)	%Ag/ Ag + Au
Metal Object A						
	Field Museum - pXRF	0.5	6.7	92.0	99.2	6.8
	Beloit College - pXRF	0.1	4.7	94.9	99.7	4.7
	Hope College - PIXE	0.3	9.5	88.8	98.6	9.7
Metal Object B						
	Field Museum - pXRF	49.4	9.2	39.8	98.4	18.8
	Beloit College - pXRF	52.4	5.9	41.8	99.1	12.4
	Hope College - PIXE	52.0	10.3	33.2	95.5	23.7

CHAPTER 8

DISCUSSION

This section will directly address the research questions outlined in Chapter 1 for each metal object. To restate, the questions are:

1. ***Origin:*** What is the chemical composition of the Cinnamon Bay metals and can this help determine their origin?

2. ***Technology***: What manufacturing techniques were employed to produce the Cinnamon Bay metals? How do these techniques compare to those employed on other objects in the Caribbean region?

3. ***Meaning***: Can the chemical and physical data be combined with contextual site data to help determine the function and role the Cinnamon Bay metals served at the local level? Will these observations reflect or contradict regional patterns already observed?

Each question will be discussed in separate subsection and framed within the data presented in the previous chapter. These discussions will include ethnohistoric data and the other contextual site level data currently available from the shoreline site at Cinnamon Bay.

Origin

The chemical composition of Metal Object A is consistent with unalloyed, unrefined, naturally occurring alluvial gold (also known as a placer deposit) (see Table 6). This is what is commonly referred to as “pure gold,” which was known as *caona* among indigenous populations at the time of European contact (Martinón-Torres et al., 2007:196). Artifacts from the Caribbean with compositions of gold higher than 90 weight percent, silver levels between three and eight weight percent, and copper levels at or below one weight percent are considered to be from such origins (Martinón-Torres et al., 2012:442-445). The generated data from this project validates Wild’s compositional hypotheses for Metal Object A (Wild, 2013:926).

There is a relatively small dataset available for these types of gold objects in the Caribbean. The best comparative examples come from Cuba. Two objects in particular, the Esterito and Laguna de Limones samples, have strikingly consistent chemical compositions with gold contents higher than 90 weight percent and silver levels between six and eight weight percent (see Table 6). Trace elemental data for these objects is lacking and a particular source location for these objects has not been identified to date (Martinón-Torres et al., 2012:445). In general, the metal objects from Cuba derived from unalloyed (or pure) gold that appears to originate from at least two separate sources based on the variation in silver weight percentages determined by PIXE for each object (Martinón-Torres et al., 2012:445).

Sourcing the exact location of naturally occurring alluvial gold is difficult because ore formations with small amounts of gold stretch along the island chain from the Virgin Islands all the way to Cuba. Nuggets of gold have been recovered locally on St. John and on a select number of the surrounding cays (islets) in very small concentrations (Tucker et al., 1985:25). A comparative analysis of geological alluvial gold has not been systematically carried out on any island in the Caribbean to date. Future testing of these sources is needed in order to achieve a comparative data set to help determine the exact origin of objects containing alluvial gold.

Ethnohistoric records indicate gold was widely available from Hispaniola, Puerto Rico and Cuba (Oliver, 2000:197). The Spanish observed indigenous populations acquiring gold locally from rivers, not mines (Oliver, 2000:199). During resettlement, the Spanish enforced mining and panning activities on these islands that eventually contributed about 20 percent (or about 50 tons) of all exported gold from the New World by 1650 (Oliver, 2000:197) (see Figure 12). Based on these ethnohistoric observations and combined with the local availability of this raw material, it is reasonable to propose Metal Object A was manufactured from local native gold from St. John or at least within the Greater Antilles.

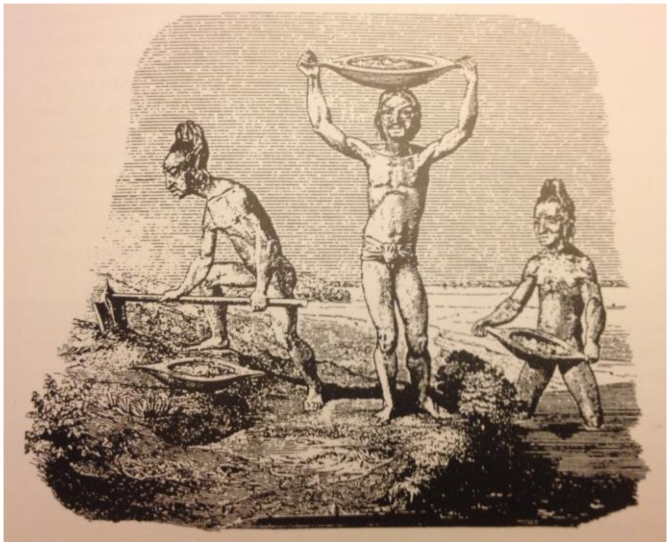

Figure 12. Sixteenth century engraving from Fernández de Oviedo depicting indigenous gold panning techniques (from Oliver, 2000:199)

The chemical composition of Metal Object B is consistent with artificial ternary alloys having various levels of gold, silver and copper (see Table 6). This type of artificial alloy is commonly found throughout metallurgical traditions in the Central and South America and was known as *tumbaga* among indigenous groups from these regions. In the Caribbean, indigenous groups referred to this type of alloy as *guanín.* Wild's hypothesis for the presence of this alloy at Cinnamon Bay is also confirmed (Wild, 2013:928).

Typically, gold alloys with copper levels that exceed 25 weight percent do not exist in nature (Martinón-Torres et al., 2012:445) and consequently metal artifacts with these compositions required high-temperature alloying. As mentioned earlier, there is zero archeological evidence for high-temperature metallurgy occurring in the Caribbean prior to the arrival of Europeans (Martinón-Torres et al., 2012:448). In addition, the chroniclers Bishop Las Cases and Fernández de Oviedo independently note gold was not smelted and only collected from the rivers (Oliver, 2000:199-201). The combination of the archaeological and ethnohistoric data suggests the Metal Object B was likely imported into the Greater Antilles.

Gold-copper alloys are quite rare in the Caribbean, especially chemically identified objects with secure contexts. 16 known samples are currently reported in all of the Caribbean and 12 come from Cuba (half of which were excavated from a single burial (number 57) in the cemetery at El Chorro de Maíta) (Martinón-Torres et al., 2007:197). Identifying the sources of these objects has primarily relied on stylistic and chemical comparisons between silver contents in objects throughout the Circum-Caribbean region. Silver levels for Colombian gold tend to be relatively high (often between 10 and 18 weight percent) (see Uribe and Martinón-Torres, 2012) and these levels are somewhat consistent with the gold utilized in the Cuban alloys. Metal Object B's silver levels fall just within the lower threshold of silver level ranges found in Colombian alluvial gold making this region a potential source candidate.

Other sources of alluvial gold in Colombia, particularly the coastal deposits that border with Ecuador, have high levels of palladium and platinum (Martinón-Torres et al., 2012:448-449). These elements are absent from the Cuban assemblage as well as Metal Object B in any significant amount. Trace elemental data could provide a better lens into the exact sources for the raw materials found in the gold-copper alloys, but this type of dataset is currently limited in the Caribbean and Circum-Caribbean region (M. Martinón-Torres, personal communication, 2015). The PIXE trace elemental data presented in this project (see Table 5) provides additional data that should allow for more specific determination of the metal's origin as additional research is undertaken.

The chemical data alone does not offer an exact source location for Metal Object B, but proves the object is not of local origin. Silver levels in the object are consistent with some studied Colombian ore formations and this offers at least one potential candidate. Even though Metal Object B has a somewhat simple morphology, data from the technological reconstruction of the object provides the strongest argument for supporting Colombia origin and will be discussed in the next subsection.

Technology

Metal Object A has a morphology that is consistent with other pure gold objects recovered in the Caribbean. In particular, Martinón-Torres et al. (2012) analyzed the physical and chemical composition of laminar artifacts from Cuba share distinctly similar morphologies (see Figure 13). These objects do not exceed 20 millimeters in length or width and have thicknesses that are almost identical to Metal Object A in terms of overall size, shape and thickness. None of the laminar gold objects from Cuba are perfectly symmetrical and two are broadly sub-circular, similar to Metal Object A (see Figure 13).

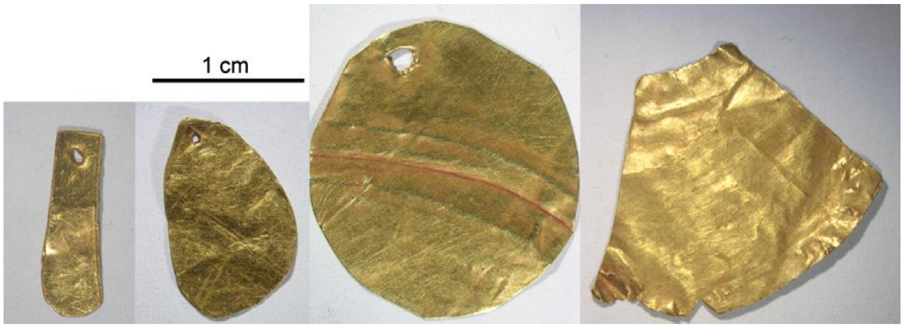

Figure 13. Selection of pure gold laminar objects under the stereomicroscope. From left to right: Esterito, El Morrillo, Loma del Aíte, Laguna de Limones (photographs by Dominique Bagault, CR2MF) (from Martinón-Torres et al., 2012:443)

The most obvious feature of Metal Object A is the central perforation. This hole suggests the object could have been either suspended or attached to another material (sewn to cloth for example). The perforation seems to be rather crudely made based on a large burr (referring to either a raised edge or piece of metal still attached after the object was modified) remaining on the underside of the perforation (see Figure 14). It also appears this perforation was created using two separate needles with different widths (see Figure 15). Interestingly, this unfinished look and overlapping punctuation pattern is also found on the Esterito sample from Cuba (see Figure 16).

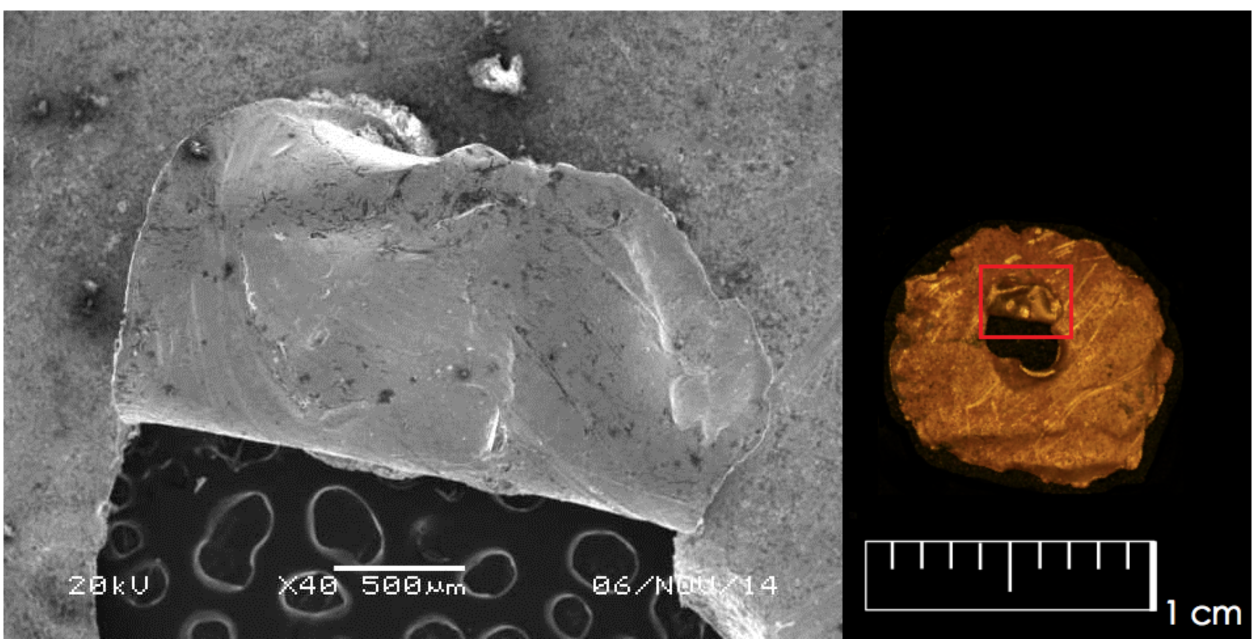

Figure 14. SEM image of Metal Object A detailing large burr

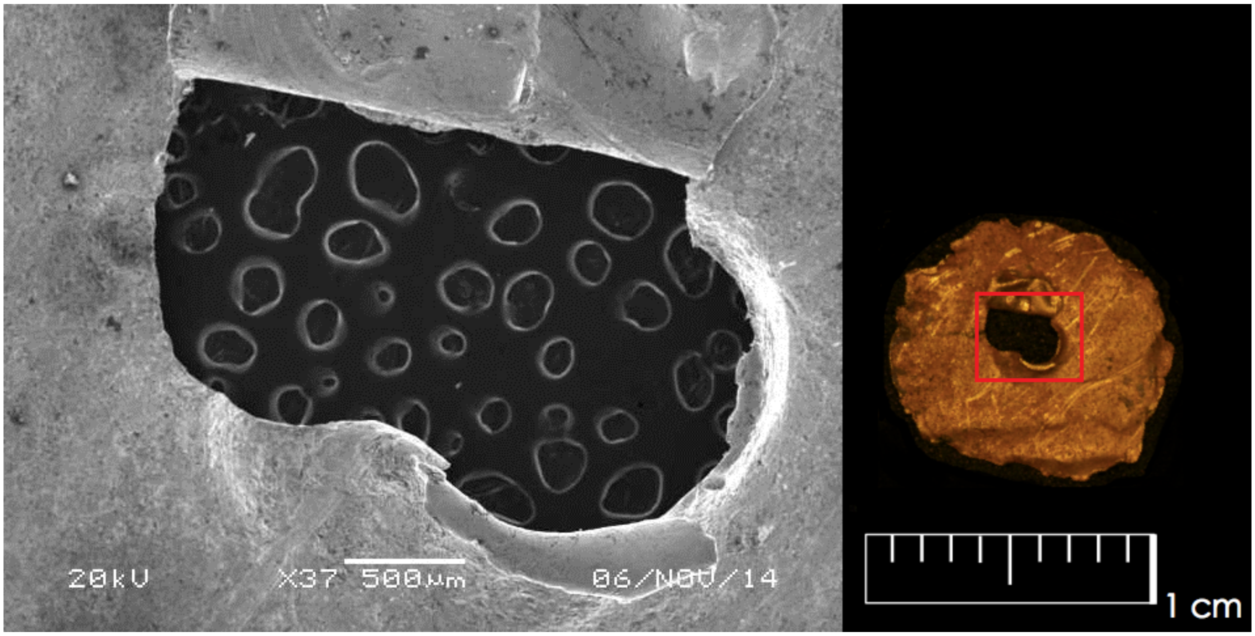

Figure 15. SEM image of Metal Object A detailing overlapping perforations

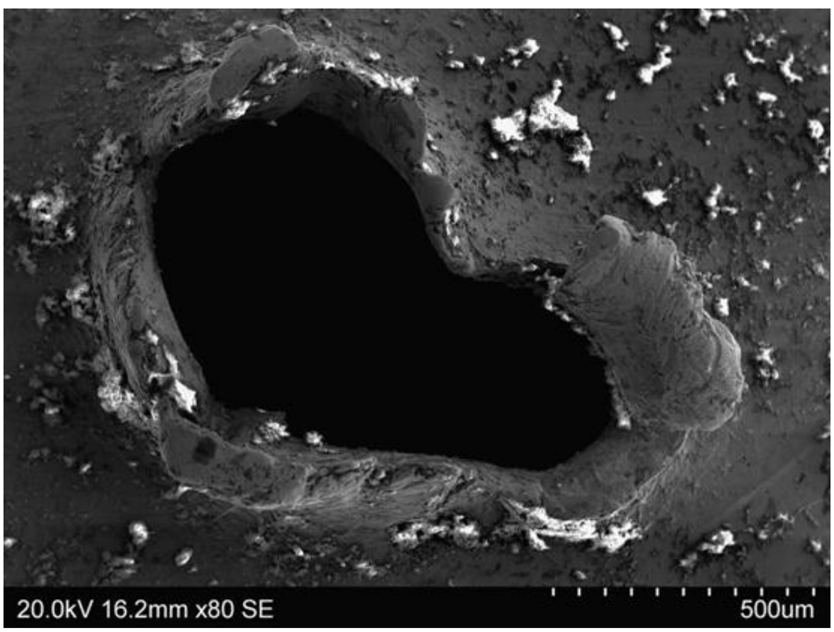

Figure 16. SEM image of Esterito sample showing overlapping perforations (from Martinón-Torres et al., 2012:443)

As noted by Martinón-Torres et al. (2012) in regards to the Esterito sample, “it is not possible to determine whether the two of them [perforations] were made in rapid succession or at different moments of the object's life history" (443). Either way, these two objects show potential remodification and this should be considered during future interpretations.

After using the chemical data to validate the alluvial origin of the gold, this information combined with the small size of the object lead to the initial hypothesis that this particular object was made from a single gold nugget. However, after being observed under the SEM, it appears an imperfect overlap possibly exists representing two separate gold nuggets being used to make this piece (see Figure 17). This feature is also found in the El Morrillo sample from Cuba (see Martinón-Torres et al., 2012:443). Other surface features include cracks and stress marks on the surface of the object that likely result from intense hammering (see Figure 18). Other light scratches running parallel at various widths in various directions are related to polishing with a loose abrasive (see Figure 18) (Martinón-Torres et al., 2012:443). These surface finishes are almost identical to finishes on the three similar gold samples from Cuba as described by Martinón-Torres et al. (2012) (see Figure 13).

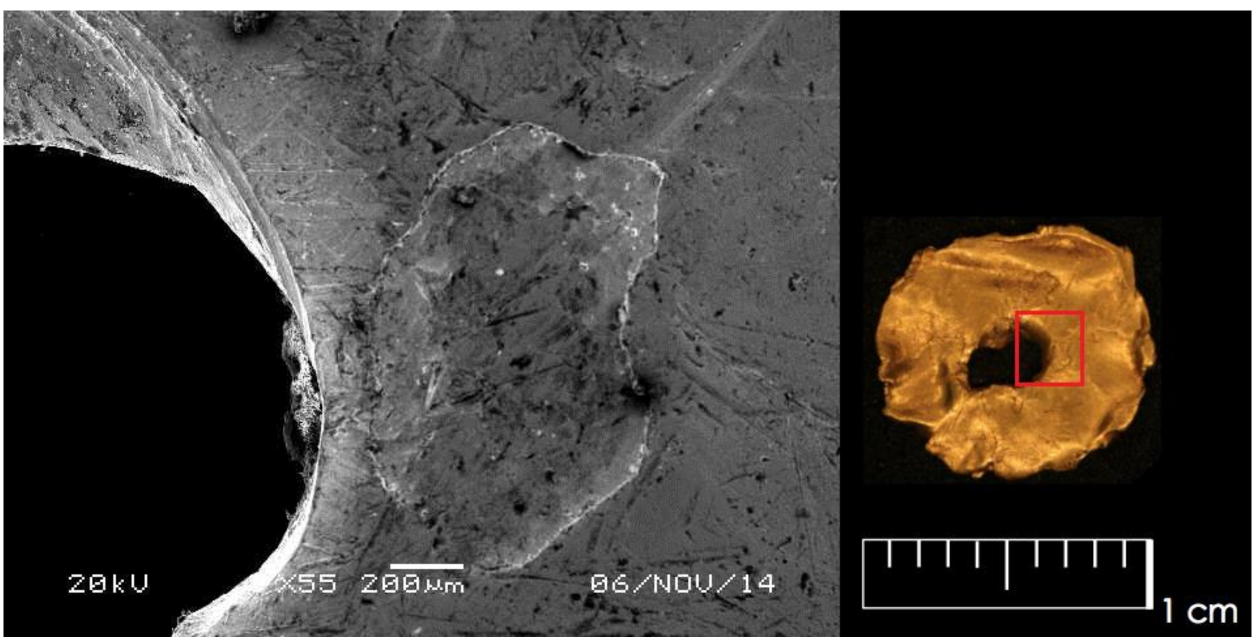

Figure 17. SEM image of Cinnamon Bay Metal Object A detailing imperfect overlap potentially representing two different gold nuggets

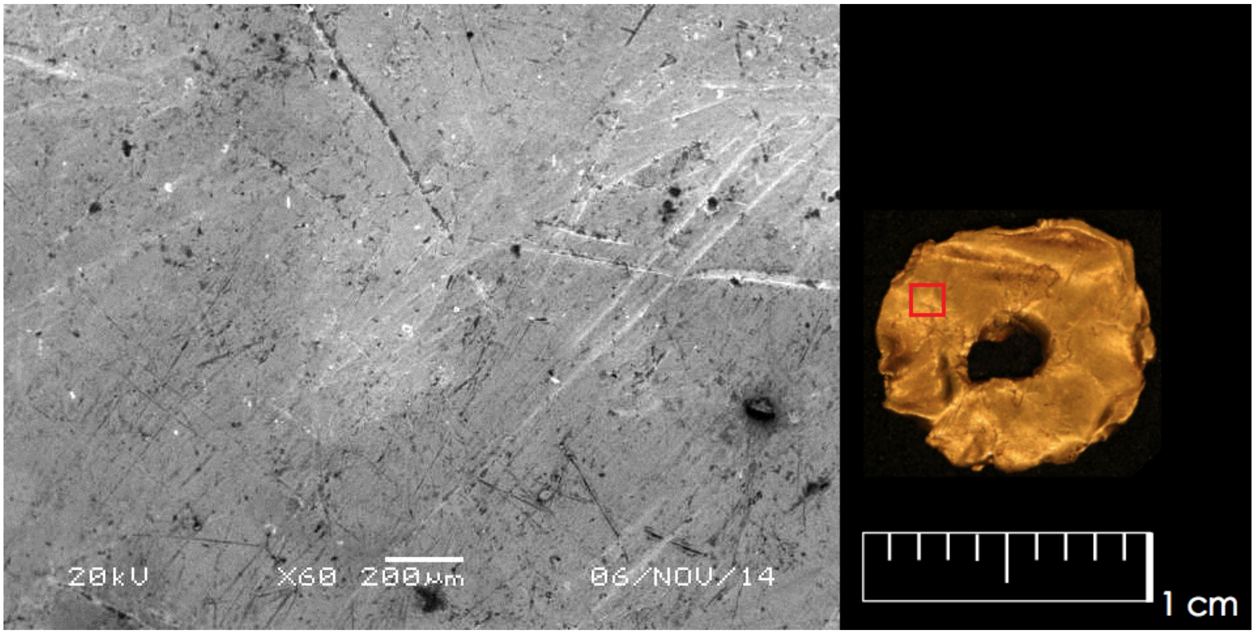

Figure 18. SEM image of Metal Object A detailing surface crack and stress marks associated with intense hammering and scratches consistent of polishing using a loose abrasive

A final physical feature to note from Metal Object A is the flakes of metal folded around the edge of Metal Object A (see Figure 19) (also see Appendix B). Interestingly, the El Morrillo sample shares a similar shaping technique (see Martinón-Torres et al., 2012:443). This likely demonstrates an attempt by the manufacturer to homogenize the overall size and shape of the object (Martinón-Torres et al., 2012:443). The Esterito and Loma del Aíte samples have more finished edges and show evidence of decoration that includes engraving or embossment of the surface. This is the largest difference between Metal Object A and the comparable pure gold laminar pieces from Cuba. The lack of embossment or engraving on Metal Object A could indicate a different use and purpose and this will be discussed further in the next subsection. Regardless, Metal Object A appears to fit nicely within the known range of metal artifacts manufactured from pure gold that have been documented throughout the Caribbean region.

Metal Object B's morphology is also strikingly similar to the gold-copper alloyed laminar objects examined by Martinón-Torres et al. (2012) from Cuba (446). Interestingly, 12 of the 16

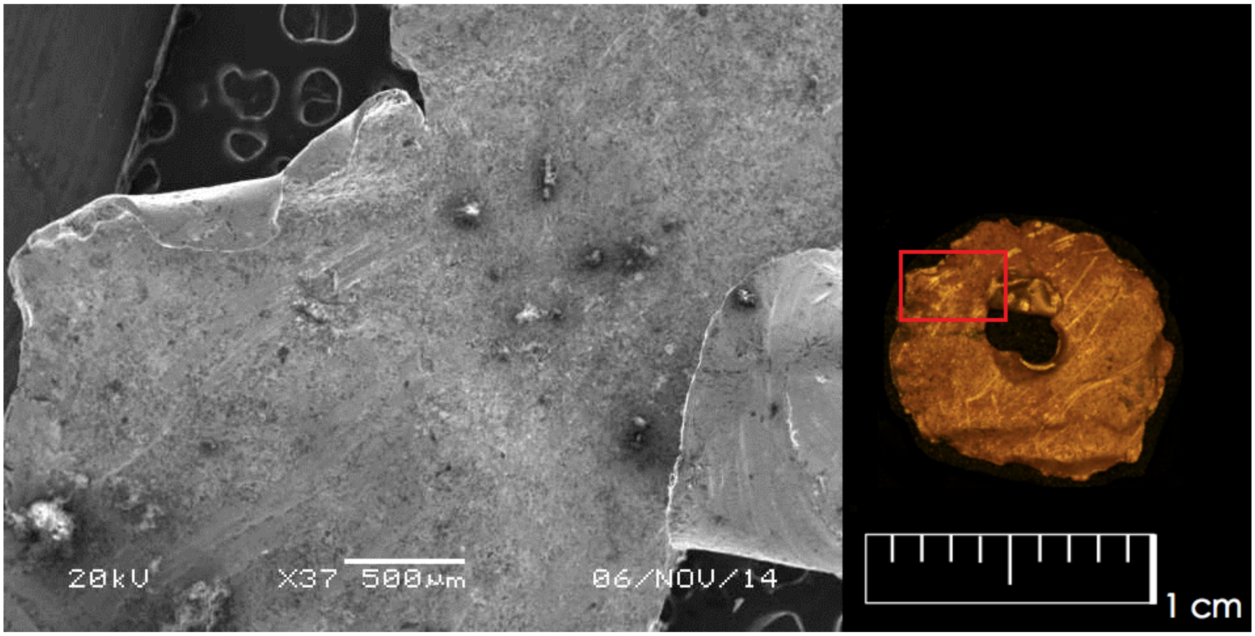

Figure 19. SEM image of Cinnamon Bay Metal Object A detailing evidence of folding metal along the edge

total reported gold-copper alloys (75 percent) in the entire Caribbean region come from Cuba (see Table 2). Furthermore, seven of the 12 Cuban alloys were recovered from the site of El Chorro de Maíta, many of which were found interred with burial 57 (see Figure 20). The flat, perforated gold-copper alloy laminar objects are "superficially similar" to those made from pure gold (Martinón-Torres et al., 2012:446). But, as noted by Martinón-Torres et al. (2012), "there are more differences than similarities" between the two types of metal (446).

Metal Object B shows signs of intense polishing action across the surface and perforations that appear perfectly polished even when viewed under the SEM (see Figures 21 and 22). These surface finishes are consistent with gold-copper alloys examined from Cuba by Martinón-Torres et al. (2012) and likely result from a polishing agent that was "very fine…[and] involved the use of textiles and a lubricated abrasive rather than sand alone" (446). It is difficult to discern if the two perforations on Metal Object B were created using a punch, drill or cutting

Figure 20. Group of artifacts recovered from burial 57 in El Chorro de Maíta, including several laminar copper-gold objects (photograph by Roberto Valcárcel Rojas) (from Martinón-Torres et al., 2012:446)

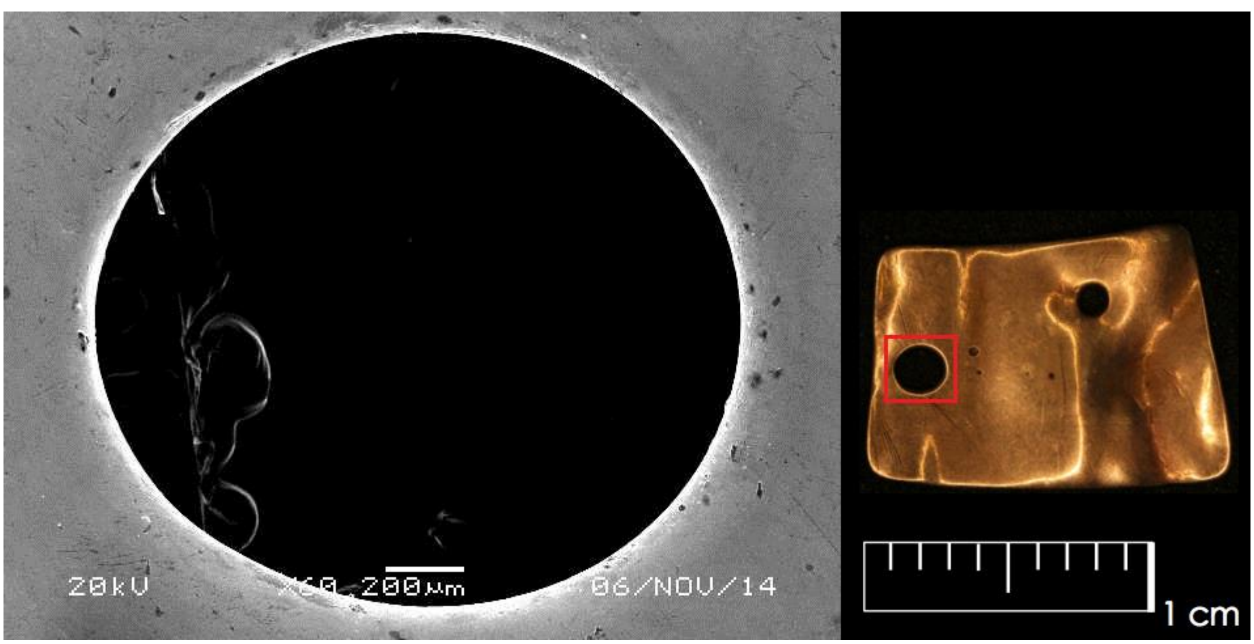

Figure 21. SEM image of Cinnamon Bay Metal Object B detailing intense polishing around larger perforation

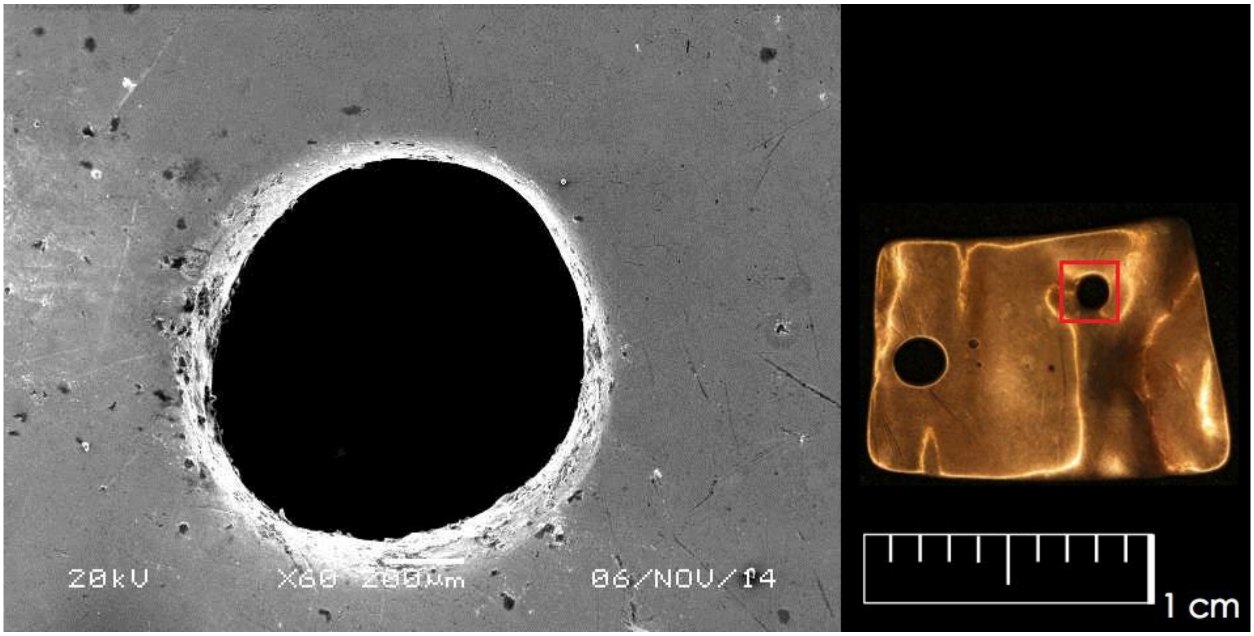

Figure 22. SEM image of Cinnamon Bay Metal Object B detailing intense polishing around smaller perforation

implement. There was no identification of shallow cut marks along the interior of either of the perforations, but these could have been polished down. The angle at which the SEM could investigate these interior areas of the object was limited (see Figure 23). Interestingly, the Cuban gold-copper laminar objects all exhibit a single perforation that tends to be in a more oval shape (see Figure 20). Metal Object B is different and has two perforations that were made with two distinctly sized implements and their shapes tend to be more sub-circular.

The Cuban copper-gold alloy laminar objects were made by cutting the trapezoidal shape of the body from a thin sheet that was “subject to hammering after casting” prior to any cutting (Martinón-Torres et al., 2007:197). This process appears to be similar to how Metal Object B was manufactured, but in general, hammer marks across the surface are difficult to identify. A large crack cuts down the center of the object possibly reflecting the application of intense hammering, but it is difficult to discern if this is related to post-depositional formation processes or stress from flattening the material (see Figure 24) (also see Appendix C).

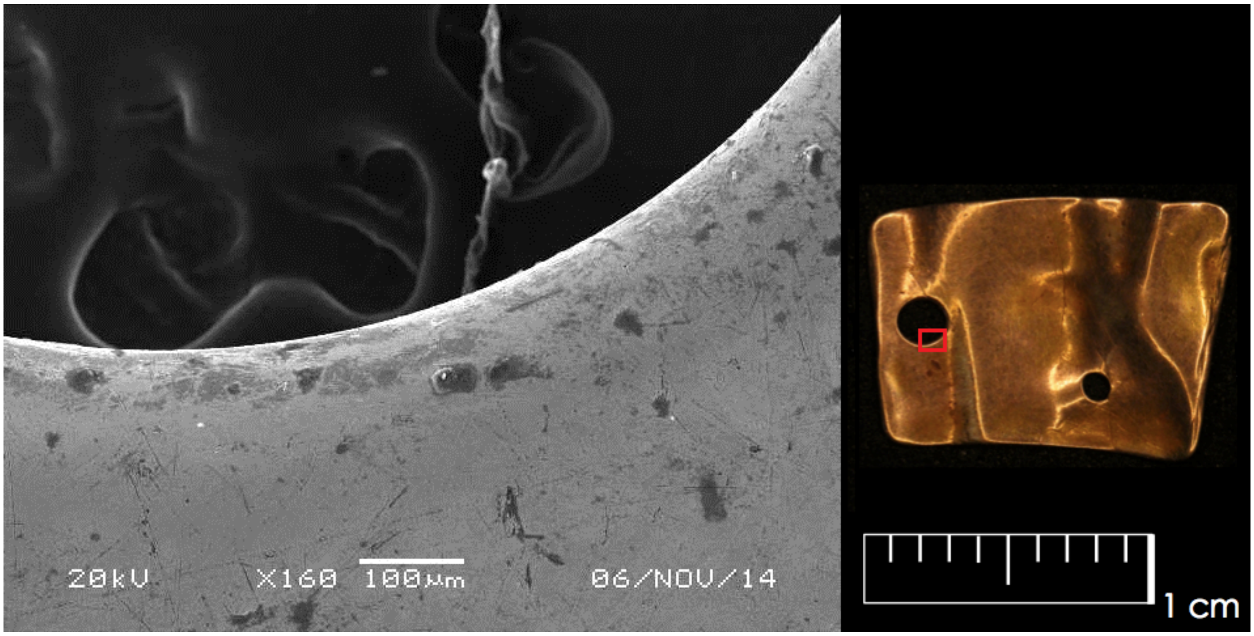

Figure 23. SEM image of Cinnamon Bay Metal Object B detailing intense polishing around interior edge of larger perforation

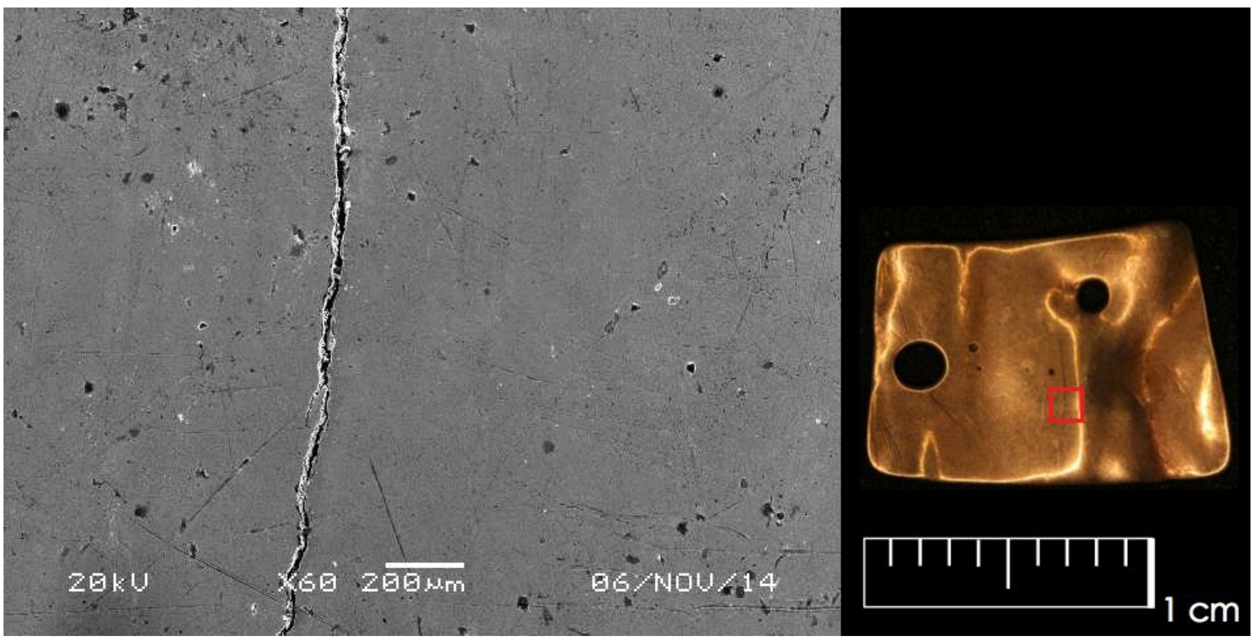

Figure 24. SEM image of Cinnamon Bay Metal Object B detailing crack cutting through the center

Metal Object B appears to be manufactured in an identical process maintaining the trapezoidal shape observed in the Cuban assemblage, just slightly more compact. The edges of the object are heavily polished and disguise cut marks that likely originated during the object's removal from a sheet (see Figure 25 and 26) (also see Appendix C). Repeated shallow cut marks identified in multiple areas along the edge of the object and near the larger perforation provide evidence for working the material towards a particular shape (see Figure 27 and 28) (see also Appendix C).

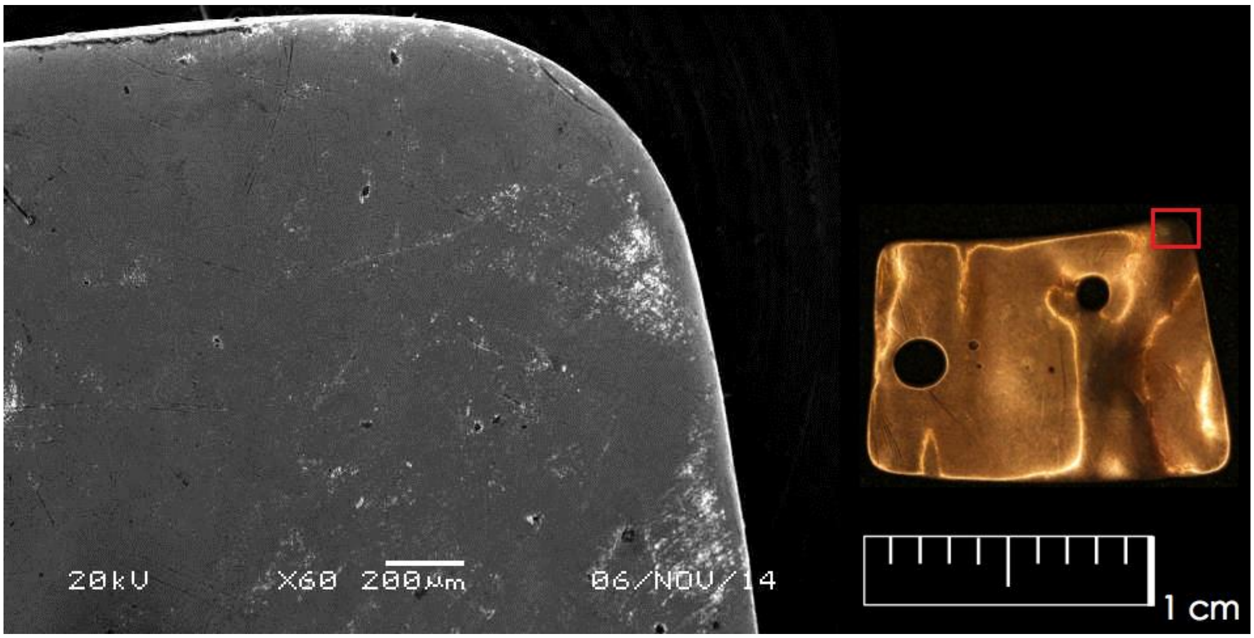

Figure 25. SEM image of Metal Object B detailing polishing along edge

The starkest difference between Metal Object B and the Cuban laminar gold-copper alloy objects is the lack of repoussé decoration on Metal Object B. In the Cuban assemblage, the objects typically show “shallow grooves parallel to the edges” (Martinón-Torres et al., 2007:197). Martinón-Torres et al. (2012) also note the objects form a shared group of stylistic and technological attributes suggesting they were produced from the same workshop (446). Metal Object B has a smooth, completely polished surface running throughout the entirety of the object and lacks any signs of engraving or chiseling.

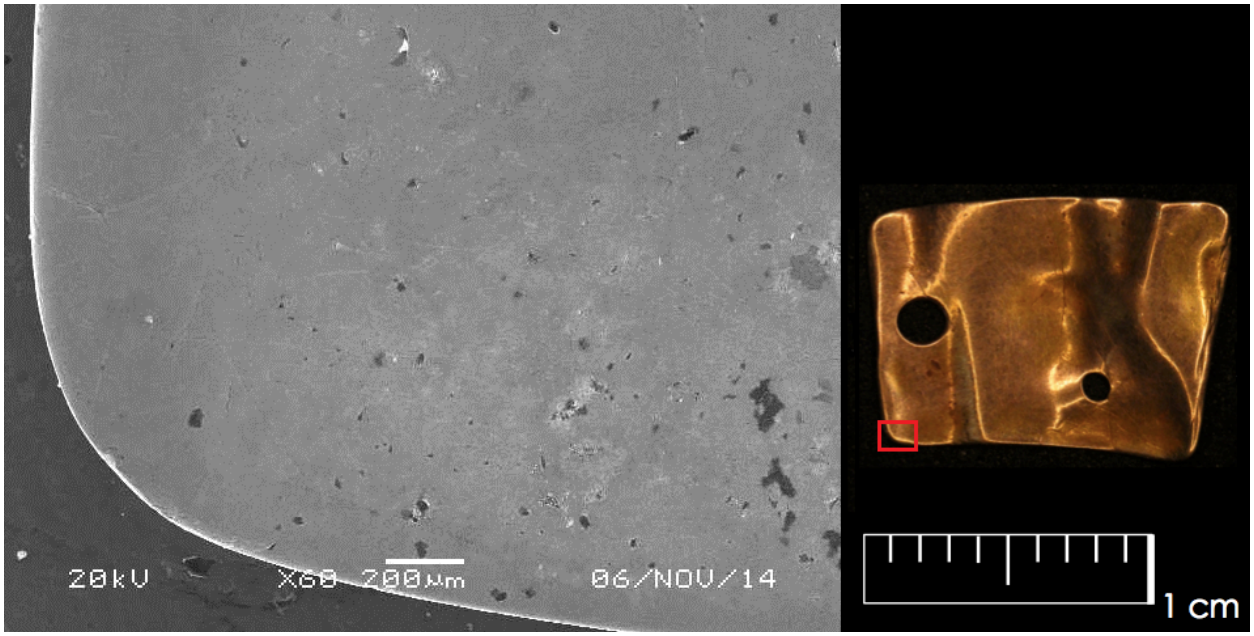

Figure 26. SEM image of Metal Object B detailing polishing along edge and corner on opposite side

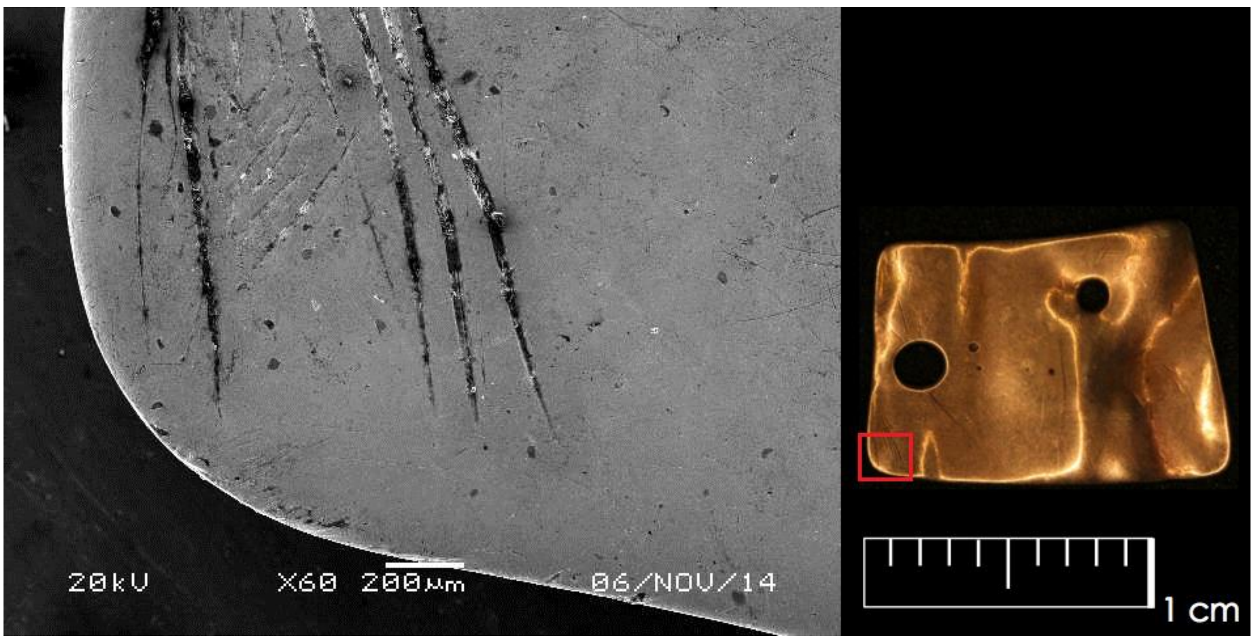

Figure 27. SEM image of Metal Object B detailing shallow cut marks along edge

Color is the final physical characteristic of the metal objects to be discussed (see Figure 9 and 10). The color of Metal Object A fits well within the typical range of other pure gold objects displaying a yellowish, iridescent tint. Metal Object B, shows a distinctly different iridescent reddish tint that is similar other flat, laminar gold-copper alloy objects recovered from Cuba (see

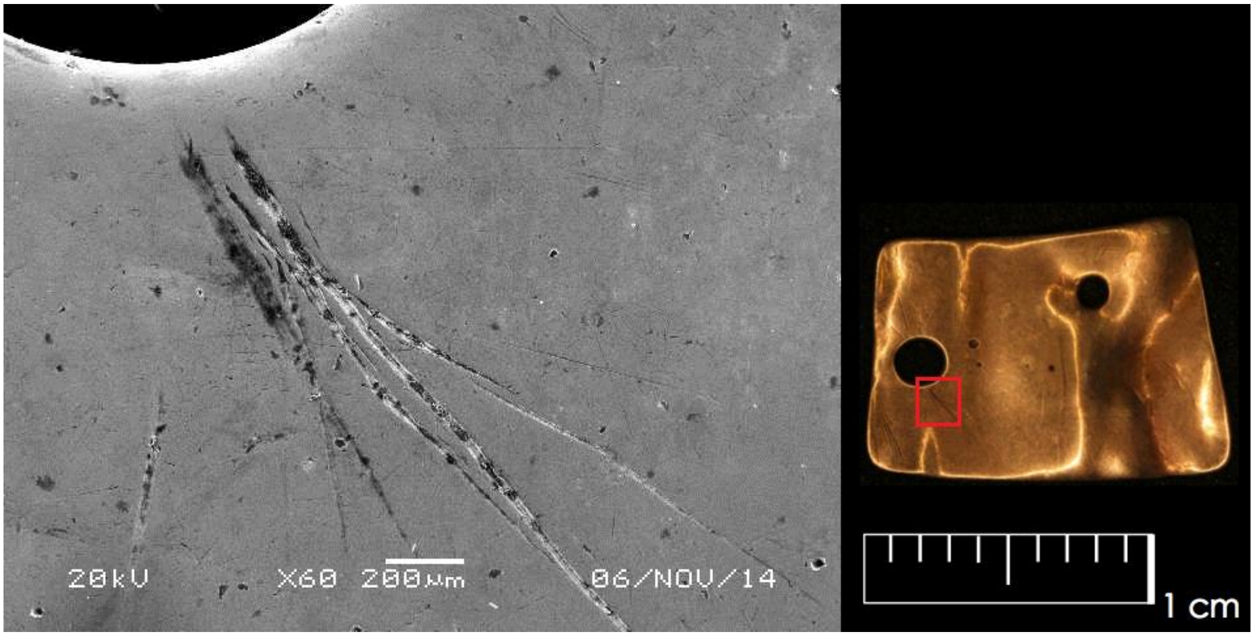

Figure 28. SEM image of Metal Object B detailing shallow cut marks near larger perforation

Figure 20). Similar gold-copper alloyed objects from Columbia tend to have “surfaces [that] were frequently made to appear golden by virtue of depletion gilding techniques” (see earlier discussion on the laminar metal fragment from the Anse du Coq site; Martinón-Torres et al., 2012:451). In contrast, Metal Object B and the majority of the gold-copper alloys from Cuba do not appear to show signs of surface depletion and instead “show a characteristic reddish tinge” (Martinón-Torres et al., 2012:451). Martinón-Torres et al. (2012) suggest, “…perhaps golden surfaces were considered too similar to *caona*” (451). If this was the case, more data is needed to prove this preference actually existed.

Martinón-Torres et al. (2012) suggest a Colombian origin for the flat, gold-copper alloy objects from the El Chorro de Maíta site based on the iconography of the ornithomorphic (bird-like) metal head interred alongside them (449) (see Figure 20). In Colombia, similar hollow bird heads were cast using lost-wax techniques by Tairona goldsmiths (Martinón-Torres et al., 2012:449). The El Chorro de Maíta bird head is almost identical to the Colombian examples. In

Colombia, the bird heads are typically used to “crown the pectorals” made in this region (Martinón-Torres et al., 2012:449). Martinón-Torres et al. (2012) also note flat, highly polished, perforated pendants were also produced in the region, specifically by the Nahuange goldsmiths of Sierra Nevada de Santa Marta on the Caribbean coast of Colombia (449). If these stylistic associations are correct, then a Colombian origin for Metal Object B seems to be a reasonable hypothesis that will require further investigations (i.e. trace elemental analysis from Colombian ore sources) to validate.

Meaning

Previous research into the role and use of metal in the Caribbean has largely relied on the use of ethnohistoric data. Spanish inventories that documented objects of exchange or appropriation between 1495 and 1496 identify the majority of pure gold occurred in sheets and “adorned with these [objects]: guaízas, inhalers, ornaments, vomit spatula, cotton belts and hats, spear throwers, [and] idols” (Valcárcel Rojas & Martinón-Torres et al., 2013:505). Most, if not all of these material types are strongly associated with ritual and the elite, but are also found to be accessible by individuals outside these social circles (Valcárcel Rojas & Martinón-Torres et al., 2013:505-506). Guanín was mentioned only twice in the above-mentioned inventory and not associated with being applied on or with another material (Valcárcel Rojas & Martinón-Torres et al., 2013:505). The limited presence of guanín on the inventory could reflect its “real scarcity in general” (Valcárcel Rojas & Martinón-Torres et al., 2013:505). Records also indicate pure gold and gold-copper use occurred across islands and crosscutting various related groups (and likely unrelated groups based on linguistic data that suggest barriers in language) (Valcárcel Rojas & Martinón-Torres et al., 2013:506).

Oliver (2000) also utilizes ethnohistoric data to characterize indigenous metal in three primary ways based on use: (1) as an object on its own; (2) as a body ornament; or (3) affixed to another material (Oliver 2000:203). Archaeological and ethnohistoric data indicate the latter two uses to be most common. Oliver (2000) further hypothesizes that non-local gold-copper alloys were always "associated with 'power'" (203). Around 900 CE, when large ceremonial centers began appearing in Hispaniola and Puerto Rico, "powerful golden metals, particularly *guanín*, were appropriated by chiefly lineages and converted into '"sacred political capital'" (Oliver, 2000:203). Oliver (2000) offers another interesting observation as well:

> Gold and metals are never far from those in authority and always attached to objects that mediate between the supernatural and the ordinary worlds. Moreover, golden items, either worn by humans or by biomorphic ritual objects, are often affixed to points of articulation between 'inside-outside' (mediation, liminal space) such as the eyes for vision, the mouth for ingestion/vomiting, the ears for sound and even the navel for alive/dead. It is evident that *caona* and *guanín* allowed access of interaction between contrasting domains, such as the sacred or the profane or the visible and invisible cosmic domains. (Oliver, 2000:204)

Metal use is without a doubt linked to aspects of ritual and negotiation of identity (Martinón-Torres et al., 2007:451). If metal played a role not only as a symbol, but also an active conduit of power during the process of social restructuring, its archaeological presence at a site may offer at least one avenue to investigate local manifestations of social transformation.

Ethnohistoric sources provide a helpful background in understanding the meaning of Cinnamon Bay metals, however, this data should be applied with temporal and spatial caution. The Cinnamon Bay metal objects appeared approximately four centuries prior to the arrival of any European in the Virgin Islands. As mentioned in Chapter 1, associated calibrated 2-sigma radiocarbon dates have yielded a date range of 1100-1200 CE for Metal Object B (recovered from Unit 4, Level 7, 60-70 cmbs) and a date range of 1180-1280 CE for Metal Object A (recovered from Unit 2, Level 5 30-40 cmbs) (Wild, 2013:941). In addition, ethnohistoric accounts are typically from west of this region (i.e. Hispaniola and Puerto Rico). Even though many objects may share physical characteristics, each likely functioned in its own unique context in a somewhat unique way.

Archaeological evidence indicates almost the entire valley of Cinnamon Bay was occupied during indigenous times (see Chapter 4). In a general sense, the valley has received limited attention and the overall layout and definition of space as it relates to specific patterns of behavior are poorly understood. However, one portion of the site, the threatened shoreline, has received detailed attention and revealed remarkable patterns of behavior related to intensive occupation and ritual offerings (see Wild 1999, 2013).

The indigenous shoreline site was first investigated in 1992 (see Chapter 4) and "sequential yet separate deposition of ceramic styles [were] observed" (Wild, 1999:306). In 1998, the NPS excavation test units (three 4 by 4 meter) adjacent to the 1992 investigations revealed a similar in situ undisturbed context (See Figure 7). An extensive report detailing the excavation methods and material remains (including the extensive ceramic data) is forthcoming (K. Wild, personal communication, 2015). Currently available data, highlighted and discussed in Wild (1999), Quitmyer (2003), Knippenberg (2011), and Wild (2013) is used to better contextualize the Cinnamon Bay metal objects.

Occupation at the shoreline portion of the Cinnamon Bay site (VIIS-191) began around 1020 CE based on a range of 2-Sigma radiocarbon dates (see Table 7). All three test units reveal "sequentially separated subseries deposits" where broken vessels have been purposely stacked or have had round holes purposely punched out of the bottom (Wild, 1999:306). In addition, groupings of shell “restricted to a specific species” were also identified (Wild, 1999:306). Most interestingly, an articulated turtle plastron and an intact deposit of piled, unopened bivalve shells placed upon a decorated ceramic vessel were exposed within the cultural levels (Figure 29). These specific ceramic, shell and faunal deposits have been linked inextricably with ritual offering (Wild, 1999:306). In addition to the two metal objects discussed in this project, other cultural material recovered from the excavation units include various ceramic adornos, shell inlays and pendants, carved stone beads, carved three-pointed zemi stone, plain three-pointed stones, a stone belt fragment, and nose plugs (see Figure 30 and 31). Wild (1999) suggests these objects are not only directly related to the elite and ceremonial activity, but reflect the presence of “Classic Taino culture” as defined by Rouse (1992) (Wild, 1999:305-306).

Wild (1999) argues that the intact sequential deposits of offerings are evidence of a practice described by the chronicler Bartolome de Las Casas where offerings were made in a specific structure that belonged to the cacique (or chief) and left in place until they perished (306). Rouse (1992) acknowledged this practice occurred once a year (14). Wild (1999) argues this is why preservation at the site contains an unmixed sequence of distinct pottery styles through time because “mixing of material on a daily basis would be restricted” (307). Wild (1999) further argues this physical space received continual offerings over the course of 500 years maintaining its function as a place for ancestor worship even as ceramic styles changed significantly over this period (307). The most apparent changes in ceramic style are reflected in the anthropomorphic adornos when headdresses were are added to them during late occupational periods (Wild, 1999:308). The addition of headdresses possibly reflects a shift in ideology and social organization refocused towards a specific elite ancestral lineage (Wild, 1999:307).

Table 7. Carbon 14 Dates from Cinnamon Bay Ceremonial Area – Conclusions

Probable temporal ranges based on radiocarbon dates, sequential depth, and artifact types (from Wild, 2013).

Beta Analysis #	Unit #	Level	cmbs	Predominate Ceramic Type	C-14 2-Sigma Range	*Probable Date Range	Diagnostic Artifact Assemblage
184206	Unit 3	1	0-10	Historic	2 Sigma 1650-1950	1650-1950	Mostly historic and modern remains mixed with some prehistoric sherds
184208	Unit 3	2	10-20	Chican	2 Sigma 1320-1440	1320-1440	Taino ceremonial objects with Esperanza sherds mixed with some Boca Chica and Capa design elements
184209 69973	Unit 3 Unit 1	3	20-30	Chican	2 Sigma 1290-1450	1290-1400	
184211	Unit 3	4	30-40	Santa Elena	2 Sigma 1180-1280	1180-1280	Santa Elena ceramic design elements with residual Monserrate II elements and Taino like ceremonial objects
		5	40-50	Santa Elena	No Data		
184217	Unit 3	6	50-60	Monserrate II/Santa Elena	2-Sigma dates for these levels are identical, AD 1020-1270. a timeframe too long to clearly date the sequential artifact shifts that occur in these levels.	1 Sigma 1140-1240	Santa Elena and Monserrate II ceramics with Taino like ceremonial objects
184212	Unit 3	7	60-70	Monserrate II		Sequential possibility 1100-1200	First appearance of carved zemi stones, inlays, Ostiones designs & Monserrate black and red design. Full reintroduction of zoomorphic design elements.
184218	Unit 3	8	70-80	Monserrate II			
69974	Unit 1 Unit 3	9, 10, 11	80-115	Monserrate I		1 Sigma 1050-1100	Monserrate designs with a minor introduction of zoomorphic elements.
Multiple samples	Trunk Bay			Monserrate I		Multiple dates 800-1200	Monserrate design elements with anthropomorphic faces on lugs and flat faces.
							Ken S. Wild 12/7/2013

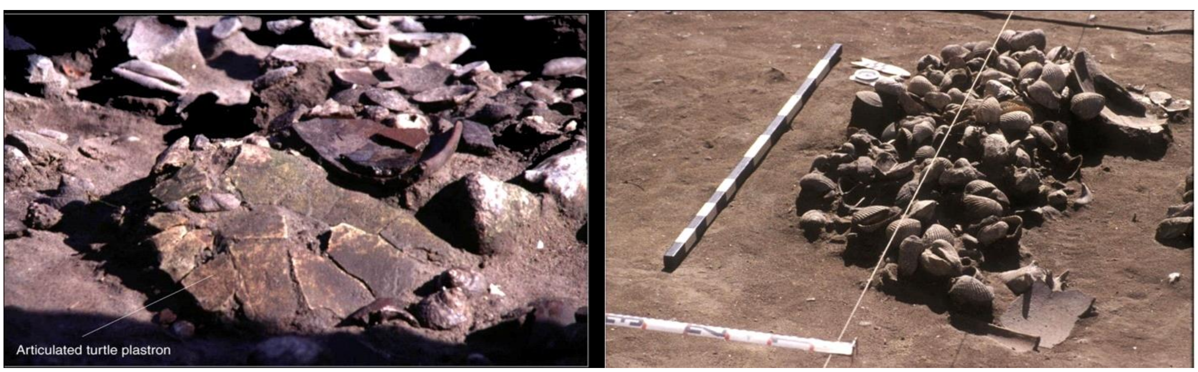

Figure 29. **Left:** *In situ* remains of an articulated turtle plastron (underbelly shell) found near the surface. **Right:** Near the surface, intact and unopened bivalve shell offering remains in a large ceremonial vessel (from Wild, 2013)

Figure 30. Example of inlays, pendants, beads and carved zemi stone found in the upper Monserrate II levels. **Top row (50-60 cmbs):** inlays, carved shell and stone beads. **Middle row (60-70 cmbs):** shell pendant, gold/copper pendant (Metal Object B), stone beads. **Bottom row (70-80 cmbs):** shell inlays, stone beads and carved quartz zemi head (from Wild, 2013)

Figure 31. Elenan Period artifacts. **Right half (30-50 cmbs):** Santa Elena sherds. **Top left (30-40 cmbs):** shell and gold inlay (Metal Object A), bat nosed adorno, nose plug, and shell beads**. Bottom left (40-50 cmbs):** nose plug, shell pendant and inlays (from Wild, 2013)

Wild (2013) further proves the sequencing of secure deposits at the shoreline site of Cinnamon Bay by analyzing multiple radiocarbon samples from charcoal that were recovered from each of the 10-centimeter arbitrary levels that were excavated at the shoreline indigenous site on Cinnamon Bay (see Table 7). Wild's radiocarbon dates suggest a chronological sequence that correlates with similar changes of pottery styles in eastern Puerto Rico. The apparent difference is that this sequence in pottery style change occurs a couple centuries later on St. John (Wild, 2013:930).

Metal Object B (the gold-copper alloy) is directly associated with what Wild (2013) identifies as the late Monserrate period, or Monserrate II (928) (see Table 7). *Monserrate* is a pottery style typically associated with eastern Puerto Rico and is the dominant pottery style present in Metal Object B's ten-centimeter level. Compared to deeper and earlier strata with similar pottery styles, this level contained a "significant increase in ceremonial artifacts" (Wild, 2013:928).

Metal Object A (pure, or alluvial gold) appears during the next phase of occupation based on a change in ceramic styles. Wild (2013) identified the dominant pottery style for Metal Object A's ten-centimeter level as Santa Elena (928) (see Table 7). Other artifacts recovered from this level include "carved shell…stone beads, and many elaborate zoomorphic vessels" (see Figure 31). Also, the "first bat nosed anthropomorphic head was recovered, but without a headdress" (Wild, 2013:929) (see Figure 31).

The shallowest levels of the excavation units were dominated by ceramic styles associated with Boca Chica and Capá which are typically associated with western Puerto Rico and the Dominican Republic (Wild, 2013:929). These styles dominate the material record until occupation at the site ends between 1420 and 1440 CE. Wild (2013) also notes these upper levels contain an increase in “elaborate anthropomorphic faces with bat noses and headdress design elements characteristic of cacicazgo affiliation” (929). Wild (2013) suggests the presence of this imagery could indicate “influence or association extending from a cacicazgo center” (929). These ideas are currently speculative and will require further investigation. Changes noted in the ceramic styles through time are also being further examined and a detailed report is currently underway (K. Wild, personal communication, 2015). As mentioned in Chapter 4, Rouse’s (1992) ceramic styles, subseries, and series have received heavy criticism in recent years and need to be used with caution when drawing comparisons across sites and islands. Interpretations of Cinnamon Bay benefit from having numerous radiocarbon dates of its occupational sequence.

The faunal remains recovered from the 1998 NPS excavations at Cinnamon Bay are discussed in a report by Irvy R. Quitmyer (see Quitmyer, 2003). Quitmyer (2003) notes there was little variation through time in the way people procured marine food resources at the site. The earlier Monserrate occupations, as defined by Wild (1999, 2013), demonstrate more limited uses of marine resources as compared to later occupations (Quitmyer, 2003:154). There was an increase in the variety of species during later periods, but terrestrial animals were never the focus of their diets and there was a noted decrease in the relative abundance of hutia and land crabs through time (Quitmyer, 2003:152). A sharp increase in total mollusk species and an overall decrease in fish species were also noted over time (Quitmyer, 2003:152). Outside of these broad temporal changes, Quitmyer (2003) importantly states, “The midden volume charts the evolutionary direction of the site’s function as a ceremonial center, implying that it required great increasing quantities of food to fuel this enterprise” (Quitmyer, 2003:154). In this way, the faunal data support Wild’s (1999, 2013) interpretation of ritual activity occurring at Cinnamon Bay.

The lithic assemblage from the shoreline indigenous site at Cinnamon Bay was reviewed by Knippenberg (2011). Knippenberg (2011) also conducted a brief survey of the available raw material on St John and neighboring St. Thomas. Knippenberg (2011) notes, “St. John has many places where dark finegrained proper quality igneous rock can be procured” (2). Knippenberg (2011) does not report data in detail, but offers general observations about the Cinnamon Bay lithic assemblage. Knippenberg (2011) noted a majority of the raw material was “exploited [from] the nearby gully for their flaked stone raw material” (2). As for ground stone tools, Knippenberg (2011) notes a “fair amount” present and “to a lesser degree use-modified rocks” as well (3). Any counts, weights or detailed physical description of these materials are absent.

Knippenberg (2011) does offer an interesting observation concerned with the general characteristics of the entire assemblage. Knippenberg (2011) notes, “the assemblage bears strong relations with the Taino flaked stone assemblages on Puerto Rico reported by Reniel Rodriguez, notably the one from the last occupation phase at El Paso del Indio” (3). The lithic assemblage shows clear differences to those typically found in other groups living in the Lesser Antilles during the same time period. People at Cinnamon Bay also largely preferred local, on site raw material over “better” material available at nearby locations on the south side of the island (Knippenberg, 2011:5). This pattern is in contrast with most other communities in the Lesser Antilles who were actively involved in trading and moving high quality chert (Knippenberg, 2011:5). Knippenberg suggests that interaction “between the Lesser Antilles and the Virgin Islands became less frequent” (6). These general observations offer at least some data to consider when working towards a better understanding of activity at the shoreline site at Cinnamon Bay and how the site relates to the rest of the region.

The variety of data currently available from the site of Cinnamon Bay provide some remarkable insights. Lithic and ceramic data have further exposed key similarities to groups living in eastern Puerto Rico and the rest of the Greater Antilles. Sequential intact deposits of stacked unprocessed mollusks, pockets of purposely stacked ceramic sherds and shell, and ceramics with their centers intentionally removed indicate potential offerings were being made in this location. A range of other material typically associated with elite and ritual activity are also present. Faunal remains further suggest a diversification in diet overtime to support ritualized activity. Most interestingly, radiocarbon dates suggest these behaviors continued for close to 500 years and remained unchanged through distinct shifts in ceramic styles.

Considering the above contextual data, it is plausible to assume the Cinnamon Bay metals likely served as an accentuation of these behaviors and helps identify their use as offerings and helps explain the relative abundance of this rare resource on St. John. As mentioned earlier, the Cinnamon Bay site is just the fourth indigenous site in the entire Caribbean region to have multiple pieces of metal recovered. If this area of the Cinnamon Bay site where the metal was recovered was continuously used as a dedicated offering space, and if we assume metal was commonly used as an offering, it is then reasonable to find multiple types of this material at this location.

In the Circum-Caribbean region, offerings of metal are in fact reported outside of burial contexts. As mentioned earlier, Martinón-Torres et al. (2012) linked the production of the hollow bird head recovered at El Chorro de Maíta in Cuba to the Tairona in Colombia (449). The Musica people, who are recognized as being closely related to the Tairona, also possessed a strong metallurgical tradition. The Muisca began occupying the interior highlands of Colombia during the seventh century CE (Plazas and Falchetti, 1985:56). This would have been just a few centuries prior to the initial occupation at Cinnamon Bay. Most interestingly, authors Plazas and Falchetti (1985) state, “Muisca gold pieces are very crude and are found in great quantities, suggesting mass production and popular use as religious offerings” (56). Consequently, if the Cinnamon Bay metals came from this region, it is not irrational to hypothesize that the objects could have been used for similar purposes. The site level contextual data at Cinnamon Bay also supports this consideration.

To my knowledge, metals have not been recorded being used as dedicated offerings in outside of burial contexts in the Caribbean. However, this practice existed in Colombia, an area that the chemical and physical data suggest to be a possible origin for the Cinnamon Bay metals. Therefore, it is reasonable to consider metal as a material type being used as an offering in the Caribbean, especially since this fits well within the patterns of behavior already observed at Cinnamon Bay.

The previously discussed ethnohistoric evidence indicates the Cinnamon Bay metal objects did not exist as an isolated material type (e.g. a statue). Wild (2013) suggests Metal Object A was used as an incrustation for carved wooden idols, specifically as an eye inlay, similar to the other shell inlays recovered at the site (926; see also Wild, 1999). This suggestion is highly possible. Oliver (2000) notes, “very often marine shells were used instead of, or in combination with metal-sheet encrustation on eyes, mouth, ears and limb joints…especially the iridescent and multicolored mother-of-pearl materials” (204). However, the object’s overlapping perforations (see Figure 15) suggest a specific width was sought for that central perforation. The apparent attempt to increase the size of this perforation could be related to a particular fiber thickness and may suggest the object was instead used to adorn a cloth material such as a textile or garment.

In contrast, Wild (2013) suggests Metal Object B was used as a pendant (Wild, 2013:928). The stylistic and morphologic comparisons drawn earlier to the Cuban and Colombian metal assemblages support this hypothesis. Metal Object B is especially similar to the flat, laminar trapezoidal gold-copper alloy pendants recovered from burial 57 in El Chorro de Maíta in Cuba (see Figure 20). The clearest difference is the two perforations on Metal Object B compared to the single perforations on the similar Cuban objects. Further research will have to investigate this apparent variance.

This discussion of the Cinnamon Bay metals centered around three themes: (1) origin; (2) manufacturing techniques; and (3) meaning and/or use. It focused primarily on the site level context while addressing a larger regional context in which the metal appears to have existed. The chemical data suggest both a local and non-local origin for the Cinnamon Bay metal objects, while the physical data produced evidence of manufacturing techniques similar to those found on indigenous laminar metal objects from Cuba. Finally, the contextual and ethnohistoric evidence correlate the metal object’s highly revered use as offerings within a dedicated space that primarily served this function for five centuries at Cinnamon Bay.

CHAPTER 9

CONCLUSION

This project was designed to provide new insight into the spatial, temporal and cultural context of the metal objects excavated from the shoreline indigenous site at Cinnamon Bay on St. John, USVI. This study provides datasets comparable to the ongoing chemical and physical study being conducted on indigenous Cuban metals by Marcos Martinón-Torres, Roberto Valcárcel Rojas and María Filomena Guerra. Even though the Cuban assemblage from the site of El Chorro de Maíta likely arrived in the Caribbean following Spanish arrival, the Cinnamon Bay metal objects have strikingly similar chemical and physical data to the Cuban metals suggesting similarities in their manufacture. This analytical data, combined with ethnohistoric and contextual site data, offer a deeper understanding into the Cinnamon Bay metal objects' origins, technology, and meaning.

The origins of the Cinnamon Bay metal objects were primarily investigated through the combination of their chemical and physical data. The presence of pure, unalloyed gold in Metal Object A at Cinnamon Bay confirms its use during indigenous occupations. Geological evidence suggest this unalloyed gold object was likely produced locally on St. John, or at least by groups living in the Greater Antilles. In addition, the chemical data suggested Metal Object B was produced artificially. Morphological ancillary data further suggest this gold-copper alloy was potentially imported from Colombia. Understanding the basic composition and local versus non-local nature of the metal objects provides a starting point to move towards a better understanding of the patterns of behavior that existed at the shoreline site of Cinnamon Bay.

It is clear that different manufacturing processes were used for the pure gold and gold-copper alloy objects. Both Cinnamon Bay metal objects have striking similarities with the metal assemblage recovered from the contact period site of El Chorro de Maíta in Cuba in terms of employed production techniques and overall morphology. These shared characteristics suggest the metal objects came from a similar source or that they are indicative of spatial and temporal continuity in metallurgical traditions in the region. This notion should be expanded upon during future Caribbean archaeometallurgical studies.

Contextual site level data suggests the two metal objects at the shoreline site of Cinnamon Bay are likely associated with patterns and behaviors consistent with ritual offerings in a dedicated space that lasted for almost five centuries (Wild, 1999:307). Confirming the presence of gold and gold-copper alloys in this context provides significant insight into metal use and their distribution throughout the Caribbean region. Given that the Cinnamon Bay objects may be of Colombian origin, and that the indigenous peoples in Colombia used gold and gold-copper alloys as dedicated offerings, it is reasonable to observe this same pattern in the Caribbean region. It is important to note that these objects were likely attached to or part of other material types. This project failed to properly identify their original association. However, ethnohistoric data combined with contextual data suggest Wild’s (2013) hypotheses about their function are strongly plausible, and their potential use as incrustations for wooden objects, pendants, or as decorative attachments to cotton textiles should be further investigated. This will help develop a more profound understanding of the meaning of ancient metal objects at Cinnamon Bay.

Future archaeometallurgical studies in the Caribbean need to prioritize and provide detailed contextual data that can help enrich our understanding of the symbolic use and meaning of this rare cultural resource. This tedious research process can produce site level data equipped to help identify actual patterns of behavior at the local level. Such well-formulated observations can help reveal interaction between groups of people among sites and overseas. Investing in this groundwork is paramount in reconstructing a better understanding of ancient lifeways in the Caribbean.

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APPENDIX A

RESULTS OF REFERENCE MATERIAL ANALYSES BY THE FIELD MUSEUM'S pXRF

Consensus Values for Industrial Alloys Manufactured by le Comptoir Lyon-Alemand, Louyot et Cie (see Beck, 1991)

	et3 (wt%)	et6 (wt%)	et7 (wt%)
Cu (Copper)	18.9	3.8	0.0126
Ag (Silver)	6.0	3.9	0.32
Au (Gold)	75.0	92.3	99.61

Results of Field Museum's pXRF for sample et3 (see Beck, 1991)

et3	Cu (wt%)	Percent Difference (Accuracy)	Ag (wt%)	Percent Difference (Accuracy)	Au (wt%)	Percent Difference (Accuracy)
Run 1	17.07	10.18	8.86	38.49	71.24	5.14
Run 2	16.58	13.08	9.05	40.53	72.81	2.96
Run 3	16.64	12.72	8.94	39.36	72.99	2.72
RSD (Precision)	1.59	-------------	1.07	-------------	1.33	-------------

Results of Field Museum's pXRF for sample et6 (see Beck, 1991)

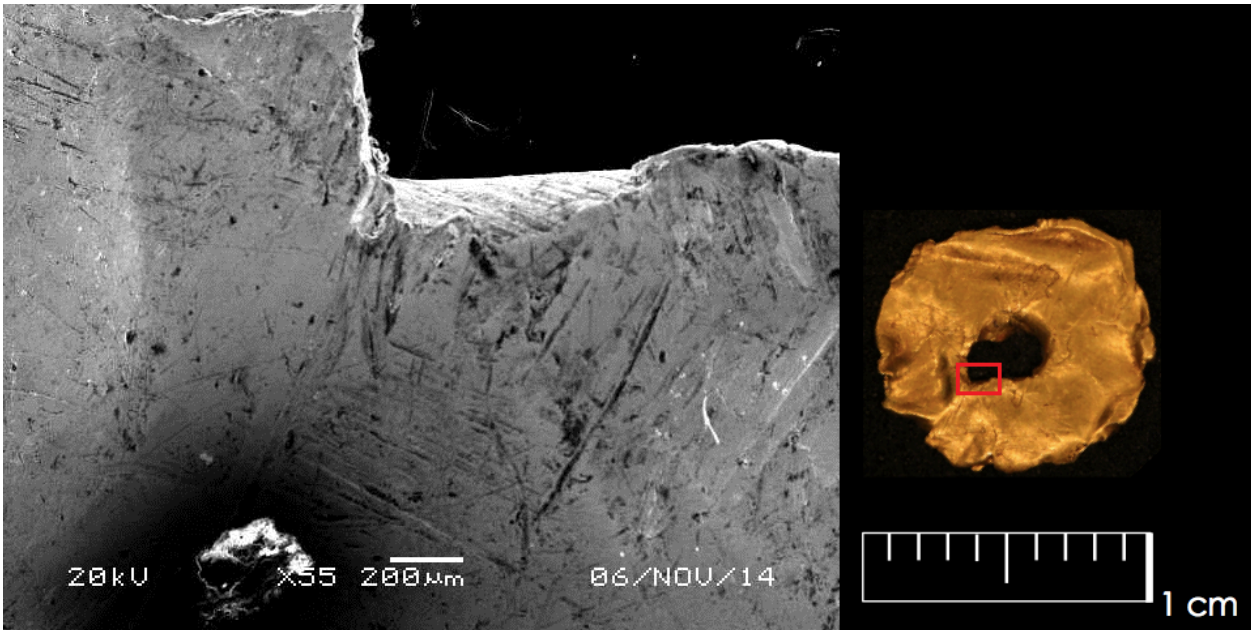
et6	Cu (wt%)	Percent Difference (Accuracy)	Ag (wt%)	Percent Difference (Accuracy)	Au (wt%)	Percent Difference (Accuracy)
Run 1	4.65	20.12	6.02	42.74	89.05	3.58
Run 2	4.78	22.84	5.79	39.01	88.72	3.96
Run 3	4.79	23.05	5.83	40.49	88.95	3.70
RSD (Precision)	1.65	-------------	2.09	-------------	0.19	-------------

Results of Field Museum's pXRF for sample et7 (see Beck, 1991)
ND is an abbreviation for "Not Detected" and means the results fell below detection limits for this instrument

et7	Cu (wt%)	Percent Difference (Accuracy)	Ag (wt%)	Percent Difference (Accuracy)	Au (wt%)	Percent Difference (Accuracy)
Run 1	1.09	195.43	ND	200	98.02	1.61
Run 2	1.08	195.39	ND	200	98.54	1.08
Run 3	1.15	195.67	ND	200	98.85	0.77
Run 4	1.11	195.51	ND	200	98.89	0.73
RSD (Precision)	2.80	-------------	Not Available	-------------	0.41	-------------

APPENDIX B

ADDITIONAL SEM IMAGES FOR METAL OBJECT A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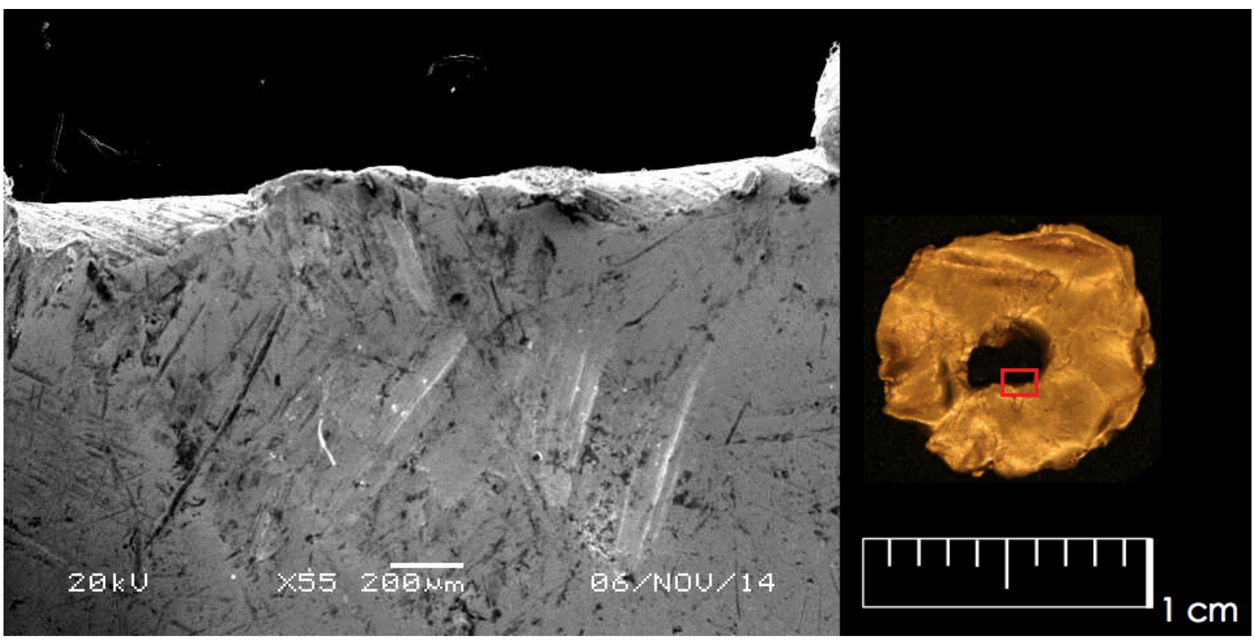
06/NOV/14
1 cm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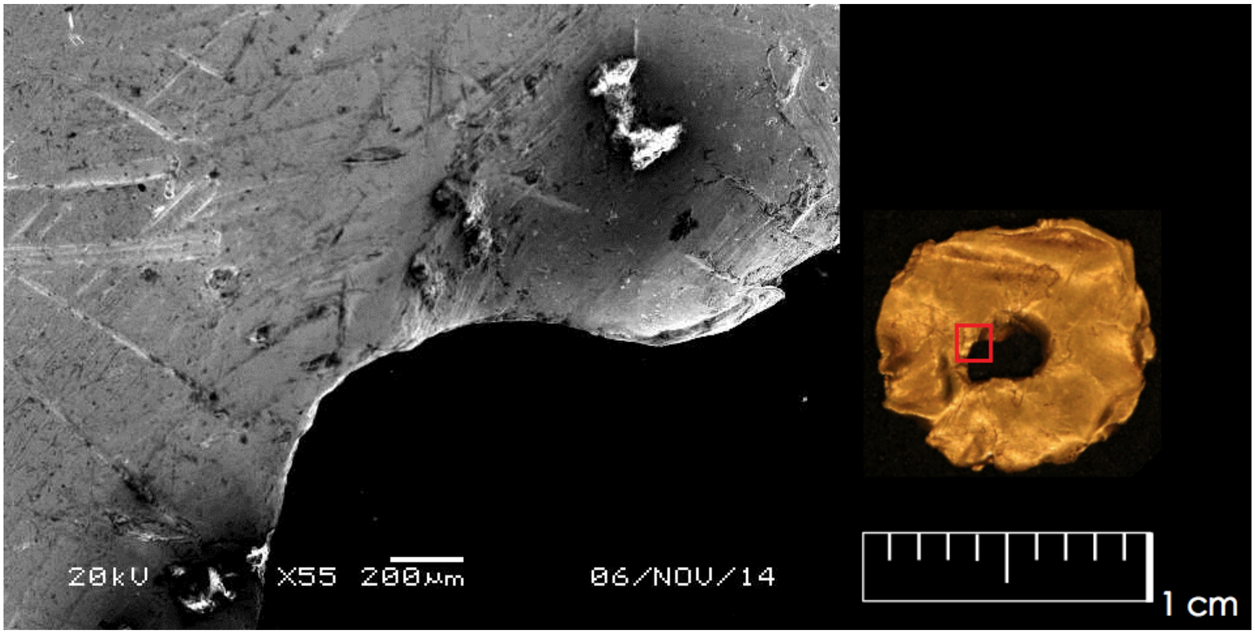
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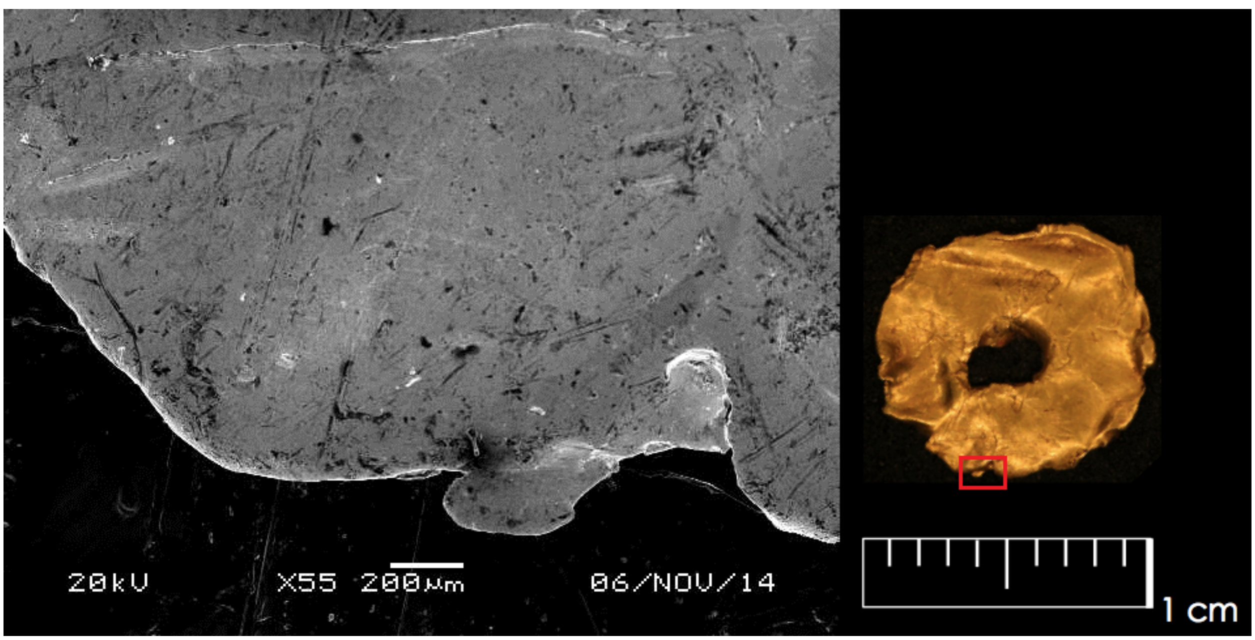
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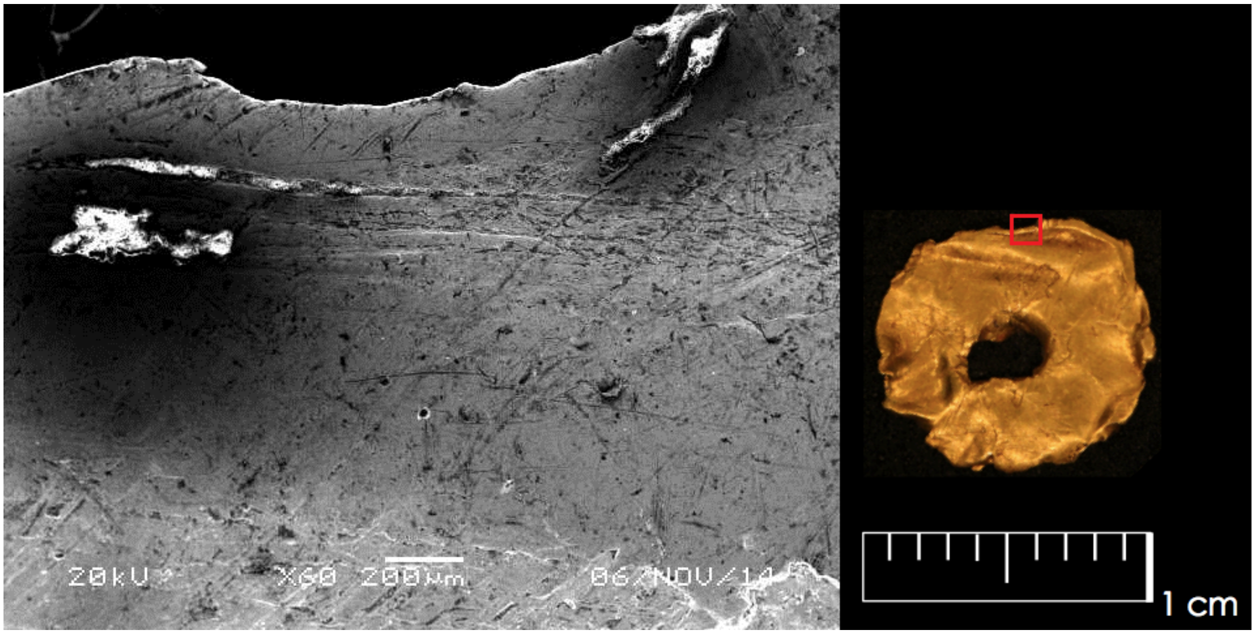
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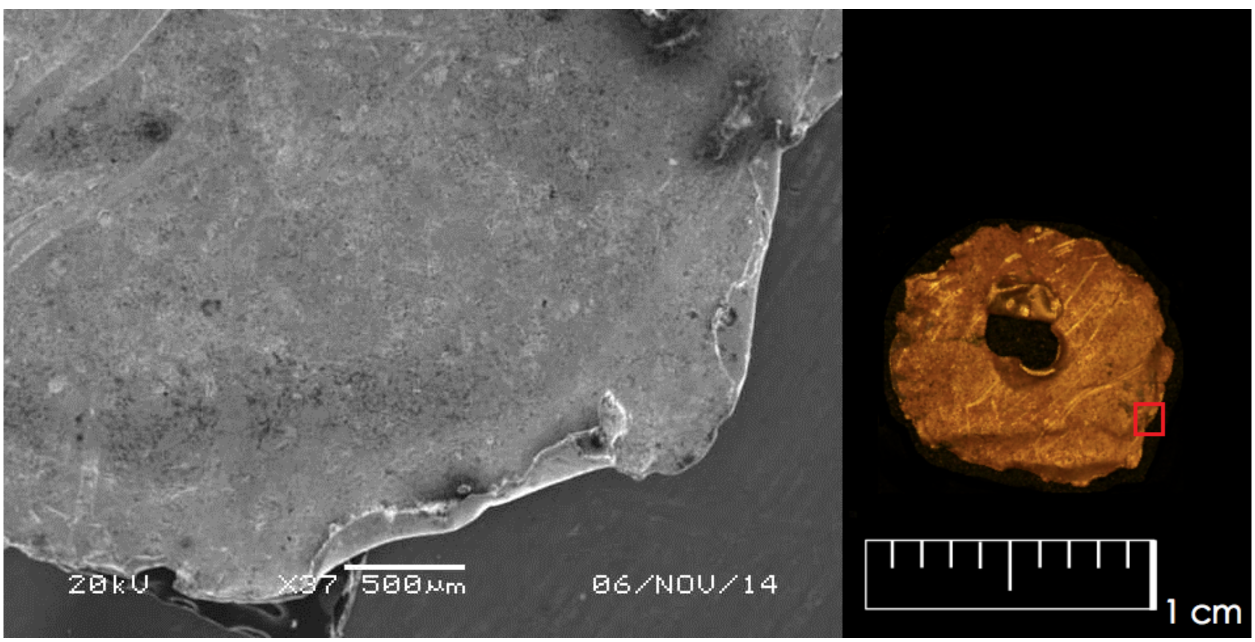
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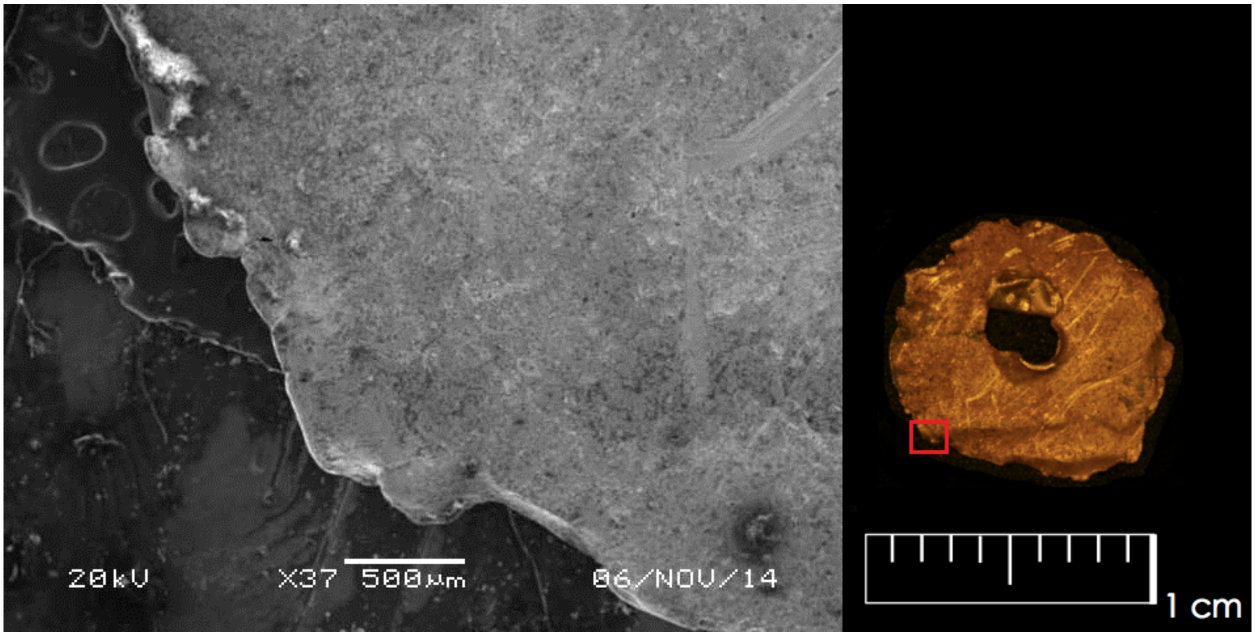
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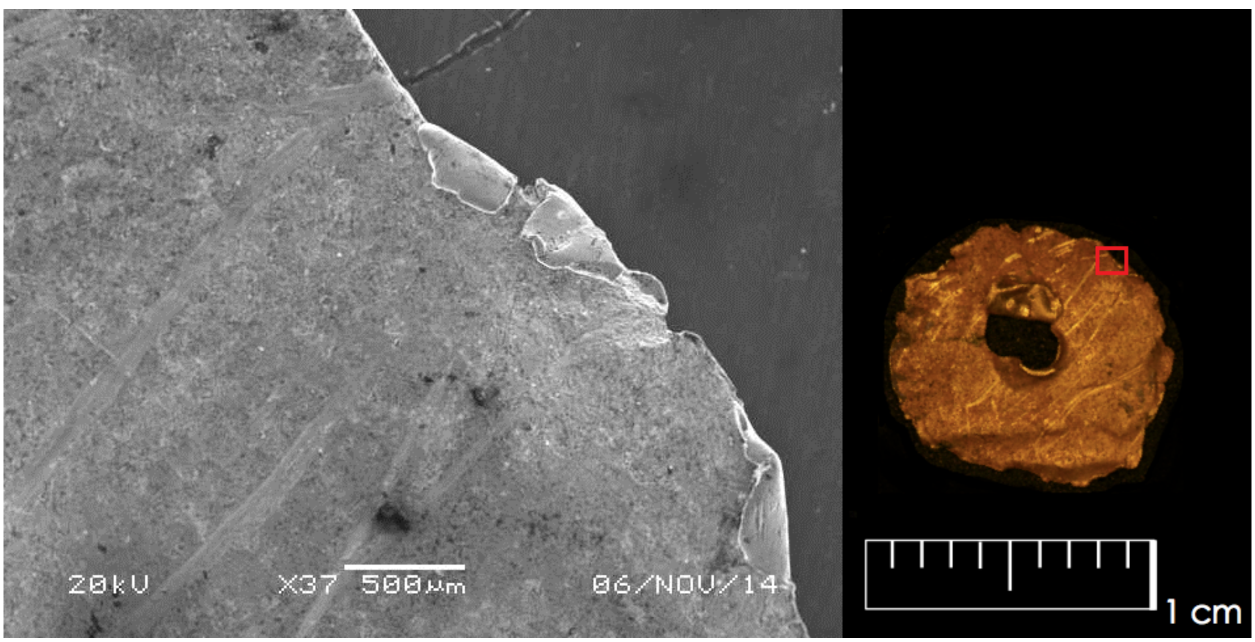
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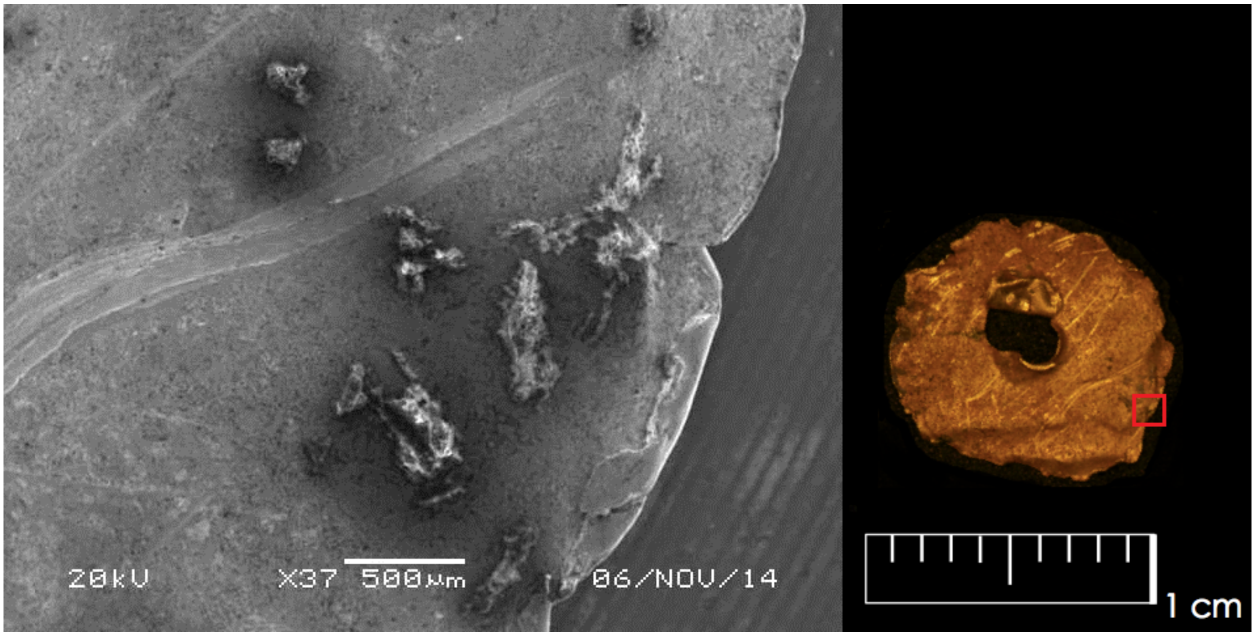
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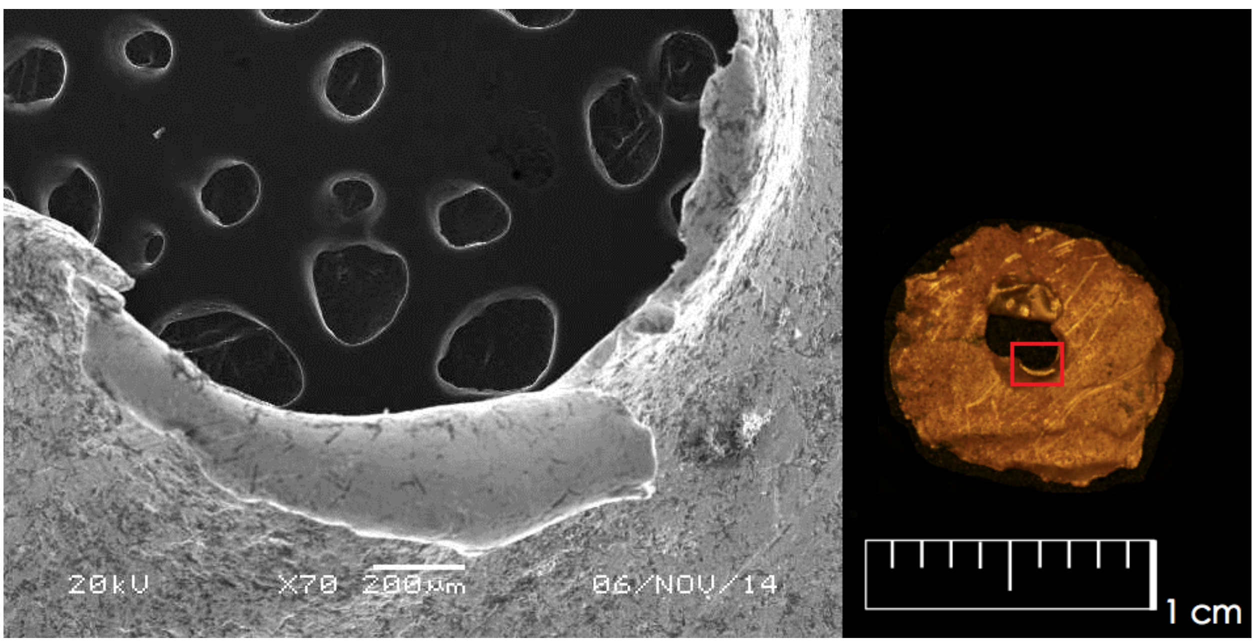
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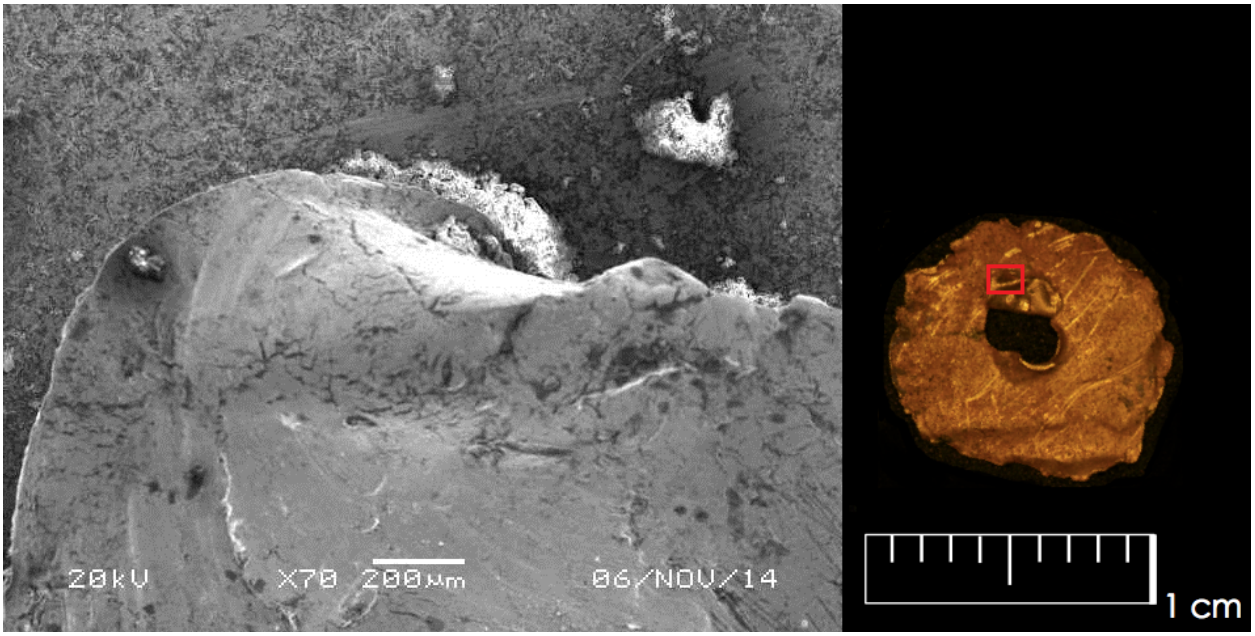

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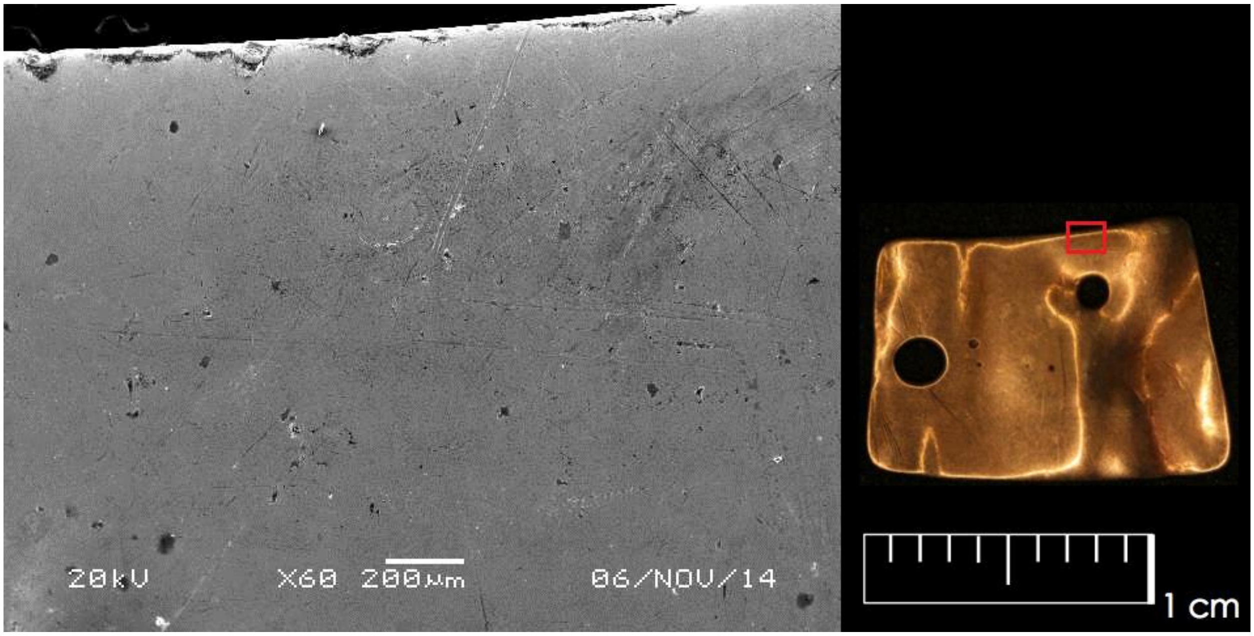
APPENDIX C

ADDITIONAL SEM IMAGES FOR METAL OBJECT B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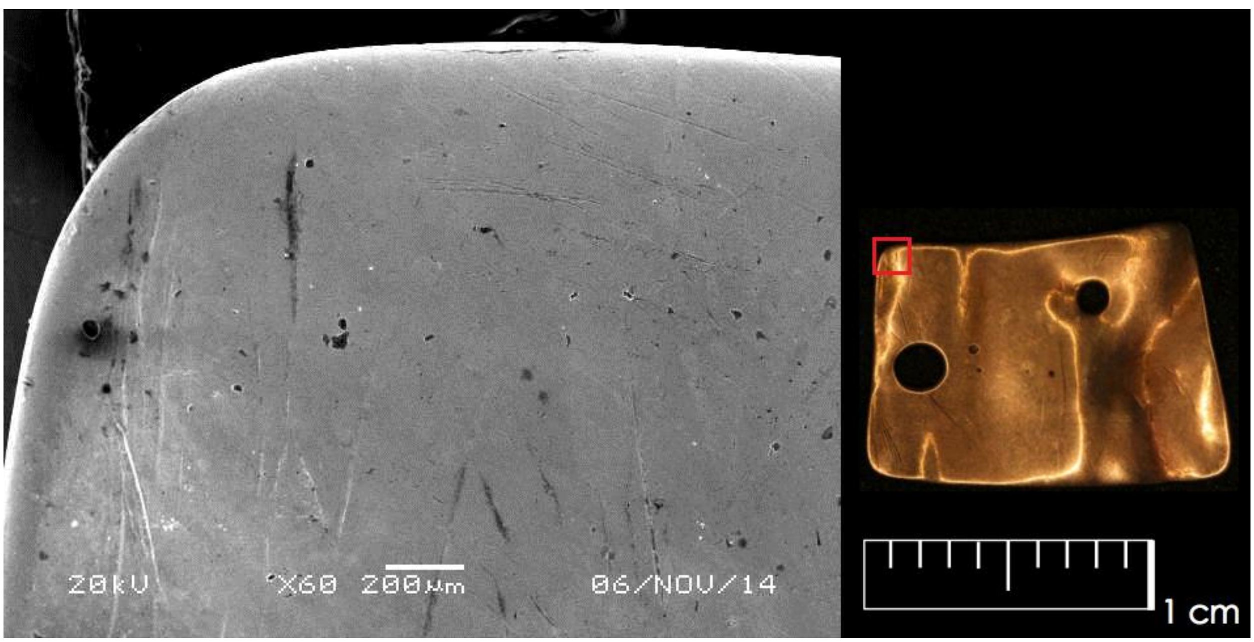
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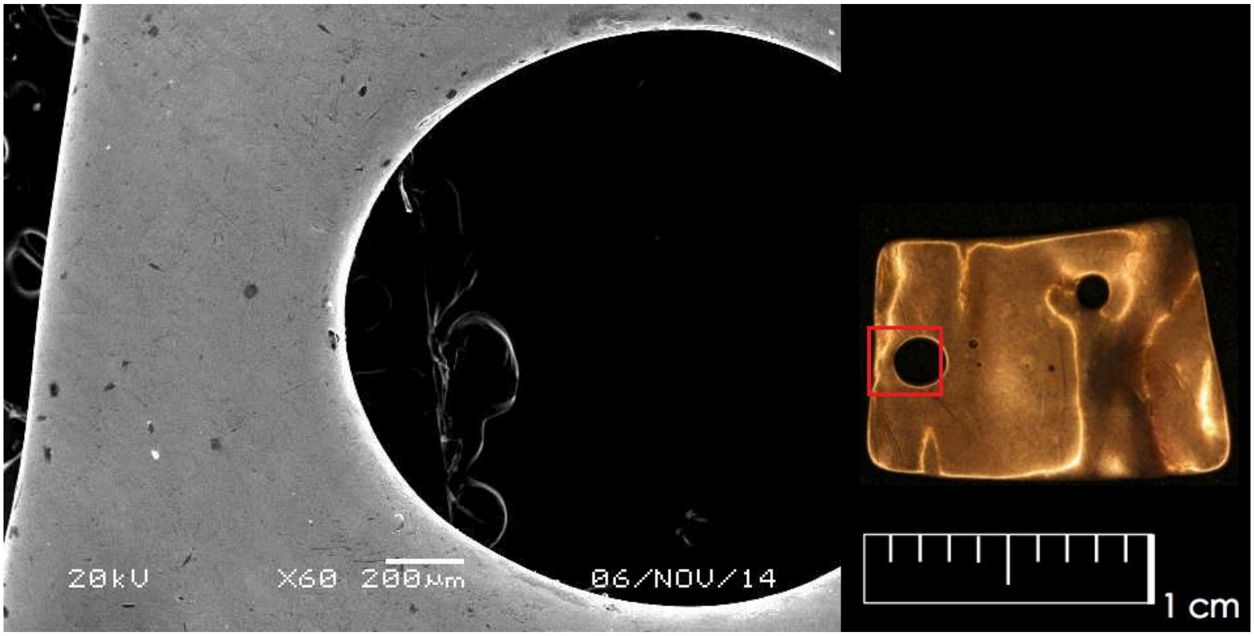
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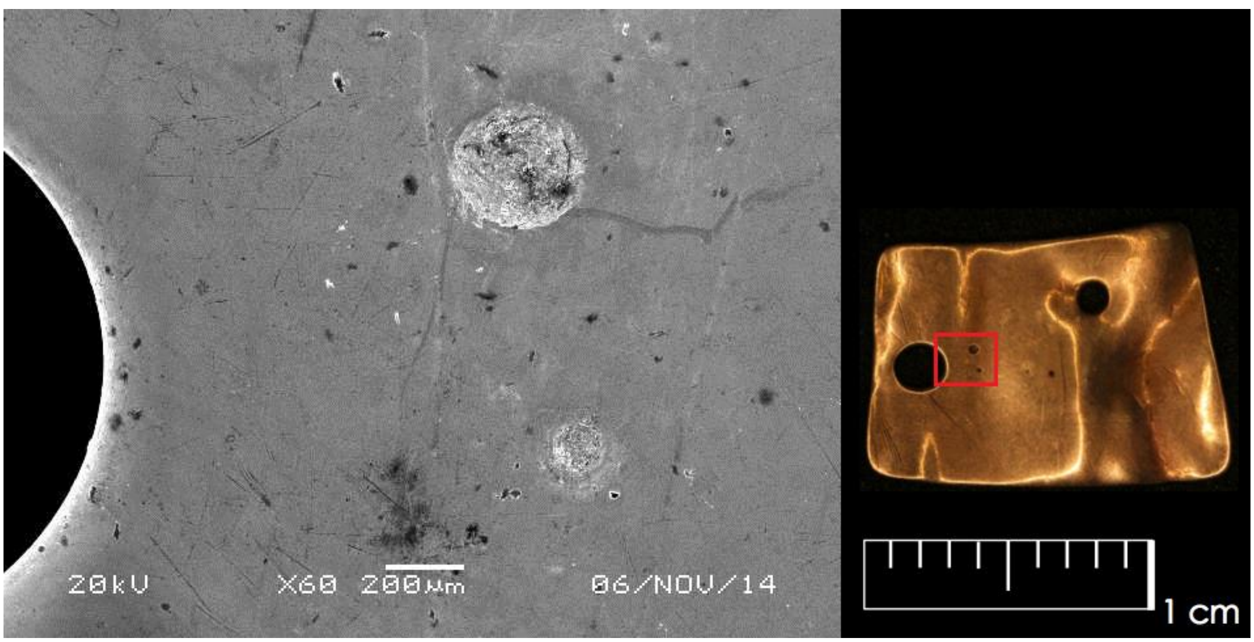
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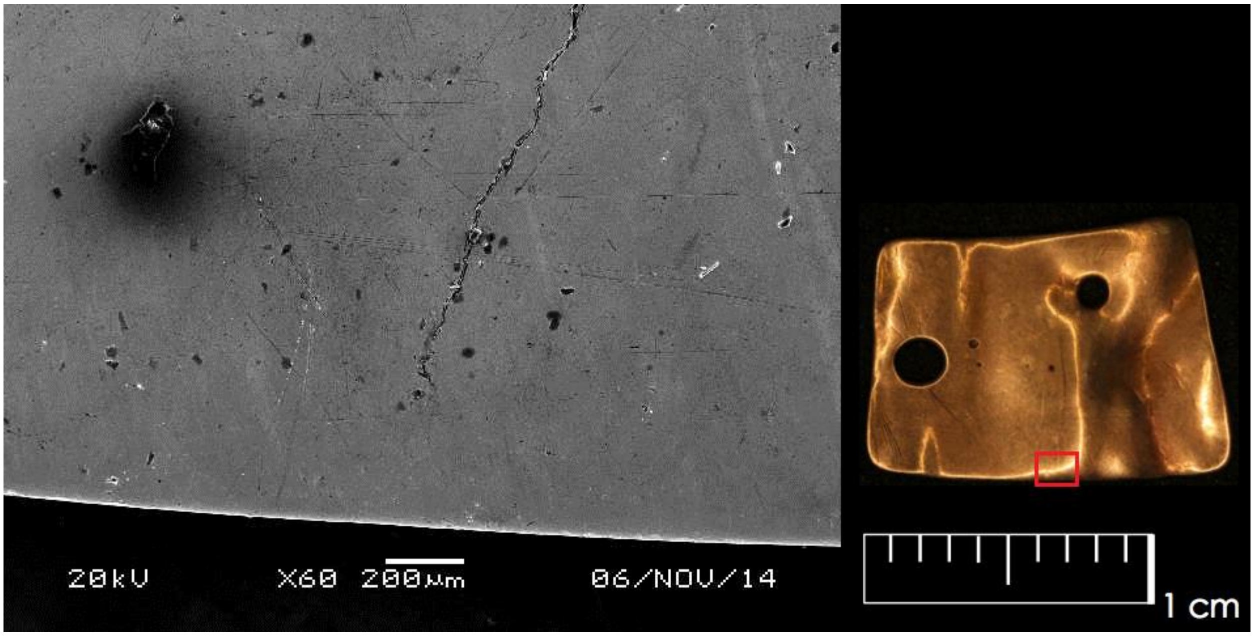
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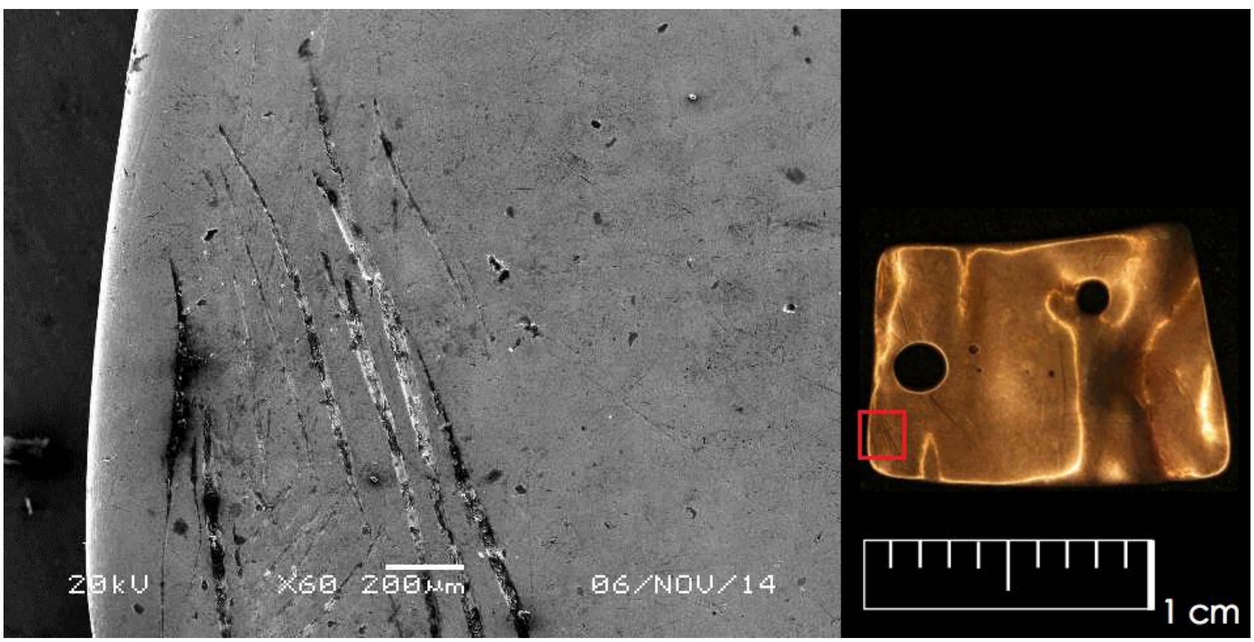
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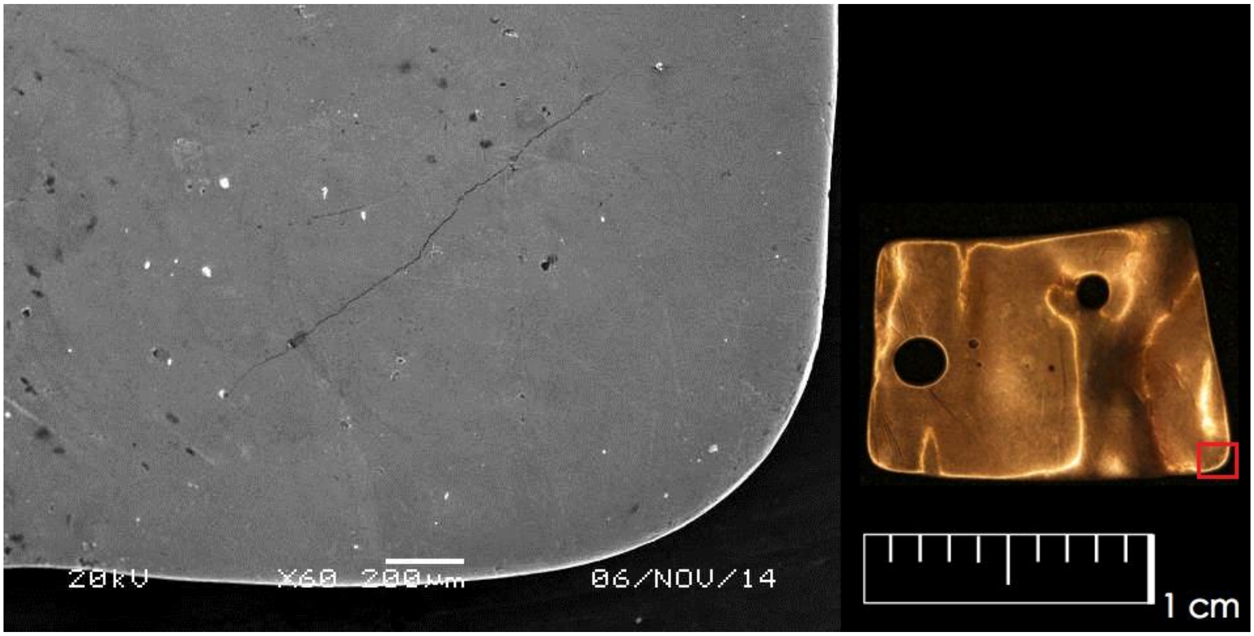
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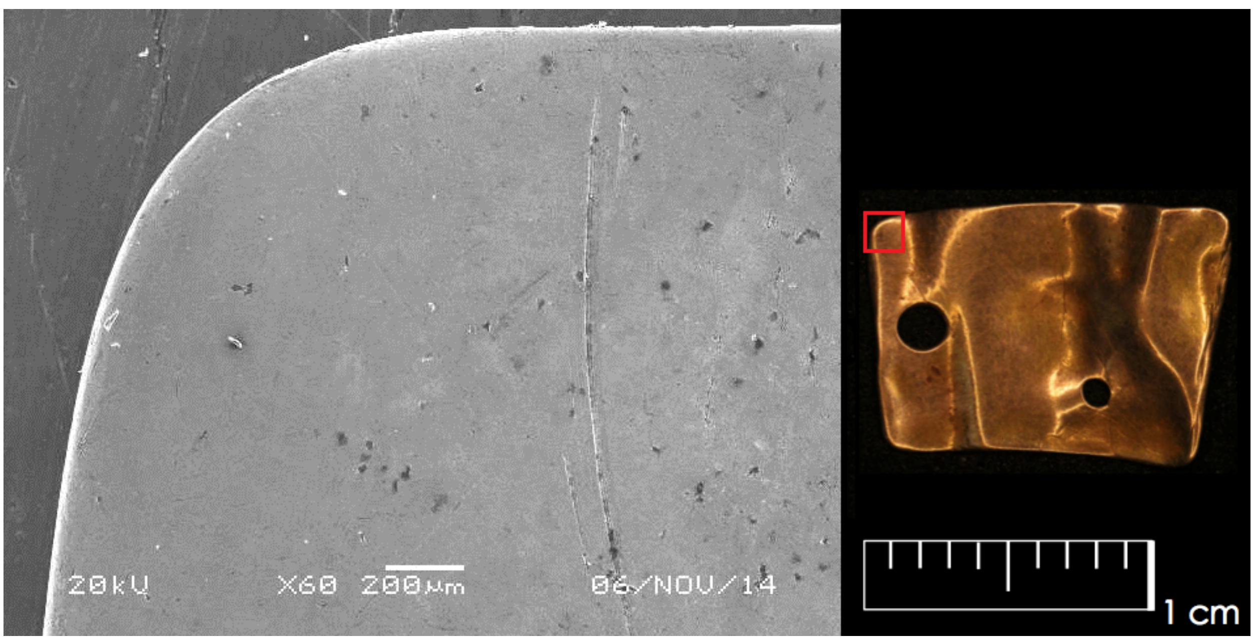
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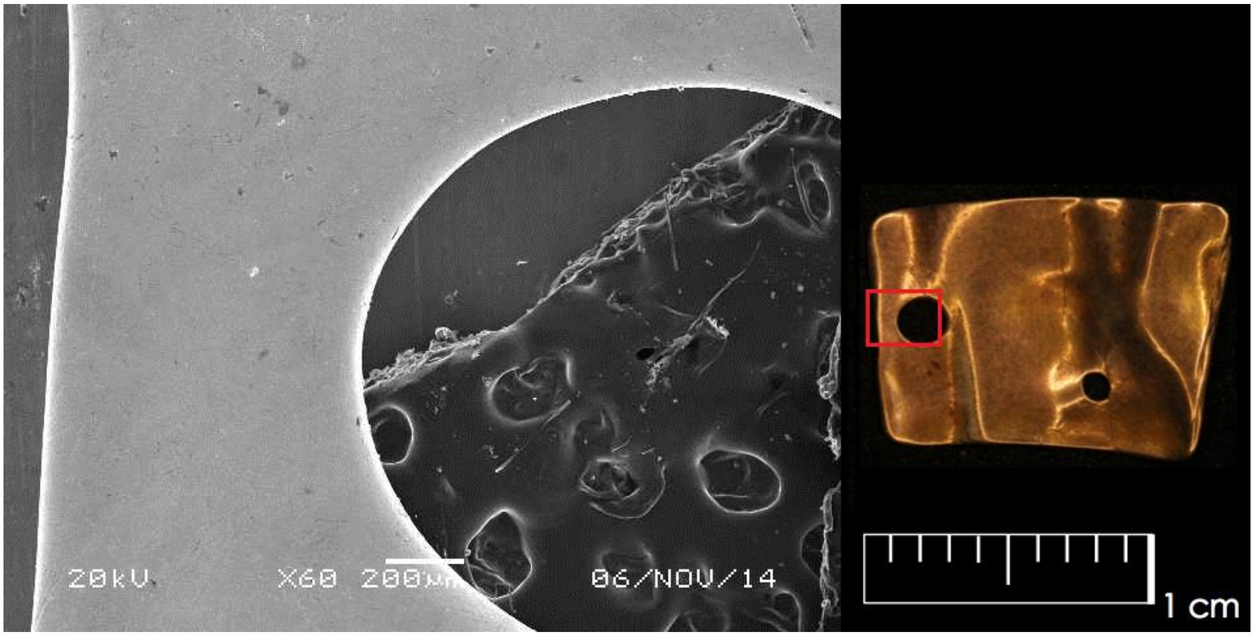
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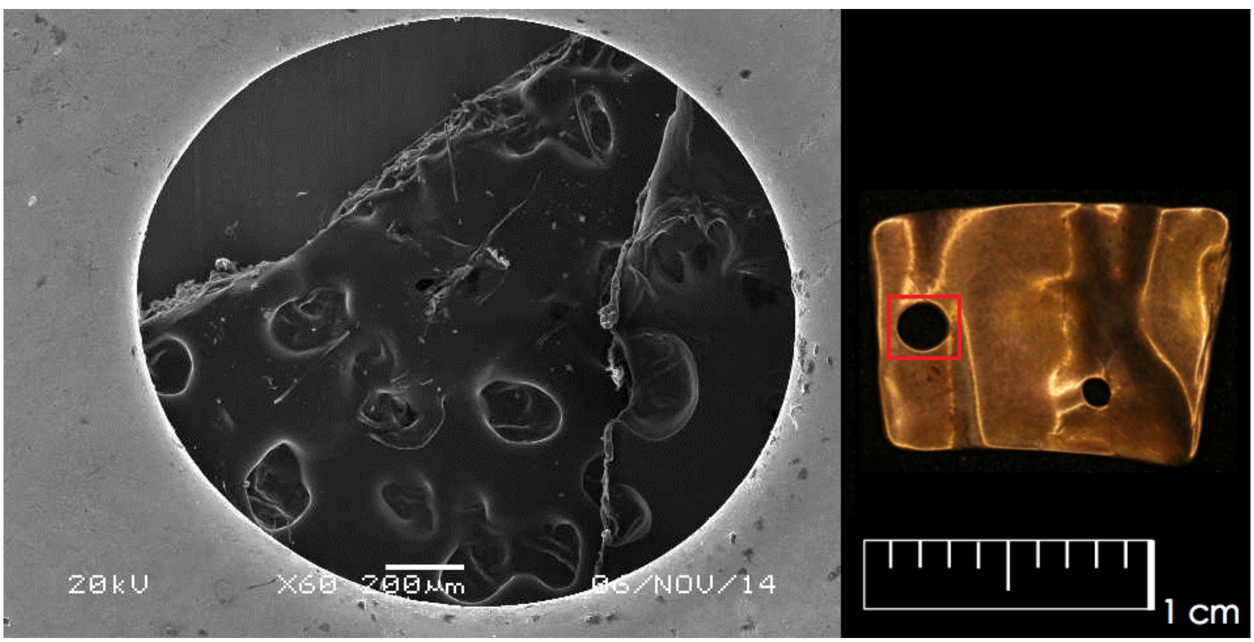
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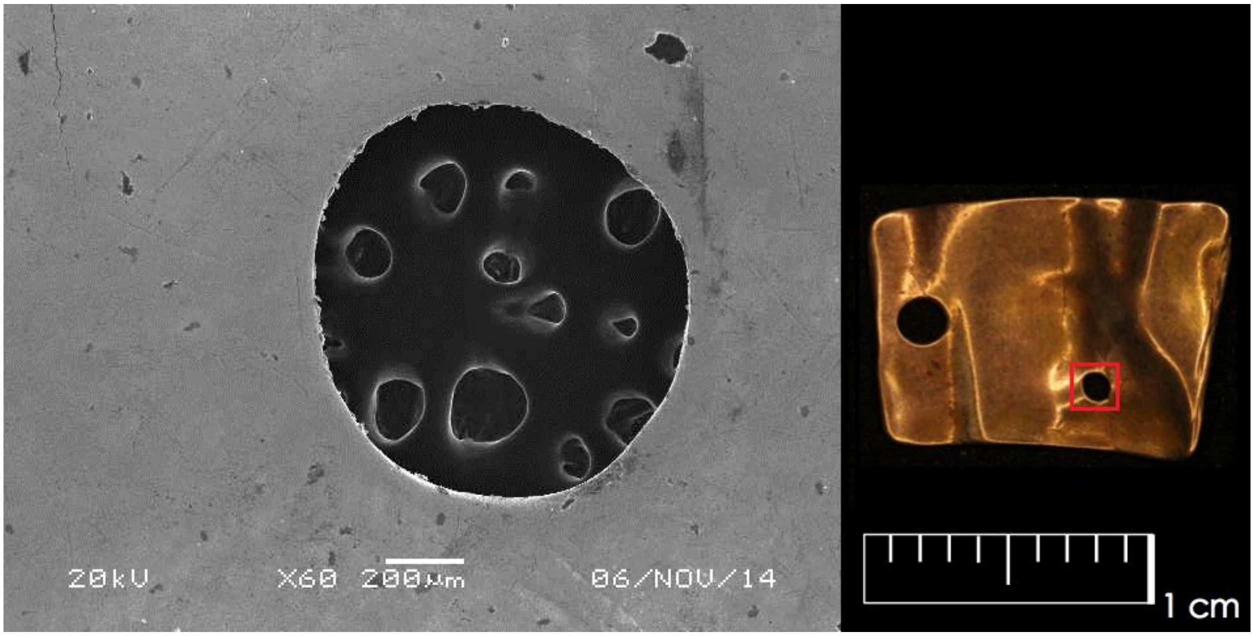
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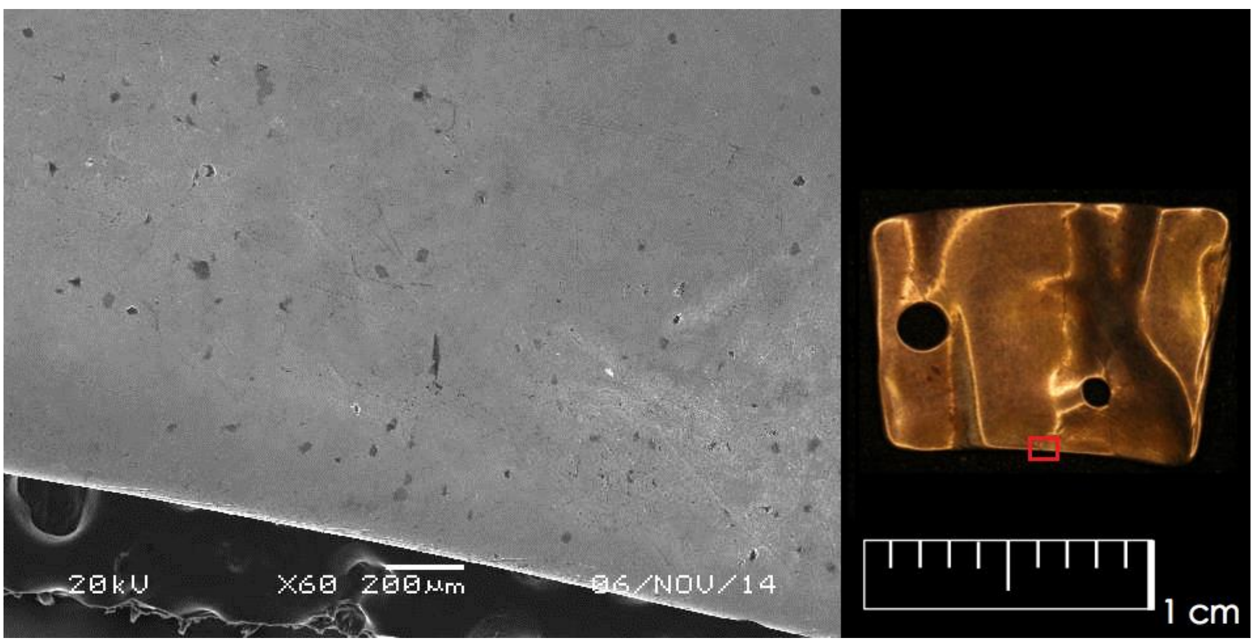
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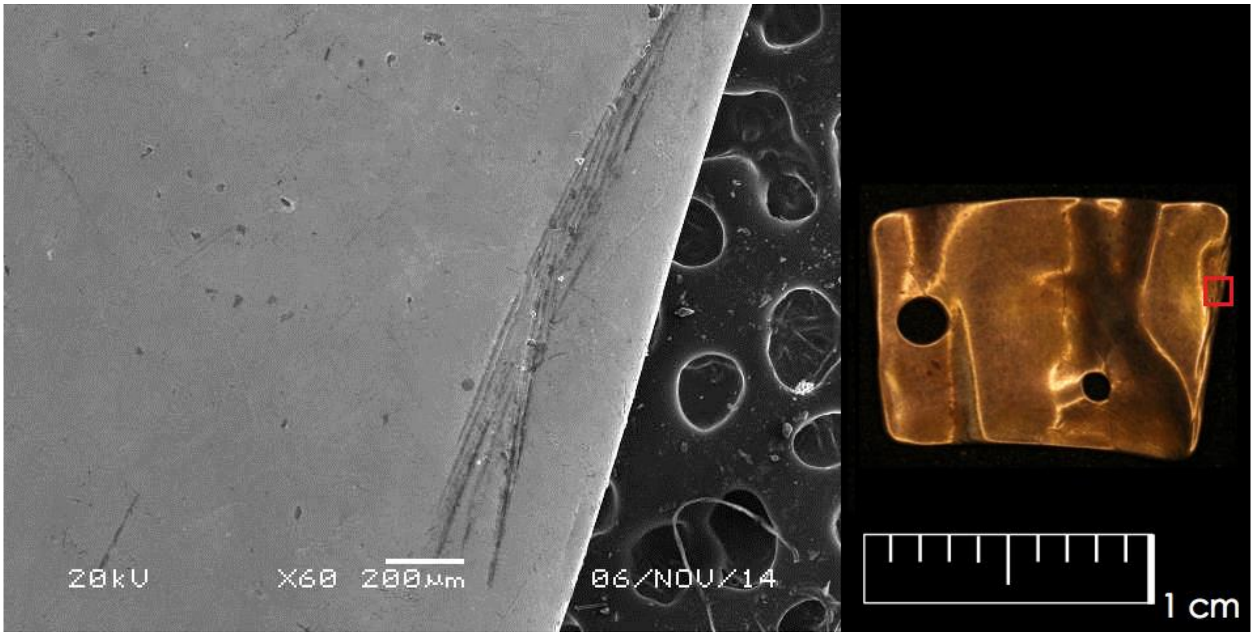
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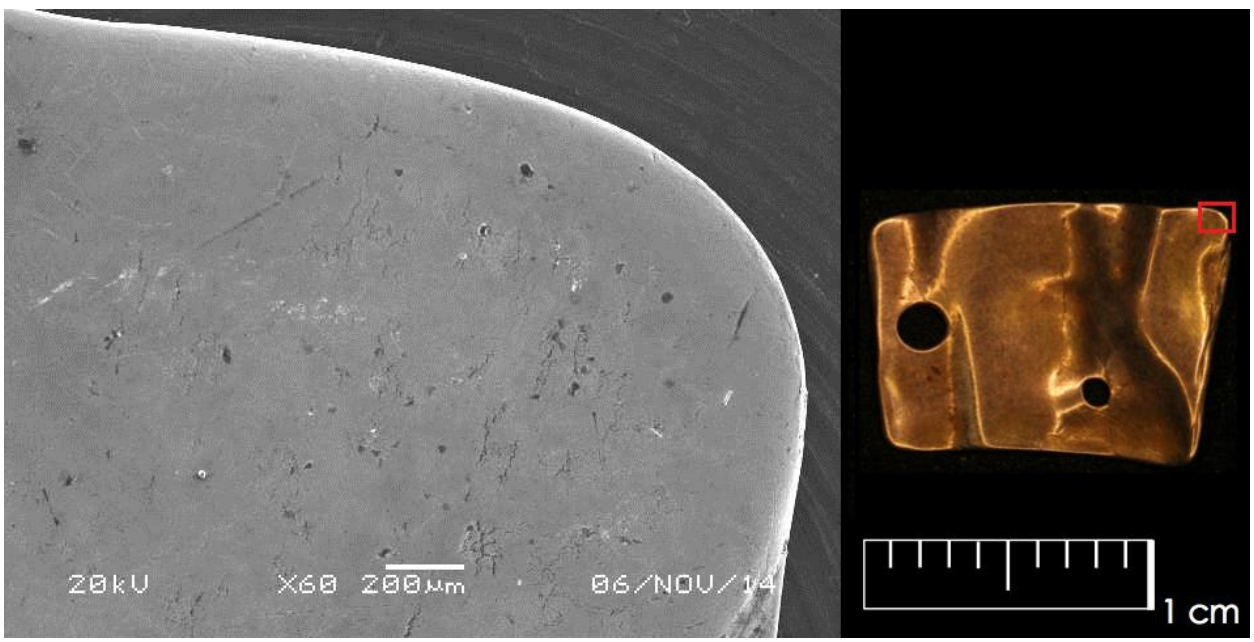
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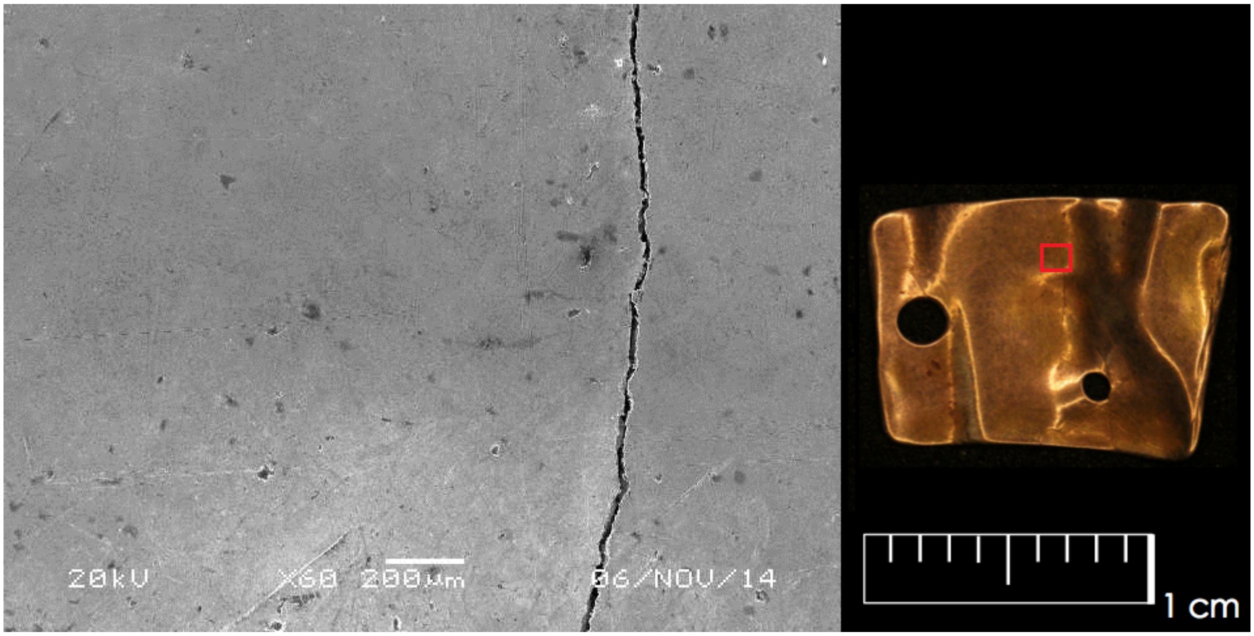
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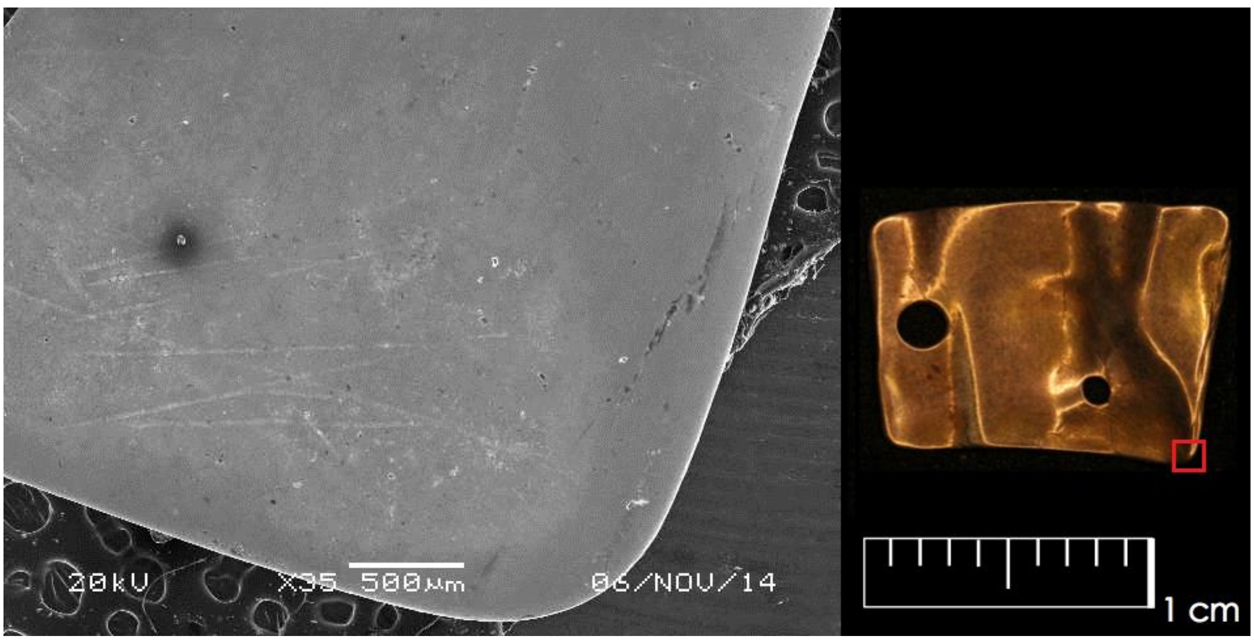
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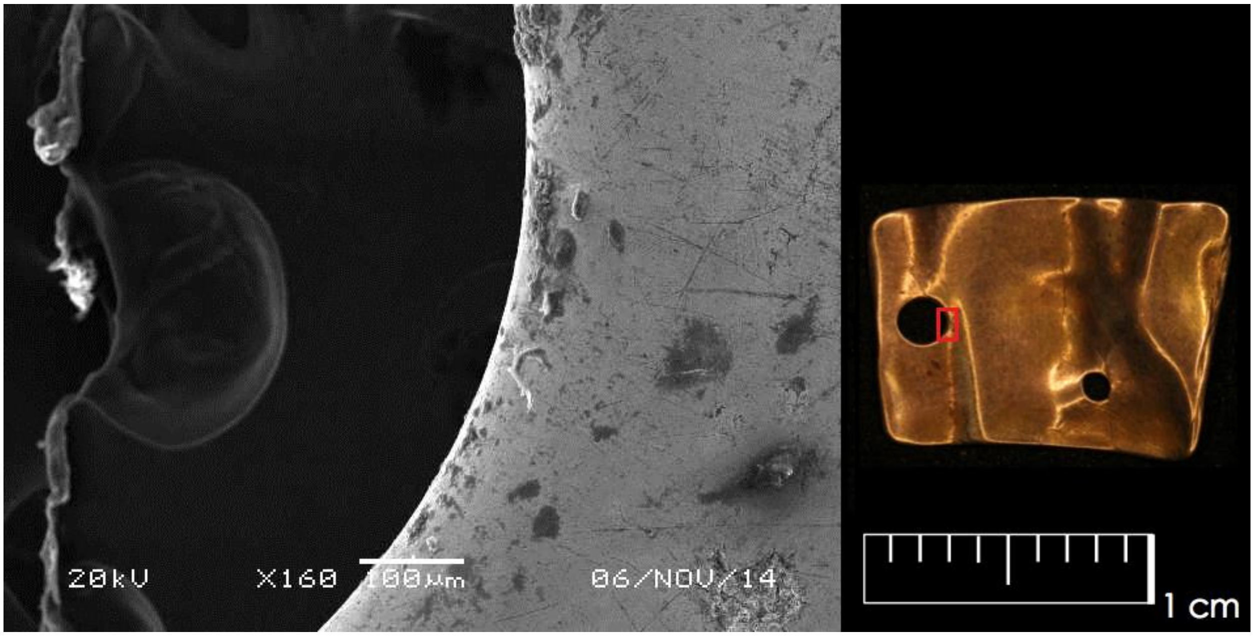
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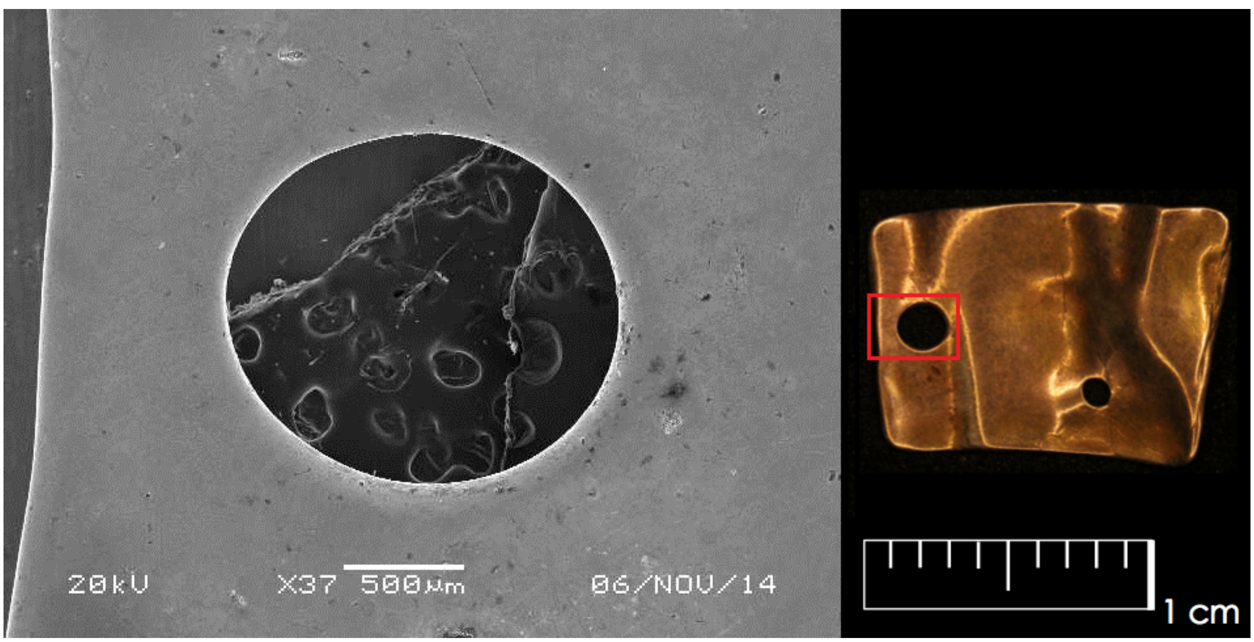
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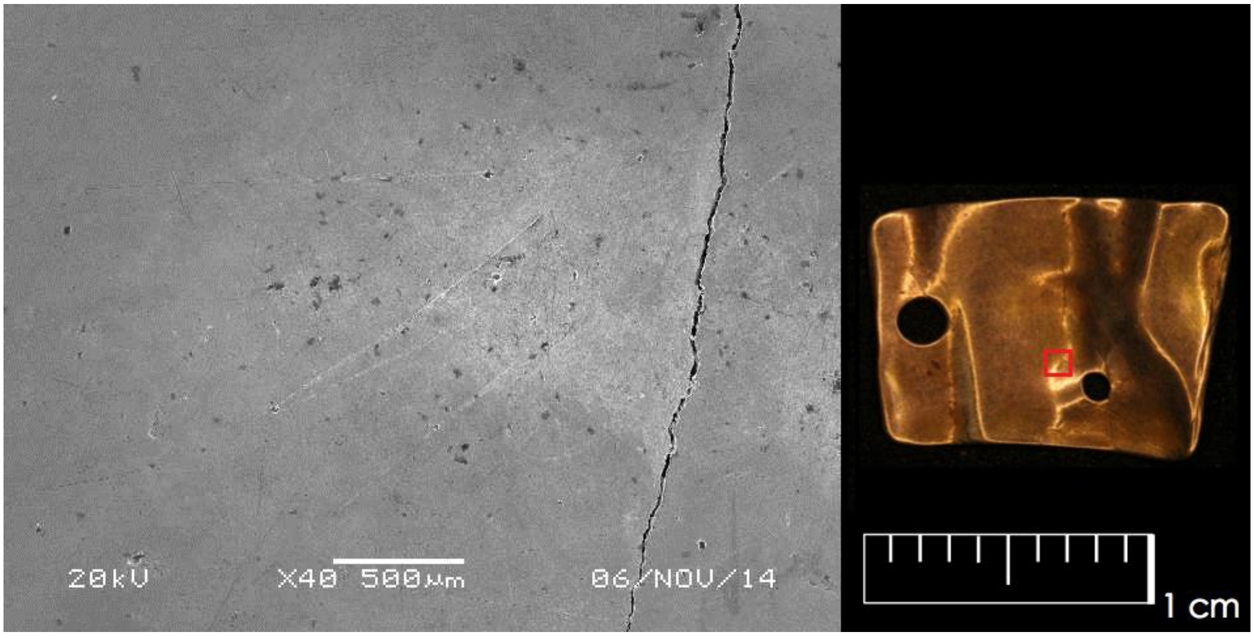
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