

INITIAL pXRF ANALYSIS OF CHINESE CERAMICS FROM SPANISH SHIPWRECKS ON THE PACIFIC COAST

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Spanish Galleons sailed between Mexico and the Philippines for more than two centuries beginning with the first successful round trip in 1565. The voyage was demanding, often extending to several months. At least three ships were lost on the Pacific coast. Along with spices and fabrics, cargo included Chinese ceramics. Archaeologically recovered porcelains and stoneware from three wreck sites and an abandoned cargo from a fourth vessel were tested using portable X-ray fluorescence (pXRF) to determine whether trace element spectra could provide a means of distinguishing the different collections. The ceramics date from the late sixteenth to early seventeenth centuries. Preliminary analysis suggests subtle differences in the composition of glazes, and similarities between two of the collections; however, a definitive answer has not yet emerged.

Recent probing using portable XRF trace elemental analysis has been conducted with porcelains and stoneware specimens from the assemblages of four historic cargos archaeologically recovered from sites spanning 1,500 mi. of the Pacific coast. All specimens were examined at San Jose State University's Integrative Anthropology Laboratory or at the curation facility at Pt. Reyes National Park Headquarters.

The Pacific coast can be a treacherous place into which for sailing ships to venture. Strong near-shore currents, storms, and fog-enshrouded, rocky, and unforgiving shorelines with only sporadically distributed harbors made the coast a worrisome place for navigators. Efforts to locate safe anchorages began with Juan Cabrillo's voyages in 1539-1543, with minimal success. Nonetheless, by 1565 Spanish merchant adventurers initiated one of the greatest long-distance trade routes of the modern world, sailing from Mexico across the Pacific to the Philippines, to trade with Chinese merchants in such commodities as wax, spice, textiles, and ceramics (Legarda 2001; Schurz 1939). However, a suitable Pacific coast harbor remained elusive, forcing vessels to travel from Manila in the Philippines to Acapulco, Mexico, without landfall. The difficult voyage brought ships at high latitudes (occasionally as far north as Washington state) with favorable currents to within 200 mi. or less off the coast. From this point, ships headed south, sailing with favorable wind and current to Acapulco (Aker 1965; Schurz 1939). The round trip often required two years or longer, depending on multiple factors. The Pacific crossing alone could take months. Despite the hardships, this transpacific trade continued unabated until the nineteenth century, with significant repercussions for California's early colonial development, including brief but consequential episodes of contact between European and native peoples prior to the mission era (Russell 2007:58).

At least three sixteenth-century vessels of European origin are known to have wrecked or deposited cargo on the Pacific coast, along with another vessel dating from the seventeenth century. Of these, one is known with certainty to have been the *San Agustín*, commanded by Rodríguez Cermeño, which was wrecked in 1595 at Pt. Reyes, just north of San Francisco (Cutter 1969:31, 37). Ceramics associated with this vessel have been found washed ashore and in archaeological contexts in coastal and inland middens (Heizer 1941).

Francis Drake's vessel, the *Golden Hind*, was not wrecked, but it was careened in the vicinity of what is known today as Drake's Bay, 25 mi. north of San Francisco. During this careening episode, Drake (who would later be knighted) abandoned a considerable portion of the cargo acquired from Spanish ships during his privateering venture, including Chinese export porcelains. Some of the ceramics lost by the *San Agustín* or jettisoned by Drake found their way into the possession of indigenous groups, such as the Coast Miwok and possibly Pomo, and were re-purposed in a variety of ways, not limited to ornaments.

Some were traded inland with other indigenous groups along traditional trade networks, perhaps impacting social and status-based relations within or between groups (Russell 2007:59).

Controversy has surrounded the Drake/Cermeño porcelains for a considerable time, as these ceramics have been found in close association, and sorting the porcelains is a refined yet subjective process. These two cargos were separated in time by a mere 20 years; however, a number of distinguishing characteristics are apparent, although not incontrovertible. Ceramics from the wrecked *San Agustín* and the cargo of Francis Drake are to some degree archaeologically commingled and separated through stylistic assessments. The purpose of the current study was to determine whether an independent means of distinguishing porcelain specimens could be applied. Finding a means of segregating one from the other is only one of many potential benefits of the XRF testing.

Two other ships included in this study are the so-called “Wax Wreck” in Nehalem, Oregon, and a ship lost in Baja California tentatively identified through archaeological and archival evidence as the *San Felipe*, lost around 1576. The porcelain and stoneware from the *San Felipe* site were systematically recovered over several years by a team of Mexican and American archaeologists. The assemblage associated with the Baja California wreck site, if in fact it is from the *San Felipe*, is contemporary with the material associated with Drake. If these two collections have similarities in elemental constituents and concentrations, they might offer a means of isolating assemblages independent of approaches based on more subjective stylistic considerations. Combining these samples with material from a later assemblage, that is, the ceramics from the “Wax Wreck,” would establish three benchmarks against which future comparisons could be made. All of these vessels were Spanish galleons of the Manila trade. From two possible candidates, researchers have tentatively identified the “Wax Wreck” on the basis of mean dates for porcelains as the *Santo Cristo de Burgos* of 1693 (Lally 2008:2). The porcelains are described as Kraak ceramics, strictly for the export trade. Drake’s cargo of porcelain would have come from Manila ships.

THE CERAMICS

Porcelains considered part of the Drake cargo and Cermeño porcelains were separated based on stylistic determinations as well as wear patterns by the late Clarence Shangraw of San Francisco’s Asian Art Museum and by Edward Von der Porten (Shangraw and Von der Porten 1981; Von der Porten 1972). The Cermeño or *San Agustín* collection and the Drake collection are both curated by the National Park Service. In general, the collections are divided by evidence of water wear, design variation, and type. The *San Felipe* material tested for this study was on loan from Mexico’s National Institute of Anthropology and History (INAH), and the material from Oregon was also on a special loan.

The *San Felipe* porcelains all have sharp breaks and minimal abrasion, and lack any indication of wear consistent with long exposure to water or tumbling. The specimens represent a wide range of types. The Pt. Reyes collection consists of porcelains and stoneware that are conjectured to have come from two historic episodes and two different cargoes. Among other criteria, the porcelains were divided by the evidence of specific wear patterns. Water-worn materials and those with a provenience of the beach have been classified as *San Agustín*, while specimens found in middens and elsewhere ashore, without water and sand abrasion, have been classified as Drake’s cargo (Shangraw and Von der Porten 1981).

At the core of this argument is that Drake abandoned his cargo ashore and that it made its way into the possession of local bands of Miwok without being subjected to damaging effects of surf and sand. In contrast, it is suggested that the porcelains coming from the *San Agustín* wreck, which would have been stowed below decks in crates, only came to the surface and into local hands after considerable movement through surf and over a much longer period of time, as the wreck broke up. Indeed, pieces come ashore even today following seasonal storms. One aspect of this wear is that the glazes are heavily scrubbed.

METHODOLOGY

Testing of the ceramics was carried out using a Bruker Tracer SD handheld XRF instrument to generate energy-dispersive spectra, which were then used to create comparative charts for the constituent elements from each artifact, displaying particular presence/absence and relative ratios of detected elements. Calibration was conducted by Bruker Lab. The instrument was connected directly to a laptop computer on which spectra were displayed during bench-top testing using Bruker software. What resulted were signature spectra. None of the ceramics were cleaned or treated in any way. The Bruker system is one of several instruments increasingly being used for archaeological applications.

A few words are necessary about methodology and limitations of the technique. Only a very small area of the ceramic can be tested. Furthermore, deviation from a flat surface can cause backscatter or can limit penetration of the emitted beam. Every effort was made to use only surfaces of the ceramic that could completely cover the aperture of the device, and this naturally limited what parts of a sherd could be examined. Both raw body matrix and surfaces were tested for each sample whenever feasible, including glazed and unglazed surfaces, in addition to interior and exterior surfaces. Curved surfaces are problematic, as they do not fully cover the “eye” of the XRF instrument, which may give false readings; therefore testing was limited to those samples or areas of a given specimen that had flat surfaces.

Two other limitations of this study were the small number of specimens tested and the lack of a reference collection: 20 specimens for Baja California, 27 for Pt. Reyes combined, and 16 from Oregon. It is highly likely that even if types can be sorted on the basis of elemental constituents, it may not be possible to eliminate the possibility that a single cargo may contain all types.

Studies of the sort discussed here are not new. Energy-dispersive X-ray fluorescence has been used effectively with Blue-and-White Chinese porcelains dating from the Yuan and Ming dynasties for collections in Beijing’s Palace Museum. Researchers at the City University of Hong Kong found that it was possible to distinguish unique characteristics through discriminant elemental analysis, enabling the determination of origin and historic period; chemical composition permitted discrimination of porcelains that visually appeared to be of one period yet were more consistent with an earlier period (Yu and Miao 1997). Characteristics of the chemicals used in distinctive blue pigments, in particular the cobalt blue, were shown by other researchers to be accurate indicators of provenance for manufacture (Wen et al. 2006).

The consistent identification of types, for instance “phoenix plates,” facilitated strong controls. Phoenix plates from the *San Felipe* and items labeled as Drake samples were nearly identical in design and spectra, while phoenix plates conjectured to be artifacts from the *San Agustín* were at variance along several indices. However, at least two samples were difficult to segregate by this method. The Drake materials and those of the contemporary *San Felipe* are comparable in elemental components and concentrations, which is what one would expect, considering the contemporaneous nature of the samples.

Specimens from Agate Beach in Bolinas, California, were also tested for comparison. These few items were taken from the private collection of a proponent of the Francis Drake in Bolinas hypothesis. Bolinas is only 5 mi. south of Pt. Reyes. Mr. Epperson (now deceased) was a passionate amateur Drake scholar and beachcomber. The Epperson collection, on loan from the Epperson family, consists of numerous items of maritime origin lacking any specific provenance, but among them are a few heavily worn porcelains. Three pieces in particular caught our attention in terms of blue-on-white designs reminiscent of the material housed at Pt. Reyes. The glazes were almost entirely worn away, so it is with caution that these pieces are compared; yet the designs were discernible. These pieces indeed yielded spectra consistent with *San Agustín* material, strongly suggesting trade in materials along established coastal routes, a significant finding in itself. It is important to note that these pieces did not present a new or radically divergent spectrum. Modern control samples of imported wares from Chinatown and some Japanese wares were also tested, each giving distinctly different spectra with different elemental signatures.

RESULTS

This study will not settle the existing controversies. A comparison of the elemental constituents in specimens shows striking similarities among Pt. Reyes sherds identified as belonging to Drake's abandoned cargo and those of the wreck in Baja California; however, there are minor peculiarities. Although more testing certainly needs to be done to fully clarify the specific element spikes shown in the spectra produced during this analysis, it appears that specimens of Cermeño and Drake materials can be sorted based on clear differences in ratios of particular elements and the concentrations of key or index elements. In other words, the presorted collections also have detectable minor differences in composition. This distinction is also evident in transitional zones among index elements.

The spectra can be overlaid for comparisons of constituent elements. There is less difference between identified types within the collections. These two collections—the supposed Drake ceramics and the *San Agustín* materials—are near in time, yet manufacturing differences are evident from the spectra. The spectral differences may represent changes in glazing technology, clay sources, or unique inclusions or tempering, but most likely represent glaze chemistry. Deciphering the differences will necessitate additional sample testing in the future. Furthermore, it cannot be stated with certainty that the collections are completely discreet. Arguments have been made that the collection at Pt. Reyes represents only a single cargo containing wide internal variation. The single-cargo argument cannot be ruled out, owing to the small sample size tested in this study and the absence of a reference collection.

On the other hand, the greater similarity observed between the hypothesized Drake material and the contemporary *San Felipe* material than between either of these sets and the hypothesized *San Agustín* ceramics suggests some degree of conformity among them in manufacturing or point of origin. It bears repeating that there is no reference with which to compare. Indeed, other collections are themselves based on the Pt. Reyes materials. Other factors potentially affecting the results include differential absorption of elements from the ambient environment and the depth of penetration of the X-rays on different samples.

THE ELEMENTS

The major element clusters from which ratios are measured are the Mn/Fe/Co (manganese/iron/cobalt) group, the Mg/K/Ca (magnesium/potassium/calcium) group, and the Kr/Rb/Sr/Y/Zr (krypton/rubidium/strontium/yttrium/zirconium) group, in which Rb is the index element, the others of that cluster being constant. A fourth grouping was present in all samples in nearly identical concentrations and reflected body fabric continuity. It should be noted that some element concentrations are within error ranges of the instrument and must be discounted. Miscellaneous elements between these clusters appear in various ratios. The major variations are found in the Fe and Co concentrations in variable ratios with Mn, particularly when contrasted with the other main clusters. As (arsenic) may or may not be present, but was found in high concentrations in red glazes, along with Kr.

Blue glaze always contained a Mn/Co ratio higher than the white glazes. This finding is consistent with other studies (Wen et al. 2006). Differences in ratios were subtle but evident in this pairing with Fe. Ni (nickel) shows up in various Cermeño specimens, but rarely in the Drake sherds. In some cases, Mn was absent altogether from white glazed surfaces, with little influence over other elements, and always absent from stoneware, suggesting that this element was indeed a component of the glaze. Two specimens of Zhangzhou ware, referred to as “deer dishes” for both Cermeño and Drake, differ only in Rb concentrations. Rb ratios within its cluster exhibit great variability in the Cermeño sherds compared to the Drake sherds, which are more constant. Interestingly, the spectra signatures of stoneware from the Drake, Cermeño, and *San Felipe* materials were virtually identical, while only a single specimen from the “Wax Wreck” collection resembled these. All other Oregon samples were markedly distinct, with very high Fe and Ni ratios, suggesting a major shift in manufacturing processes or origin.

PRELIMINARY CONCLUSIONS

In the centuries before mission development along the Pacific coast, Manila galleons carried an international cargo intended to enrich the treasury of Spain. The treacherous nature of the voyage inspired exploration on the California coast in search of a safe anchorage to support the trade and to preserve the lives of the crews. Harbors important in the development of California's early Spanish colonial settlement, such as San Diego or Monterey, were settled as much out of interest in commerce and securing sovereignty over territory as for religious purposes. Sporadically in the centuries before the missions were established, the crews of explorers and merchant ships came into contact with indigenous peoples, and pieces of cargo came into the latter's possession. These exotic items may have played an important role in exchange networks, with implications for social relations across the human landscape.

Changes in glazes, perhaps a result of increased scales of production and economic factors, can be detected in wares barely 20 years apart. Whether this observed variation is indicative of change in manufacturing or the source of the artifact, or if such variation was common in all cargos during the early Manila trade, is unknown. Designs on trade ceramics also changed as Chinese merchants came to understand the European markets (Desroches et al. 1997).

The use of pXRF as a tool to distinguish ceramics from different ships and historic periods may yet provide more than a means of settling controversies about which crews came ashore or made contact with indigenous populations, and where they did so. Findings could potentially provide insights into the changing nature of international commerce and production itself in relationships between Spanish and Chinese merchant houses. We may also be able to clue in on which cargos found their way into which indigenous communities, facilitating the temporal reconstruction of native trade patterns north of San Francisco Bay. This study was a first step. A larger sample size and testing against dated specimens from other collections will need to be carried out before a more definitive conclusion is possible.

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