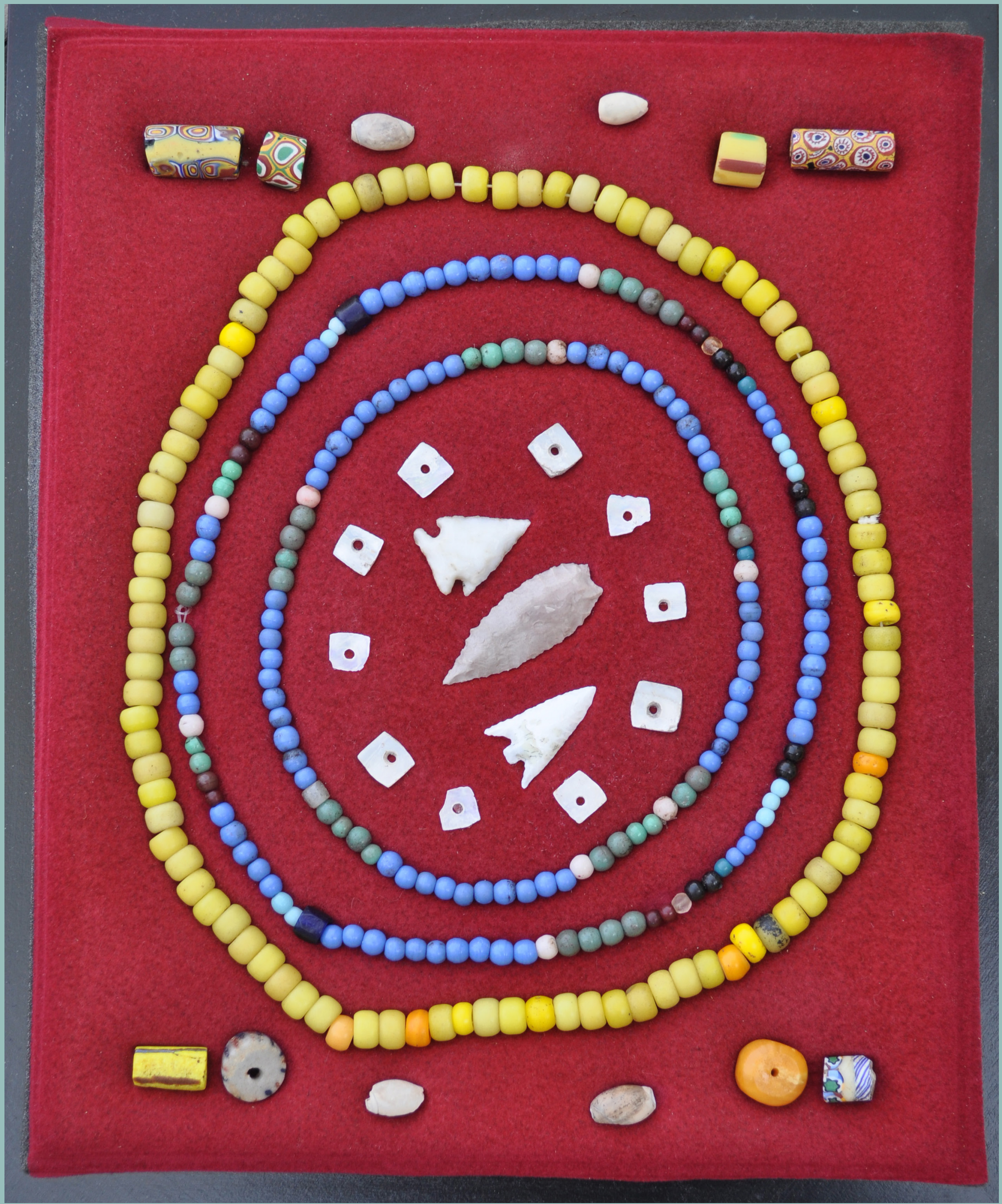
BEADS

Journal of the Society of Bead Researchers



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THE SOCIETY OF BEAD RESEARCHERS

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There are four levels of membership: Individual (worldwide) $25.00; Sustaining - $45.00; Patron - $75.00; and Benefactor - $150.00 (U.S. funds). All levels receive the same publications and benefits. The Sustaining, Patron, and Benefactor categories are simply intended to allow persons who are in a position to donate larger amounts to the Society to do so. Members receive the annual digital journal, *Beads,* as well as the digital biannual newsletter, *The Bead Forum*.

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Cover. African trade beads, shell beads, padre beads, Prosser molded beads, mother-of- pearl beads, and arrow points from the Richard Shipley Collection.

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2024 Vol. 36

Alison Carter, editor

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INFORMATION FOR AUTHORS

Manuscripts intended for *Beads: Journal of the Society of Bead Researchers* should be emailed to Alison K. Carter, SBR Editor: acarter4@uoregon.edu.

1. Papers must be 1.2-spaced, justified left, with 1-in. margins. Submissions should not exceed 10,000 words including references cited and image captions.

2. All manuscripts must be prepared with the following internal organization and specifications:
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   c. **Appendices:** these should be avoided but if necessary, they should be placed before the Acknowledgements.
   d. **Acknowledgements:** these are to be placed at the end of the article, before Endnotes and the References Cited section.
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   f. **References Cited:** these and reference citations should generally follow the style of *Historical Archaeology* <https://sha.org/assets/documents/SHAStyleGuide-Dec2011.pdf> (Section VII).
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5. Illustrations:
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6. Each manuscript will be reviewed by at least one member of the Editorial Advisory Committee. Articles of a specialized nature will also be reviewed by one or more persons who have expertise in the thematic content, cultural or geographical region, or time period dealt with in the manuscript.

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8. Manuscripts will be judged on the accuracy of their content, appropriateness for an international audience, usefulness to other researchers, and consistency with the research and ethical goals of the Society.

9. Each author and co-author will receive a digital copy of the article.

THE EDITOR'S PAGE

Welcome to Volume 36 of *BEADS: Journal of the Society of Bead Researchers*! This is our first fully digital journal issue and my first as editor. The first issue of *BEADS* appeared in 1989 and was helmed until 2023 (Volume 35) by Karlis Karklins, who is now editor emeritus. I am grateful to Karlis for his mentorship and assistance as I move into the editor position. I hope I can continue his legacy of promoting and publishing scholarship on beads and bead research.

My own interest in beads began in high school when I took a part-time job in a bead store. This continued through college where I worked in a second bead store and began undertaking scholarly research on beads. This led me to PhD research on beads, studying with noted bead scholar, Mark Kenoyer, at the University of Wisconsin-Madison and a dissertation on stone and glass beads in Iron Age Southeast Asia. As a student embarking on this work, I remember being thrilled to discover the community of scholars within the Society of Bead Researchers and the *BEADS* journal. As editor, I hope to continue the growth of the SBR community and to bring exciting new research on beads to our membership.

With Volume 36 we are moving away from our print publication to a new online journal system that will streamline submissions and make our journal more widely available to scholars around the world. The new journal website will allow for easier access to appendices and datasets in addition to the article text. Articles will also have a DOI (digital object identifier) that will give each article a unique identifier and web address. We are currently in the process of transitioning our archives to this system and we look forward to adding *The Bead Forum* as well. For those who wish to have a hard copy of the journal, we are also working on making a print on demand option available. In this time of transition, we appreciate your patience as we work to make these changes.

This volume of BEADS continues to show the diversity of bead research from Larsson's work on tooth pendants from Mesolithic societies in Europe to Hoferitza's research on 19-20th century CE Prosser molded beads. I hope you enjoy this issue!

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AN XRF ELEMENTAL ANALYSIS OF PROSSER MOLDED BEADS FROM SOUTHERN OREGON

Michele Hoferitza

Prosser molded beads were made in France and Bohemia from the 1860s to the 1970s for trade in Africa and North America. Extensive sales and distribution networks were created by the Bapterosses (France) and Redlhammer (Bohemia) companies to both continents. Their innovative manufacture makes them visually and chemically distinct. In this study, 175 Prosser molded beads found in an archaeological context in south-central Oregon were examined with XRF. The purpose of the study is to determine if elemental analysis can be used to understand where and when Prosser molded beads were manufactured. Three groups of elements that are chemically related, either naturally or by deliberate addition, were examined to identify which of them showed statistically significant variation in the composition. Results show chemical variation between beads of the same color that fall into at least two distinct production groups.

INTRODUCTION

Made in Europe for centuries, glass beads were produced in mass quantities for use as a trade commodity around the world as Europeans explored outside their continent in search of commodities and raw materials. Before Europeans arrived in North America, Indigenous people made beads from shell, bone, and stone, but glass beads quickly became adopted (Panich 2014). From the 15th to 20th centuries, European glass manufacturers in Italy, France, Bohemia, Germany, and the Netherlands increased supply to meet the growing demands of worldwide trade. In historical archaeology, the study of glass beads provides insight into the organization of trade networks between vendors, countries, and continents, as well as the economic development of consumer markets (Panich 2014). Beads also reflect cultural values and practices through their use in personal adornment and prestige signaling (Opper and Opper 1993).

In the mid- to late-19th century, high global market demand for glass beads was filled in part with mass-produced porcelain beads from France and Bohemia (Neuwirth 2011; Nourison 2001). These beads, called Prosser molded beads, have been understudied in archaeological contexts (Kirkish 2014). This research is important because it lays the foundation for the study of anthropological questions about globalization of economy and culture, international trade, manufacturing communities of practice, and indigenous commoditization and use of trade beads on two continents. Because they were manufactured by the millions and are abundantly found in archaeological contexts in North America and Africa, they provide a unique index to post-industrial international manufacturing and trade practices.

While glass beads are commonly found in the North American archaeological record (Hancock et al. 1994), Prosser molded beads were late arrivals. Consequently, when found, Prosser molded beads are often dismissed as chronological intruders in sites considered to be much older. Some researchers speculate that Prosser molded beads were sold by the Hudson's Bay Company (Kirkish 2014), but others point out the late manufacturing date may put them in the post-HBC era (Ross 1990). At least five different companies produced porcelain beads in Europe, but the industry was led by the Bapterosses Company in Briare, France, which was not only the first to produce them in 1864, but made them with high quality standards (Nourisson 2001). The Redlhammer Company in Gablonz, Bohemia, entered the market in 1890 with more haphazard recipes, but with a wider variety of shapes, and a marketing gusto that made it the prime competitor to the French producers (Neuwirth 2011). By the 1930s, global economic depression forced the competitors to become collaborators, forming a syndicate of porcelain bead producers, each providing products to common distribution companies (Nourisson 2001).

This study presents the results of an X-Ray fluorescence (XRF) analysis of 175 Prosser molded beads from an archaeological context in south-central Oregon. The beads are from the private collection of Dr. Richard Shipley of Centerville, Utah. Dr. Shipley obtained the beads and other collected artifacts from the late Ronald Rathbone of Lakeview, Oregon. Rathbone collected artifacts from the

Abert Rim region north of Lakeview, on private ranches with the property owners' permission. One of his associates reported that they typically found fire ash pits in sandy knolls near marshes where indigenous people may have camped while hunting ducks or other waterfowl. The beads were found dispersed across many such sites along with other artifacts, including arrowheads (Gerald Cole 2024, pers. comm.). Rathbone was a life-long avocational archaeologist, and his collections were accumulated over the course of fifty or more years. Based on the available information about the provenance of the beads in this study, they likely came from a non-funerary Native American context as there is no evidence to suggest they were associated with burials.

The use of private collections in archaeological analysis is a controversial subject, especially when artifacts are collected without a systematic or professional description of the context and provenance, as seems to be the case in Rathbone's collection. Such concerns are addressed by the Society of American Archaeology in their 2018 statement of the "Professional Archaeologists, Avocational Archaeologists, and Responsible Artifact Collectors Relationships Task Force" (Pitblado et al. 2018). Dr. Shipley, who served as a member of the Task Force, is considered a "Responsible and Responsive Steward" (RRS) and his collections are carefully documented. He is committed to making his collection available for research without monetization and is very gracious about answering questions and supporting scholarly research.

The Abert Rim region is east of the Klamath Basin and is part of the land historically known as the ancestral lands of the Klamath, Modoc, and Yahooskin-Paiute people. How indigenous people may have used Prosser molded beads like the ones found in this study is a subject that beyond the scope of this article, which is focused on elemental composition of the beads. Nevertheless, I hope that increased understanding of the manufacturing processes of the beads can lead to and support further research on trade and consumption practices of Prosser molded beads in the 19th century.

This study examines the question of whether the factory of origin of Prosser molded beads can be determined through elemental analysis. Differences in the geochemistry of raw material sources used by the factories in Briare and Gablonz are expected to be reflected in the chemical composition of the beads. If such differentiation cannot be confirmed, it would suggest that, in this case, either a single company made the beads found in the collection or that chemical variability between the two manufacturers' recipes or raw material sources cannot be detected.

In this paper, I first present an overview of the taxonomy of bead forms as used by archaelogists in North America.Second, I outline the history of the development of Prosser molded beads and the companies and personalities that produced them. Third, I discuss the ways researchers categorize glass beads by physical and chemical attributes. Finally, I present a background on geochemical analytical methods in glass bead research, focusing on recent developments in XRF technology that enable rapid, inexpensive, and high-precision results, and note limitations that present challenges with this methodology.

Relationships between elements in the Prosser molded beads are analyzed in three contexts. First, the elemental composition of feldspar, a main ingredient in Prosser molded beads, is considered in terms of the relative weights of the elements Al, Si, Ca, and K. For the purposes of this study, these four elements will be referred to as major elements as they are among the most common elements and form the primary ingredients in the Prosser recipe. Second, four trace elements (Zr, Y, Sr, Rb) associated with feldspars and with volcanic material are considered, as these can be geographically distinct and may act as markers for raw material sources (Heier 1962; Shackley 2011). Finally, chemicals used to create colors in the beads (Fe, Co, Cu, Zn, and Ti) are examined for variance. I suggest that variations of these three primary elemental components, when considered together, will provide the basis for differentiating Prosser molded beads produced in the French and Bohemian factories.

Information about the elemental composition of Prosser molded beads from different locations is the first step in generating a model for identifying precise manufacturing locations of Prosser molded beads, millions of which were produced and distributed to worldwide markets. Multiple questions about technology, chronology, and trade are addressed by the study of beads (Dussubieux and Walder 2022). The process of creating beads, however, tells stories of invention, innovation, economic relationships, industrial production, and international commerce.

HISTORY, CHEMISTRY, AND ANALYSIS OF PROSSER MOLDED BEADS

Glass beads exist in archaeological contexts throughout the world, and date back as far as Roman times. The first formal classification system was published by Horace Beck (1928) after finding that archaeologists could not agree on simple bead descriptions, even making such imprecise reference in the literature to a "coloured Anglo-Saxon bead of the usual type" (Beck 1928:1). Beck's cumbersome system, however, stipulated descriptions about form, perforation, color, material, and decoration, and never caught on with North American researchers (Karklins 2012).

In the 1950s, Canadian researchers Kenneth and Martha Kidd devised a hierarchal classification system that was based primarily on manufacturing technique, then physical characteristics of shape, size, and diaphaneity. Kidd and Kidd (1970) acknowledge that the sheer variety of extant beads exceeds individual descriptions. Their system, which is based on the examination of 500 bead types, was intentionally designed to be expandable (Karklins 2012). The Kidd and Kidd system distinguishes between drawn and wound beads, depending on the manufacturing technique used. In drawn beads, a tube or cane of hot glass is pulled between two people and stretched to a desired length or diameter, then left to cool. Once cooled, the tubes are cut into segments of desired length, and sharp edges are often heat rounded by various methods. Wound beads, on the other hand, are made by winding hot glass around a wire or mandrel. Such beads can be decorated before cooling and are often referred to as lampwork (Kidd and Kidd 1970; Karklins 2012).

Karklins provided extensions to the Kidd and Kidd classification system to include wound-on-drawn, mold-pressed, blown, and Prosser molded beads (Karklins 2012). Mold-pressed beads were manufactured primarily in Bohemia beginning in the 19th century and are often referred to as Czech beads (Neuwirth 2011). Blown beads were made by blowing air into a heated glass tube to create free shapes or blown into a mold. Because of their delicate nature, blown beads are rarely found intact in archaeological contexts (Karklins 2012).

Prosser molded beads are not made from molten glass, but are instead created by compressing powdered ingredients into a mold, then firing them in a kiln. Though Karklins (2012:74) refers to Prosser molded beads as "technically ceramic," they are included as a separate bead classification because of their glassy appearance due to high silica (Si) content. Though other classification systems have been suggested that depend on physical attributes, including relative size and function of beads, the Kidd and Kidd system as updated by Karklins has remained the most definitive classification tool for North American bead research (Hancock 2005; Sempowski et al. 2000).

A Manufacturing History of Prosser Molded Beads

In 1840, Richard and Thomas Prosser obtained patents in England and the US, where each lived respectively, for an automated process of making porcelain buttons (Sprague 2002). The original patent described the use of clay or "clayey earths", flint, and feldspar as base materials. In the original processes, the dry powdered ingredients were compressed in a mold without added liquid. With enough pressure, the clay material holds the shape of the mold, and the button can be turned out onto a tray for firing. The American Prosser button industry was successful, but dwindled in England when the European market was taken over by a French manufacturer, Jean-Felix Bapterosses (Sprague 2002).

After working a short time for the Minton Company in England, which produced Prosser buttons, Bapterosses obtained a European patent in 1844 for a revised process of making buttons, tiles, and beads that represented several improvements to the original Prosser system (Sprague 2002). The evolved process used powdered feldspar, calcium fluoride, silica sand, and various ingredients as needed to provide color (Karklins 2012; Opper and Opper 1991). The powder mixture was combined with a liquid to make a paste that was then pressed into a two-part gang mold to create as many as 500 beads at one time (Kirkish 2014). Bapterosses was the first to use milk as a liquid binding agent, which improved the plasticity of the material (Sprague 2002). The molded mixture was then released onto a tray which was fired in a kiln. The resulting beads have a raised equatorial band where the two mold pieces meet, and a glassy, opaque appearance. They are smooth on the top side but have a characteristic "orange peel" texture on the bottom where the bead sat on the tray in the kiln (Kirkish 2014; Kaspers 2011).

Bapterosses was an aggressive entrepreneur, and by 1851 he had purchased and renovated a failing ceramics factory in Briare, France, south of Paris along the River Loire about 40 miles east of Orléans. The more efficient production and cheaper labor in France allowed Bapterosses to undercut the English market, which stopped production of buttons by 1848. Prosser molded bead production in Briare began in 1864 and beads were widely distributed to American and African markets under the Bapterosses brand labeled "oriental" beads. With this success, the factory at Briare grew to include a dairy farm that produced milk for manufacturing operations, coal-fired kilns, a carpentry shop, a woodlot to make containers, its own printing press to produce marketing materials, and, ultimately, even an electricity generator (Nourisson 2001). Bapterosses was also a respected philanthropist, helping to build a school, hospital, church, and housing for workers, and supporting the arts and athletic recreation activities for the entire community (Nourisson 2001; Opper and Opper 1991).

The nearby Loire River and local canals provided efficient shipping pathways for raw materials. In 1879, Paul Yver, Bapterosses' son-in-law, traveled to Norway in search of feldspar sources. After rejecting an alternative in England, Yver purchased a Norwegian mine which supplied minerals to Briare until after World War II (Nourisson 2001). In addition to feldspar, quartz sand was a necessary ingredient. An excellent and local source for sand was the Fontainbleau Sand Formation in the Paris Basin, well known for high quality white silica sand with few impurities (Thiry and Marechal 2001).

While the Prosser molded bead production in Briare was developed by Bapterosses' effective entrepreneurship, the industrial process in Bohemia had more complex roots. The glass-making industry in the area dates to 1550 when new Venetian red glass production began competing with local stone cutters' garnet production (Kaspers 2014, Neuwirth 2011). By the 18th century, German glassmakers in the city of Gablonz (now Jablonec nad Nisou, Czechia) were making composition glass with various amounts of lead, resulting in sparkling colors and clear crystal, rivaling even the Venetian glass industry. Novel manufacturing techniques developed for pressing glass into molded shapes and for facet grinding helped make beads and other small glassware a popular and profitable regional industry (Neuwirth 2011).

Eduard Moritz Redlhammer, a Bohemian businessman, established a glass export company in Gablonz in 1882. His two sons, Eduard and Albert, however, lost a great deal of money in their father's export business. The senior Redlhammer, who was quite wealthy, offered his sons a final opportunity and financed a venture in bead manufacturing (Nourisson 2001). The success of the Bapterosses Company caught their attention, and the Redlhammer brothers began experimenting with porcelain beads, beginning production in 1890. The buttons and beads they produced were lower quality than those made in Briare, but their trade connections provided good marketing opportunities in India and Africa. Gablonz became known for porcelain beads, and the Redlhammer Brothers Company became the primary competition for Bapterosses. Continuous improvements to the process of mass production machinery supported the expansion of the industry, and a new factory built in 1905 was expanded in 1908 (Neuwirth 2011). The market for Prosser molded beads and buttons expanded rapidly, largely due to the astute business sense of Bapterosses and the Redlhammer brothers. Other factories making similar porcelain products existed, most notably the Risler Company in Freiburg, Germany, but none matched the volume and success of these two (Sprague 2002).

The first half of the 20th century was a series of booms and busts for the Prosser molded bead industry. European colonialism in Africa provided access to an eager market for the colorful, opaque beads, called "ushanga maka" in Swahili (Karklins 1992). Special shapes were made for the African market including triangle-shaped talhakimts worn as pendants or hair ornaments by Tuareg tribes (Kaspers 2014). In the United States, Native Americans regularly incorporated beads into cultural dress and accessories by the 19th century (Orchard 1975), and Prosser molded beads were inexpensive and readily available. For Middle East customers, Islamic prayer beads were pressed with Quran verses for Mecca pilgrimages (Kaspers 2014). For Asian markets, imitation coral molded to look like branches were produced along with beads in a variety of oriental and Hindu motifs (Kaspers 2011). Scarab beetles, sarcophagi, and other Egyptian Revival-themed beads were popular in Europe and America in the 1920s after the discovery of the tomb of King Tutankhamun (Kaspers 2014).

Some cooperation developed in the industry as distributor networks were formed and included products from multiple manufacturers (Kaspers 2011). Trade relationships fractured with World War I, however, and bead production began to decline as raw materials were diverted to war efforts. A short decade of economic recovery after the war was undercut by the Great Depression in the 1930s, and World War II further decimated both access to raw materials and markets. Decolonization in Africa and Asia in the 1960s and 1970s pushed the bead industry into further decline.

After World War II, people of German descent living in Gablonz were exiled and the communist government in the newly created Czechoslovakia took over industrial manufacturing. The Redlhammer Brothers Company was absorbed by Jablonex, the state-run bead company, which was later sold to the Preciosa company after the Velvet Revolution of 1989. Preciosa stopped making Prosser molded beads in 1993, but continues to sell traditional Czech glass beads worldwide. The post-war decline in bead trade forced the factory in Briare to access less expensive mineral materials from the Massif Central and Pyrénées mountains in the south of France (Nourisson 2001). The Bapterosses Company stopped production of beads in 1962, but continued to make "emaux de Briare" mosaic tiles for another twelve years. Production operations ceased in 1974 when the Briare factory equipment was sold and moved to Morocco.

Geochemical Approaches to the Analysis of Glass Beads

Advances in geochemical analytical methods over the last 25 years have enabled researchers to move beyond descriptive classifications and consider the spatial and temporal variability in bead production and exchange based on their geochemical composition (Hancock 2005). The primary elements in glass are ubiquitous, but the combination of elements into glass recipes is almost limitless (Blair 2022). Glass is composed of what is referred to as a "network former," typically silica (Si) or lead (Pb), a "network modifier" or flux, usually an alkali such as sodium (Na) or potassium (K), and a stabilizer, usually calcium (Ca) (Blair 2022; Henderson 1985; Kidd and Kidd 1970). Additional elements may be added acting as opacifiers, de-opacifiers, and coloring agents. Glass bead recipes can be quantified based on the major and minor elemental composition of network formers and network modifiers, as well as the trace elemental composition of opacifiers and coloring agents (Blair 2022).

Chemical analysis of ancient glasses has been a subject of ongoing scientific study since the 1960s (Brill 1999). The Corning Archaeological Reference Glasses, produced by the Corning Museum of Glass, are widely used to categorize antique glasses by chemical composition and provenance (Brill 1999). These standards were created to replicate elements in glass at the major, minor, and trace concentrations. Corning A and B glasses are sodium-rich lime silicate glasses that resemble Egyptian, Mesopotamian, Roman, Byzantine, and Islamic glass. Corning C is high in lead and barium and reflects glasses from East Asia. Corning D is a potash-lime silicate glass that is like medieval glasses produced in Europe (Adlington 2017; Brill 1999; Vicenzi et al. 2002).

Glass made in the historical era, however, contains more complex elemental combinations representing recipes that varied over time and space, as chemical science was not exact (Kidd and Kidd 1970). Analyzing post-Medieval heritage glasses through elemental composition techniques has become increasingly more accessible to archaeologists via inexpensive, portable XRF equipment. Referring to the combination of formers and modifiers, Blair (2022) categorizes heritage glasses into four categories: soda glasses, potash glasses, lead crystal glass, and lead-barium glass. Prosser molded beads, however, do not fall neatly into any of these categories.

Prosser molded beads have been called "agate" or "stone" beads, porcelain beads, or tile beads (Karklins 2012, Kirkish 2014). The use of stone and porcelain as descriptors is likely in reference to the use of clay, feldspar, and quartz as main ingredients in bead recipes. The original Bapterosses patent listed the raw materials used as 70% kaolin clay, 15% feldspar, 9% calcined gypsum, and 6% calcium carbonate (Nourisson 2001). Later recipes do not mention clay but include Fontainbleau Sand (Opper and Opper 1991). Using energy dispersive XRF in a laboratory analysis, Sprague (1983) concluded that Prosser buttons and beads are chemically identical to glass but maintain a crystalline structure absent in glass. As a result, archaeologists refer to them as ceramic (Karklins 2012; Sprague 2002). Nevertheless, with a high content of Si, often the primary foundational ingredient in glass, Prosser molded beads are included in the study of glass beads (Karklins 2012; Sprague 1983). Feldspar, quartz sand (Si) and sometimes kaolin clay (aluminum (Al) and Si) were used as basic ingredients for Prosser molded beads, which should be accounted for in the elemental analysis. The purpose of this study is not to identify specific locations of sources for quartz, clay, or feldspar used to make the beads, but rather to determine whether elemental analysis will indicate that distinction can be made between two or more manufacturing origins.

Historical archaeology has the advantage of combining known information from written records with material items informing and expanding understanding of the documentary record (Andrén 1998). One disadvantage is that objects may be collected and associated with incorrect or incomplete documentation. For example, museums in both Briare and Jablonec are dedicated to the bead, button, and tile industry that built wealth and prosperity in each city. Nevertheless, each museum includes bead sample cards from multiple manufacturers and distributors, or that are unmarked, making research difficult and confusing (Kaspers 2011). Documentation regarding raw material sources exists in Briare, but such information is not available for other Prosser factories. "Company history" documents are written by descendants of the founders or by employees and are often more marketing materials than objective observations.

This tension between what is known through documentation or texts and what is observed in the material record is referred to by Andrén (1998) as the paradox of historical archaeology. Archaeologists have increasingly turned to elemental composition to supplant gaps in written information (Burgess and Dussubieux 2007; Dadiego et al. 2021; Hancock et al. 1994). Recent studies have shown that chemical analysis can provide information about chronology, manufacturing technology, and provenance of glass (Adlington et al. 2019; Blair 2017; Hancock 1997). Specific glass manufacturers usually cannot be easily identified by chemistry in part because of the traditional secrecy surrounding recipes (Blair 2017). Nevertheless, in a review of neutron activation analysis (NAA) studies, Hancock (2005:55) surmised that elemental analysis may lead to identifying countries of origin, providing "fingerprints for tracking glass beads." A notable example showed that correlations between cobalt (Co) and arsenic (As) in beads from two different sites in Ontario indicate the coloring agent could be associated with the Hartz Mountains of Germany (Hancock et al. 2000).

Finally, the study of chemical compositions of archaeological materials requires a focused statistical analysis of the elements present in the material. Principal component analysis (PCA) is commonly used to seek patterns among large element groups. Michelaki and Hancock (2011), however, demonstrated that simple bivariate plots of geochemically related elements can suggest diagnostic elements that reveal patterns in the data that are obscured by multivariate methods.

X-Ray Fluorescence Analysis

Elemental analysis of objects can be done by a variety of methods, but historically, available technology was expensive and had limited accessibility (Glascock 2011; Walder 2018). Advances in XRF technology have provided archaeologists with a low-cost, portable method of chemical analysis. Elemental studies of glass beads have been done using Instrumental Neutron Activation Analysis (INAA) (e.g., Hancock et al. 1994; Kenyon et al. 1995), Laser Ablation Inductively Coupled Mass Spectrometry (LA-ICP-MS) (e.g., Dadiego et al. 2021; Dussubieux et al. 2022; Walder 2018), and XRF (e.g., Blair 2017; Sprague 1983). XRF can provide reproducible results that are comparable to NAA and LA-ICP-MS (Glascock 2011; Walder et al. 2021).

Energy-dispersive XRF (ED-XRF) provides information about the elements present in an object through the introduction of an X-Ray beam, and the analysis of the released energy called fluorescence. An X-Ray is high-energy, high-frequency photon radiation (Shackley 2011). The radiation excites the electrons of the atoms of the target material, causing some of them to escape the orbit of the atom. When an electron escapes a lower orbital shell closer to the nucleus, an electron from a higher shell replaces it, radiating energy in the form of photons that leave the material. The energy is detected and analyzed by the XRF device and translated by software into spectra that represent the number of photons (y-axis) for each energy level measured in kilovolts (keV) (x-axis) (Drake and MacDonald 2022; Shackley 2011). Individual elements reflect photons at specific energies and their relative presence is indicated by photons under the curve on the spectra.

The low cost and portability of XRF devices make the technology a good choice for archaeologists in some contexts, but several limitations should be noted. XRF measures only the surface of the artifact, depending on the density of the material and the elements being examined. Homogeneity of the material is important, as clusters of elements in the material could bias results. Lighter elements including sodium and magnesium cannot be detected unless the sample is evaluated in a helium environment (Blair 2022). Prosser molded beads typically do not have a surface coating and like glass are sufficiently homogenous. However, the deficiency of sodium and magnesium in this analysis is noted as a liability.

Increased access to XRF technology has given researchers a new way to analyze and categorize bead assemblages through the identification of elements that make up the bead either as naturally occurring components of raw materials, or as something deliberately added for color or opacity. The limited nature of the recipe for Prosser molded beads increases the likelihood of distinguishing between natural and intentional components.

METHODS

The beads used in this study are from the private collection of Dr. Richard Shipley of Centerville, Utah. Dr. Shipley's collection, purchased from estates of collectors, includes stone points and arrowheads from around the Great Basin as well as glass trade beads and various other artifacts from the region. The beads chosen to study were two strands from a display case labeled Frame 131 (Figure 1), identified by Dr. Shipley as coming from Ronald Rathbone, a collector in Lakeview, Oregon. The beads are identified as Prosser molded beads by the presence of a wide equatorial raised band left by the mold that is the primary diagnostic element for this type (Karklins 2012). Figure 2 shows the band in detailed pictures of some of the Shipley collection beads.

X-ray fluorescence analysis was conducted using a Bruker Handheld energy dispersive XRF Spectrometer Tracer 5i model, serial number 900F4939. While this instrument is "handheld," it contains the same technology and instrumentation as a bench-top ED-XRF instrument, unlike earlier versions of handheld equipment that is called portable or "pXRF." As a result, there is sometimes confusion over terminology as older pXRF technology often did not match the capabilities of the ED-XRF, especially in the measurement of lighter elements. Newer technology has improved the instruments in the last two decades, however, and portable systems have the same operational physics and analytical capabilities as traditional non-portable systems (Johnson et al. 2021). The instrument used in this study is considered laboratory-grade and is capable of measurement voltages up to 50kV. It was used in a laboratory setting and is referred to hereafter simply as the XRF or the XRF instrument.

The reliability of the XRF, or the ability to reproduce results, is specific to each instrument, within a small margin of error (Blair 2022; Yatsuk et al. 2022). That error is mitigated in the data through the calibration of results by using the same instrument to scan standards that have known element weights that were verified by more sophisticated technology. In the case of glass, 300 Heritage

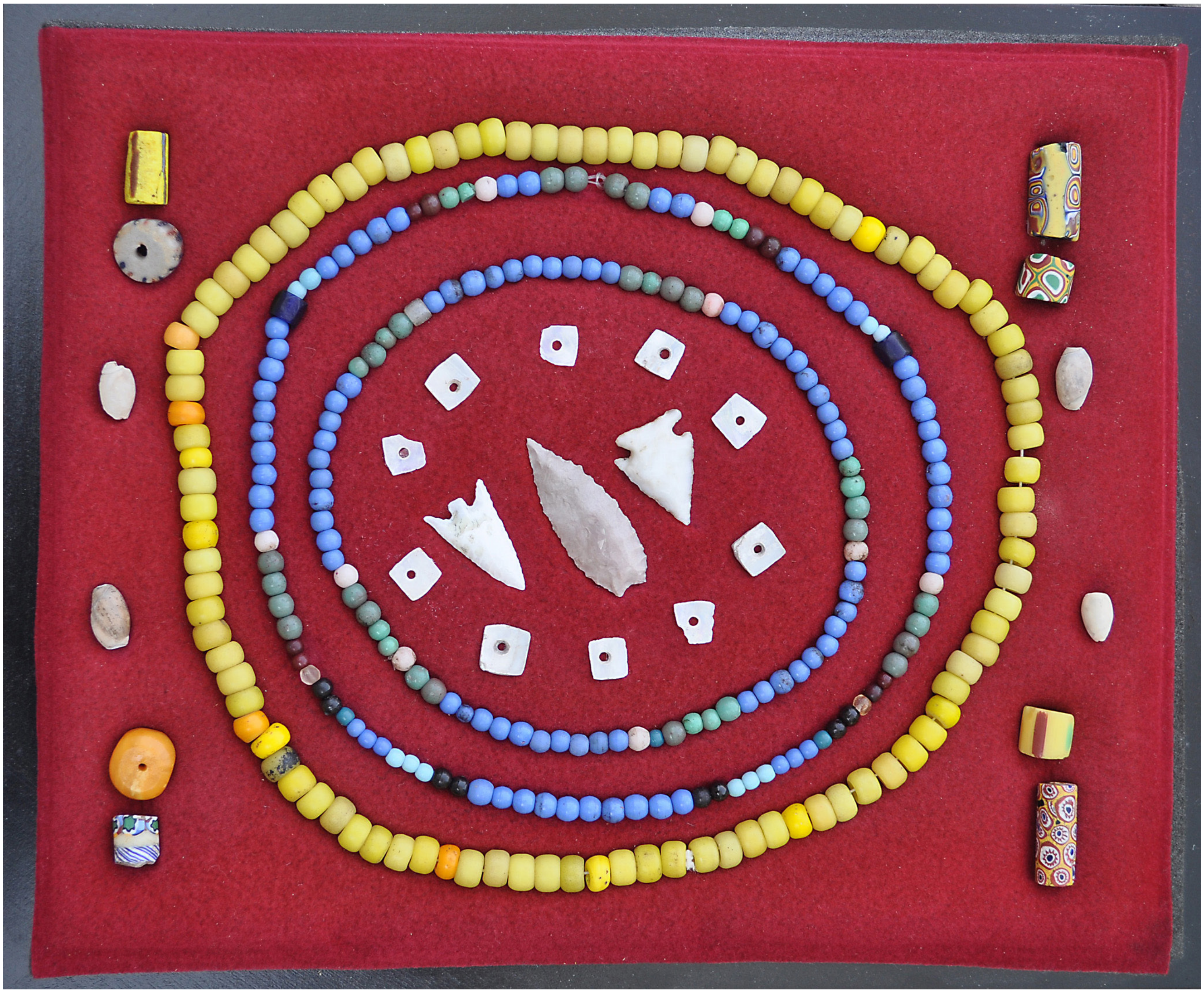

Figure 1. Frame 131 from Richard Shipley Collection. The frame includes African trade beads, shell beads, padre beads, Prosser molded beads, mother-of- pearl beads, and arrow points.

Glass standards are available that were analyzed by LA-ICP-MS (Blair 2022). The calibration of data uses the known element weights to adjust the measured unknown weights of elements and convert the photon count to parts-per-million (PPM) values, which allows comparison of elements in standardized units.

To maximize accuracy, each bead in this study was scanned twice in the same position at different voltage settings. The low voltage scan was done in a plain air atmospheric path using an X-Ray tube setting of 15 kV (high voltage) and 10 μA (current) with no filter. The high voltage scan was done in a plain air atmospheric path using up to 50 kV (high voltage) and 35 μA (current) with a filter composed of 100 μm Cu, 25 μm Ti, and 300 μm

Figure 2. Detail picture of Prosser molded beads. Equatorial band, which is diagnostic of Prosser molded bead types, is visible on some beads, worn on others. The beads are round to slightly oblate in shape.

Al. All assays were conducted using a 3-x-3 mm spot size for 30 seconds. The spectra generated by the scan were converted into values reflecting the photon count under the peak created for each element using the Bruker S1PXRF software, version 1.8.0.136.

Raw spectra data provide relative qualitative information about elements found in each bead but do not provide a standardized way to compare element weights among different beads. To compare elemental composition between beads, photon counts must be converted to PPM values. This conversion requires the XRF instrument be used to scan standards samples with known values to provide the relative baseline for results comparison (Blair 2022). For this study, twenty glass samples were scanned from the Heritage Glass standards collection of Dr. Elliot Blair, who also provided the known element weights generated through LA-ICP-MS. The spectra generated by the scan of the standards and the known values were combined into formulas in an Excel spreadsheet provided by Dr. Bruce Kaiser to calculate PPM values.

RESULTS

The Prosser molded beads selected for study are of various sizes and consist of eight colors. The Munsell Bead Color Book (2012) was used to identify standardized colors, but for the purposes of this study, common color names are used as shown (Table 1). Three clear glass beads and two cobalt blue faceted glass beads were excluded from the study as they are not Prosser molded beads. The beads range in size with length from 3.75 to 6.15 mm, diameter from 4.21 to 6.62 mm, and weight from 1.0 to 5.2 grams. Measurements show that the beads are round to oblate, as the length of most beads measured from the top to bottom of the hole is slightly smaller than the diameter of the bead. The beads in this study, therefore, are categorized as PMIa (round)-PMIb (oblate) according to the Kidd and Kidd Classification System (Karklins 2012).

The spectra generated by the XRF assays are a qualitative representation of elements present in the beads. Each element corresponds to a voltage peak intensity that varies according to the percentage of that element in that specific bead. Although the ARTAX software restricts the display of spectra to 100, cluster patterns can be observed in several elements (Figure 3). A closer view of the spectra for volcanic trace elements further reveals that group patterning exists most strongly in rubidium (Rb) (Figure 4).

The analysis successfully generated PPM values for the major elements of Si, Ca, K, and Al by bead color (Table 2). The analysis also produced PPM values for minor elements of iron (Fe), Co, nickel (Ni), copper (Cu), zinc (Zn), As, Pb, manganese (Mn), and titanium (Ti) by bead color (Table 3). The elements Rb, strontium (Sr), yttrium (Y), and zirconium (Zr) are also present in trace amounts (Table 4). The concentrations of the four major elements in each bead were analyzed by bead color (Figure 5). A one-way analysis of variance (ANOVA) for Si shows that black, burgundy, and turquoise beads have mean distribution of concentrations above the total mean of 360,481 PPM ($f=16.09$, $df=6$, $p<0.001$). For Ca, blue, olive, and white beads all have mean distributions above the total mean of 382 PPM ($f=9.28$, $df=6$, $p<0.001$). Blue beads are the only color with concentrations above the means for K (mean=40,635 PPM, $f=16.36$, $df=6$, $p<0.001$) and Al (mean=51,291 PPM, $f=16.23$, $df=6$, $p<0.001$). Blue beads also have the widest distribution of concentrations in all four elements.

One-way ANOVA analysis was also done for minor elements (Table 5), which reveals strong visual patterning by bead color in several elements (Figure 6). Blue beads have the greatest variation of Co and olive beads have the greatest variation of As. Mn shows low concentrations in all except the black beads, and is absent in blue, light

Table 1. List of Colors of Beads Included in Shipley Collection, Frame 131.

Color	Munsell Color	Number of Beads
Black	N1 Lamp Black	8
Blue	2.5P8 6/9 Bright Copen Blue	102
Burgundy	7.5R 2/8 Wine	7
Light Green	2.5G 7/8 Bright Mint Green	12
Turquoise	5.0B 8/4 Bright Aqua Blue	12
Olive Green	7.5GY 5/4 Mistletoe Green	25
White	4.0R 9/2 Shell Pink	9

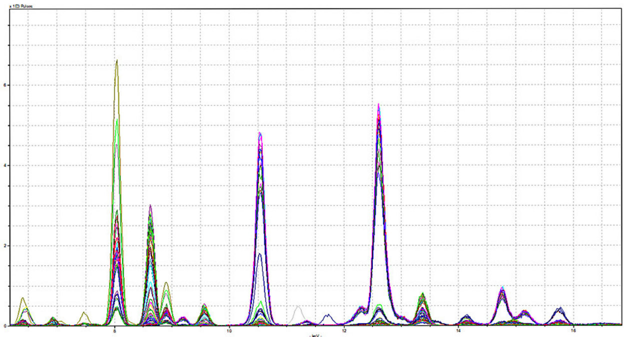

Figure 3. Display of spectra from high-voltage scans. ARTAX software can display up to 100 spectra on one screen. The colors are not associated with bead color, rather represent individual spectrum.

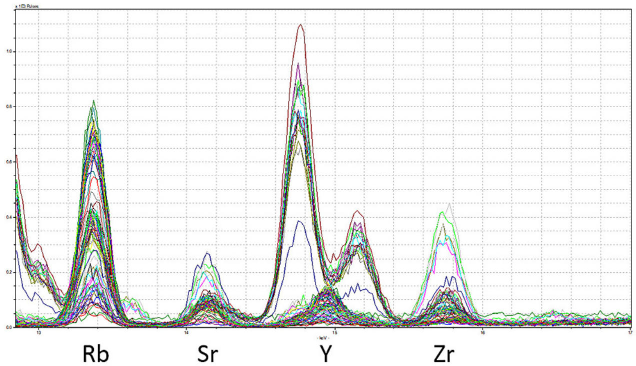

Figure 4. Detail of spectra portion showing trace elements of Rb, Sr, Y, and Zr. ARTAX software can display up to 100 spectra on one screen. The colors are not associated with bead color, rather represent individual spectrum.

green, olive, and white beads. White beads show high concentrations of Ti, which is absent in black, burgundy, and turquoise beads. Concentrations of Fe are below the mean for blue and turquoise beads and above the mean in black, olive, and white beads, with burgundy and light green showing the element more evenly distributed. Zn and Cu have generally even distribution of concentrations, although turquoise beads are low in Zn, and burgundy, light green, and olive beads are all above the mean for Cu content. Concentrations of Pb are evenly distributed in black, blue, and burgundy beads, but light green, olive and turquoise all have content below the mean, and all the white beads are above the mean.

Trace elements associated with volcanic elements were also analyzed (Table 6). A visual representation of the results (Figure 7) shows higher concentrations of Rb

Table 2. Summary of Major Element Concentrations by Bead Color.

Element (in ppm)		Black	Blue	Burgundy	Light Green	Olive	Turquoise	White
Si	Min	365,944.64	329,234.64	349,456.56	338,116.27	330,748.79	349,291.87	33,7514.77
	Max	421,721.33	433,631.51	427,669.29	412,790.44	365,509.94	425,005.58	356,348.04
	Median	382,588.79	349,838.69	400,291.52	349,793.46	340,058.22	418,541.74	343,455.55
	Mean	388,702.28	356,738.64	397,282.81	357,993.67	342,193.47	405,472.88	345,342.34
	Std Dev	22,428.01	25,912.12	28,475.17	22,867.72	8,628.94	26,043.08	7,303.45
Ca	Min	665.20	0.00	237.79	705.24	4,026.24	0.00	9,386.52
	Max	7,497.04	24,767.78	14,041.25	15,011.02	18,593.03	3,852.24	19,316.49
	Median	3,628.37	4,885.71	2,379.73	4,092.44	14,217.61	0.00	13,744.19
	Mean	3,608.78	9,088.82	3,297.38	5,544.96	13,153.34	807.98	14,088.18
	Std Dev	2,427.89	7,361.91	4,830.83	4,257.85	3,703.53	1,254.86	2,964.83
K	Min	9,129.51	9,945.69	17,388.18	8,309.54	19,440.00	5,131.01	20,526.73
	Max	36,619.02	85,230.21	52,475.11	52,539.00	41,776.45	28,090.16	40,503.98
	Median	22,673.67	40,701.00	28,488.52	21,692.99	32,207.79	7,135.87	27,394.06
	Mean	21,474.21	51,458.44	32,374.45	24,689.42	31,709.99	10,859.97	28,161.28
	Std Dev	9,423.88	22,439.60	14,321.09	12,022.89	5,758.35	7,354.30	5,962.22
Al	Min	7,997.97	6,692.66	12,563.86	8,745.87	27,048.31	924.05	32,657.90
	Max	42,290.37	156,589.21	57,882.56	62,111.81	41,172.01	28,994.73	45,134.38
	Median	31,148.40	58,582.66	34,564.30	38,580.59	34,368.10	3,489.08	39,560.66
	Mean	27,475.28	66,873.28	32,163.63	35,718.68	33,956.36	8,554.52	38,560.54
	Std Dev	13,489.54	32,614.67	18,841.35	13,653.04	3,667.28	9,684.50	4,879.52

Table 3. Summary of Minor Elements in PPM by Bead Color.

Element		Black	Blue	Burgundy	Light Green	Olive	Turquoise	White
Fe	Min	689.23	164.82	443.77	357.51	698.04	175.78	662.71
	Max	5,141.29	827.18	2,662.23	9,060.42	1,505.09	4,231.28	1,072.76
	Median	1,340.32	524.18	2,235.48	819.52	889.77	211.68	832.45
	Mean	1,836.37	499.11	1,638.52	1,475.35	924.21	607.82	844.00
	Std Dev	1,457.54	136.95	1,038.45	2,396.20	174.31	1,150.43	122.12
Co	Min	0.00	100.74	0.00	0.00	0.00	0.00	0.00
	Max	130.37	1,208.16	552.79	296.91	97.27	116.74	28.90
	Median	30.09	663.91	68.39	0.00	44.57	0.00	0.00
	Mean	44.89	631.28	125.28	28.45	43.86	9.73	6.15
	Std Dev	49.37	245.76	194.40	84.97	25.04	33.70	10.00
Ni	Min	16.36	0.00	25.83	0.00	0.00	0.00	0.00
	Max	1,047.72	273.10	632.80	2,638.30	81.28	908.92	22.62
	Median	51.48	48.53	165.56	9.91	51.89	10.70	16.16
	Mean	175.91	49.06	180.19	237.16	49.86	86.41	14.24
	Std Dev	353.77	39.53	212.28	756.44	18.25	259.28	7.74
Cu	Min	823.29	0.00	475.84	2,831.97	2,843.94	1,003.03	333.68
	Max	16,766.25	3,032.82	26,406.86	25,892.93	4,840.84	13,890.37	989.34
	Median	1,306.44	481.89	9,084.61	5,190.01	3,432.75	1,492.25	425.49
	Mean	3,226.98	547.80	14,215.89	6,437.45	3,551.36	2,870.21	476.89
	Std Dev	5,480.78	325.01	10,720.35	6,269.19	543.06	3,626.23	204.98
Zn	Min	131.37	327.64	0.00	0.00	0.00	0.00	54.70
	Max	2,608.03	4,642.02	1,657.17	11,605.01	2,723.81	1,702.76	1,870.24
	Median	704.87	1,708.53	1,151.75	0.00	545.97	18.93	111.29
	Mean	1,018.56	1,666.66	916.71	1,099.23	715.63	157.83	296.96
	Std Dev	997.65	702.15	701.24	3,320.07	690.22	486.62	590.67
As	Min	0.00	42.03	0.00	53.20	0.00	0.00	0.00
	Max	424.15	235.12	921.24	1,910.41	8,734.17	112.10	420.82
	Median	10.61	110.86	149.14	102.46	2,087.57	79.98	178.78
	Mean	89.60	115.86	326.65	358.65	2,703.53	78.07	211.54
	Std Dev	155.67	35.19	401.04	619.13	2,918.68	26.94	154.32
Pb	Min	49.43	25.86	38.42	0.00	0.00	23.98	145.53
	Max	478.05	101.33	594.81	1,471.38	57.75	367.82	218.44
	Median	123.88	62.36	200.17	46.17	0.00	28.87	180.76
	Mean	179.75	55.95	316.51	159.04	4.07	61.88	178.39
	Std Dev	149.59	17.67	249.15	413.84	14.46	97.25	23.75
Mn	Min	3782.19	0.00	0.00	0.00	0.00	0.00	0.00
	Max	16,744.68	0.00	1,858.01	8,328.22	0.00	2,826.57	0.00
	Median	9,207.85	0.00	0.00	0.00	0.00	0.00	0.00
	Mean	9,659.36	0.00	265.43	694.28	0.00	235.55	0.00
	Std Dev	5,046.18	0.00	702.26	2,404.07	0.00	815.96	0.00
Ti	Min	0.00	0.00	0.00	0.00	0.00	0.00	351.83
	Max	16.04	128.39	0.00	176.44	193.62	0.00	1,053.86
	Median	0.00	0.00	0.00	35.52	11.46	0.00	501.04
	Mean	3.50	8.73	0.00	51.50	35.31	0.00	560.27
	Std Dev	6.05	23.39	0.00	58.56	51.80	0.00	209.49

Table 4. Summary of Trace Elements in PPM by Bead Color.

Element		Black	Blue	Burgundy	Light Green	Olive	Turquoise	White
Rb	Min	22.75	53.23	50.42	21.45	51.23	26.64	79.94
	Max	204.31	457.40	365.47	397.76	240.41	172.84	124.51
	Median	53.79	252.85	194.23	54.98	195.56	40.29	95.94
	Mean	76.53	241.21	206.36	101.75	186.51	64.25	98.33
	Std Dev	61.12	100.63	130.04	107.33	47.35	49.26	13.68
Sr	Min	0.00	0.00	0.00	0.00	0.00	18.15	0.00
	Max	87.13	76.25	76.55	84.04	75.53	78.73	41.85
	Median	71.58	0.00	0.00	73.18	0.00	77.84	12.50
	Mean	50.13	10.72	28.99	55.57	5.85	68.54	14.40
	Std Dev	41.96	20.44	36.60	34.01	20.31	18.70	16.14
Y	Min	3.36	4.40	5.16	3.23	4.79	3.22	9.75
	Max	29.34	88.43	88.24	97.70	153.12	22.36	18.47
	Median	6.20	30.19	21.43	5.33	101.12	3.88	13.15
	Mean	10.20	31.78	38.97	27.05	98.32	6.57	13.34
	Std Dev	8.86	19.90	34.90	39.81	37.96	5.71	2.61
Zr	Min	212.84	252.70	259.23	243.08	242.43	281.02	230.86
	Max	289.58	306.30	305.31	294.44	277.31	307.10	236.64
	Median	266.64	274.61	268.99	272.53	253.41	303.90	232.45
	Mean	258.51	275.47	278.08	270.29	254.77	299.19	232.78
	Std Dev	27.31	10.08	19.65	13.48	8.88	9.11	1.95

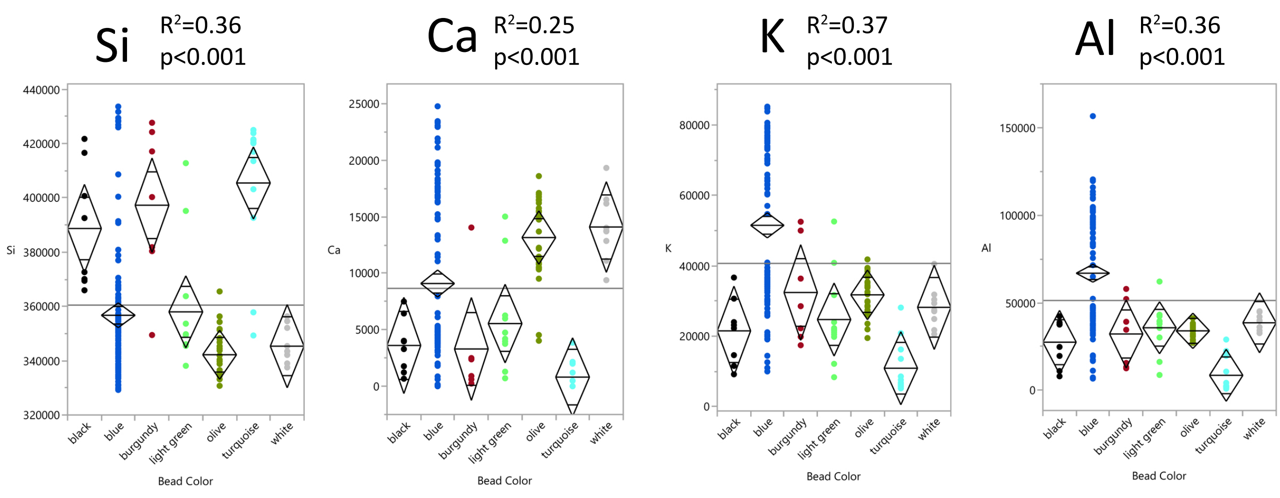

Figure 5. Box plots for major forming elements Si, Ca, K, and Al by bead color. Gray horizontal line is the mean for all beads. Each diamond shows the mean and standard deviations for each bead color.

in blue and burgundy beads. Concentrations of Sr are below the mean for blue, olive, and white beads. Only the olive beads have concentrations Y above the mean and are widely distributed. Concentrations of Zr in all colors have wide distribution, with white beads all falling well below the mean.

In summary, XRF analysis indicates that Prosser molded bead colors have specific combinations of diagnostic major, minor, and trace elements that appear as either intentional additions to recipes or as natural geochemistry of the raw materials used. The absence of some elements in specific colors and presence in others indicate that that element

Table 5. One-Way ANOVA Statistics for Minor Elements in All Bead Colors.

Element	Mean	F Ratio	DF	P
Fe	759.62	7.96	6	<0.001
Co	382.277	65.99	6	<0.001
Ni	73.75	2.00	6	0.07
Cu	2213.19	30.00	6	<0.001
Zn	1255.27	6.97	6	<0.001
As	524.19	18.80	6	<0.001
Pb	77.97	9.31	6	<0.001
Mn	513.01	78.99	6	<0.001
Ti	42.59	141.98	6	<0.001

was likely added deliberately to manipulate color. Grouped patterns of concentrations in basic elements indicate that distinctions can be made between manufacturing events that reflect either a difference in recipe, or a difference in raw material source. I explore these patterns in greater detail below.

ANALYSIS

The purpose of this study is to determine whether an examination of elemental composition of Prosser molded beads can provide information on the geographical origins of

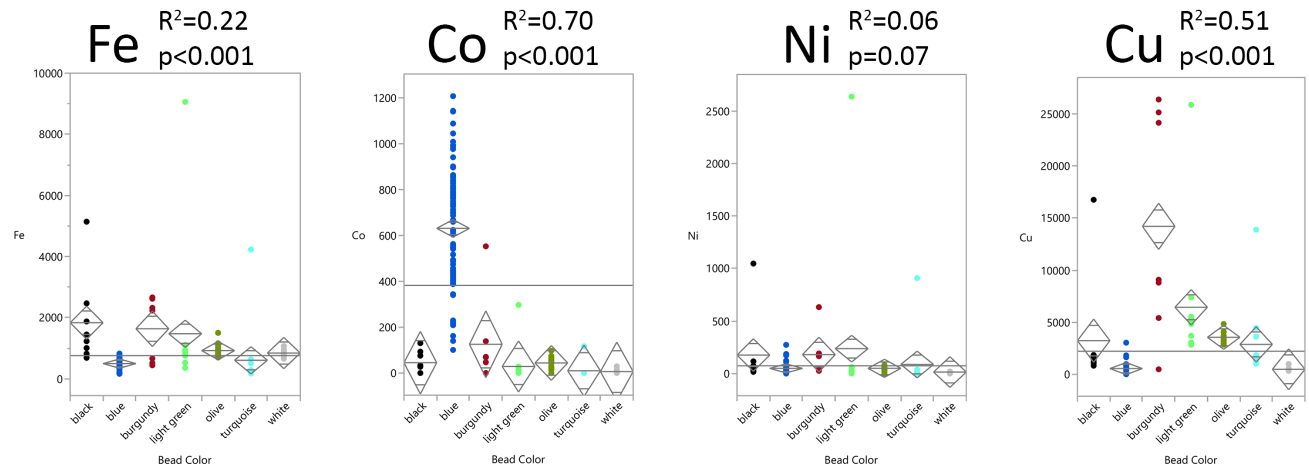

Figure 6a. Box plot charts for minor elements Fe, Co, Ni, and Cu by color. Gray horizontal line is the mean for all beads. Each diamond shows the mean and standard deviations for each bead color.

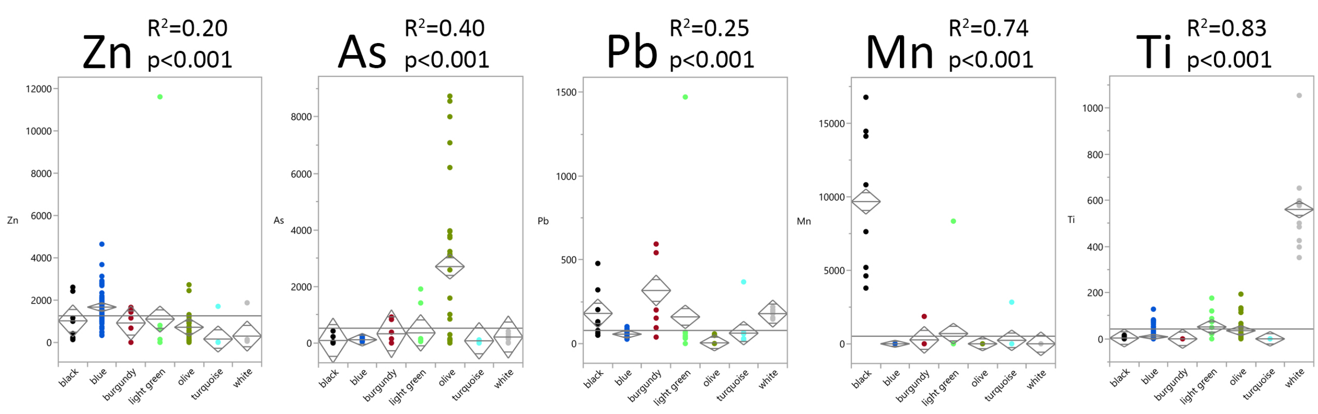

Figure 6b. Box plot charts for minor elements Zn, As, Pb, Mn, and Ti by color. Gray horizontal line is the mean for all beads. Each diamond shows the mean and standard deviations for each bead color.

the raw materials used to make the beads, thereby helping to identify the location and perhaps time of their manufacture. To this end, I will examine the elements in three different groups: the major elements in feldspar (Si, Al, Ca, and K), the trace elements, particularly rubidium and strontium, which commonly replace K and Ca in feldspar, and lastly, I

Table 6. One-Way ANOVA Statistics for Trace Elements in All Bead Colors.

Element	Mean	F Ratio	DF	P
Rb	195.38	15.03	6	<0.001
Sr	19.71	20.17	6	<0.001
Y	37.92	34.19	6	<0.001
Zr	270.82	41.11	6	<0.001

will examine the elements commonly added to glass recipes as coloring agents. These three analyses will identify which elements have significant variation that can be interpreted as diagnostic of provenance.

Feldspar is an aluminosilicate mineral that consists of Al, Si, and a third alkali element, usually Ca, Na, or K. The ratios of Si to Al vary from 1:1 to 3:1. The predictable chemistry of alkali feldspar provides a way to compare elemental contents of beads to suggest whether raw material sources for each bead are similar. From the distribution chart showing each of the four elements in the collection (Figure 8), we can see that the ratio of Si to Al is roughly 7:1, indicating that all the beads were made with the addition of quartz sand to feldspar, as feldspar alone would not have more than 3:1 ratios of these elements, and kaolin clay ratios are generally 1:1 to 2:1 (Ross and Kerr 1930). Each of the four elements shows a wide distribution in beads with concentrations above the mean, with Si showing numerous high outliers. While it is impossible to determine how much of the Si exists as the result of sand versus feldspar, the ratios indicate that the combination of the two minerals was the main part of the bead recipe as expected. Applying a smooth curve fit to the histograms reveals that each element has bimodal distribution (Figure 9), suggesting two potential provenances.

To evaluate each of the four elements in relation to each other, a scatterplot matrix was created (Figure 10). Each scatterplot shows distinct bead clusters, with a strong positive linear relationship between K and Al where the two clusters are clearly separated between low K (K<50,000 ppm) and high K (K>50,000 ppm). Selecting only the beads in the high K group demonstrates that these beads have distinct characteristics that are illustrated by their groupings in each of the other plots (Figure 11). The high K bead group consists of fifty blue beads, two burgundy beads, and one light green bead. In the following discussion, this distinct cluster of beads will be referred to as the "high K" beads and will be the same beads that are shown highlighted in subsequent figures.

Plotting K, Al, and Si in a ternary plot (Figure 12) shows a linear pattern with the high K beads showing decreased amounts of Si as K increases. Replacing Ca for Si on the plot, however, shows distinct bead groupings, with the high K beads grouped in a lower Ca content cluster.

The grouping patterns in the statistical comparisons of beads in the context of Si, Al, Ca, and K strongly suggest variation in either basic recipes of the beads or distinct sources for feldspar as a raw material if the ratios of feldspar and quartz sand remain constant. In addition to Ca and K, alkali feldspars also may contain Na, and it is noted that the lack of data for this element is a weakness in this analysis. Nevertheless, the strong associations between Al and K indicate that some differentiation in manufacturing process (recipe or source) can be distinguished.

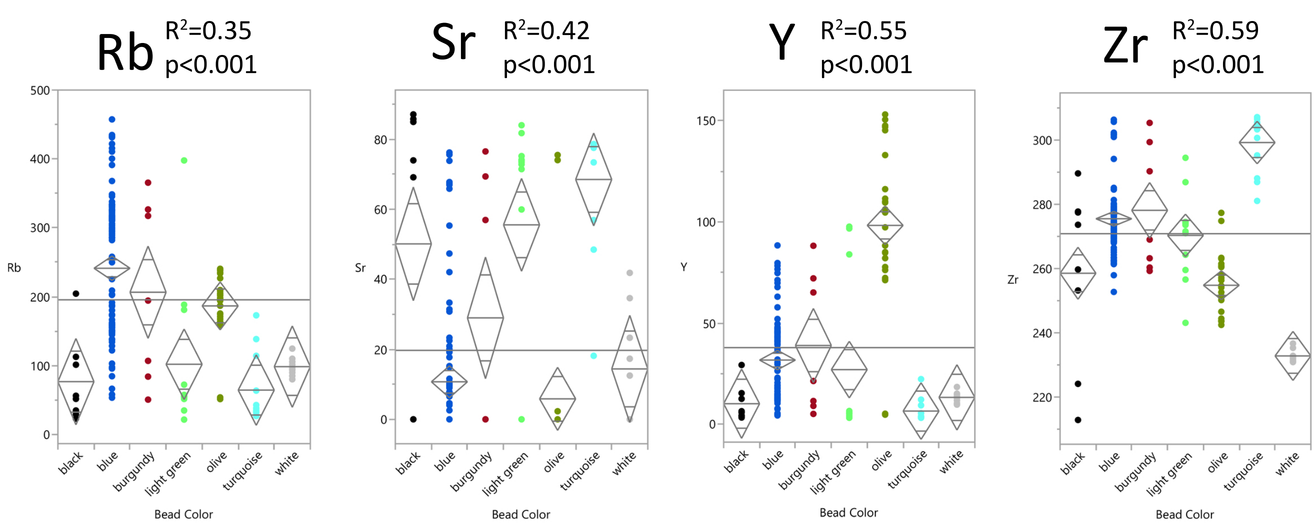

Figure 7. Box plot charts for trace elements Rb, Sr, Y, and Zr by bead color. Gray horizontal line is the mean for all beads. Each diamond shows the mean and standard deviations for each bead color.

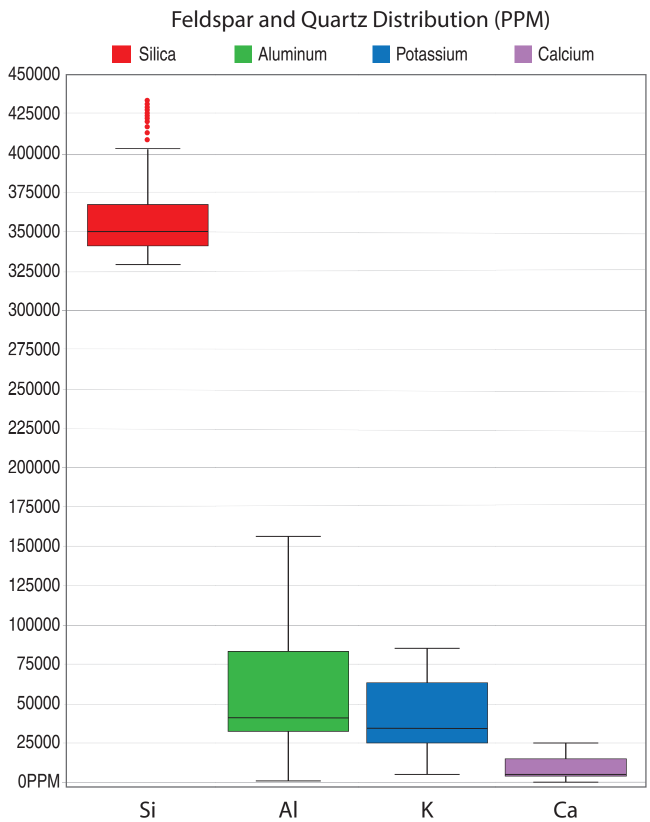

Figure 8. Comparison of quantified concentrations (ppm) of Si, Al, K, and Ca.

In alkali feldspar, other trace elements may occasionally replace the Ca/Na/K position in the chemical structure through various natural geologic processes (Ribbe 1975). Rubidium, for example, can replace K, or Sr can replace Ca, resulting in feldspar with distinct ratios of these two elements (Heier 1962). The four mid-Z elements (elements with a mid-range atomic number) Rb, Sr, Zr, and Y are typically associated with volcanic material and are considered sensitive provenance indicators for obsidian (Glascock 2020). In the case of Prosser molded beads, they may appear in relation to the feldspar and in contrast to the alkali components analyzed above. The relationships between these four trace elements are first examined in a scatterplot matrix (Figure 13a). Strong clustering patterns can be seen in each comparison, suggesting that the relationships between the four elements are not random. Figure 13b is the same scatterplot matrix but the high K beads are highlighted. In each scatterplot, these beads maintain their clustered relationship, suggesting that their variation is correlated.

Principal component analysis (PCA) can be used to further understand the relationship between the mid-Z elements of Rb and Sr and the K and Ca they may replace. These four elements are combined to create a visual representation of how their variability is correlated (Figure 14). Rubidium and K have vectors that are very closely aligned, indicating that they are strongly correlated. Strontium and K, however, have vectors that appear at approximately right angles to Rb and Sr as well as to each other, indicating they are not correlated. The accompanying PCA scatterplot shows that the high K beads previously identified are grouped in the lower right quadrant. Two other clusters are shown, which suggests the presence of at least three groups that co-vary.

Major elements and trace elements appear because of natural occurrences in the raw materials, but coloring agents occur as the result of deliberate decision-making by the manufacturer. Beads of the same color made in the same place with the same raw materials and recipe should have consistent amounts of coloring agents for each color. Otherwise, variation of these elements suggests some intentional difference at the manufacturing level. Color variations in glass are obtained using various elements. Co and Cu are most used for blue and green, and combinations of the two elements can produce a variety of shades. Zinc and Ti may be used to produce white, and iron can produce red colors. Beads of the same color are expected to contain similar amounts of coloring agents to obtain similar colors.

In a scatterplot matrix of these elements (Figure 15), we would expect that beads of the same color would fall into groups reflecting the intentional coloring of the material. While the olive-green beads indeed seem to group together, blue and white beads show wide variation in Co and Ti respectively, and burgundy beads show wide variation in Cu content. Since the coloring elements are intentionally added to the bead mixtures, significant variation must also reflect intentional differences. The blue beads have been shown to appear in at least two clusters in the previous elemental analyses (see Figures 10, 11, 12, 13 and 14). This distinction is shown clearly in a bivariate plot of Co against K, a major element in feldspar which has been shown above to impact variation (Figure 16).

Since coloring agents are added with intention rather than occurring naturally, the color of the beads can be used as a control variable in the analysis of other elements. Returning to the ternary plot of the major elements Al, Ca, and K, the blue beads are seen to divide into two distinct groups (Figure 17). Each group of blue beads has different amounts of Co, which does not visually influence the color. Nevertheless, the beads with lower K also have lower Co content, and the high K beads have higher Co, as shown in Figure 17 by the histograms for each, indicating co-variance.

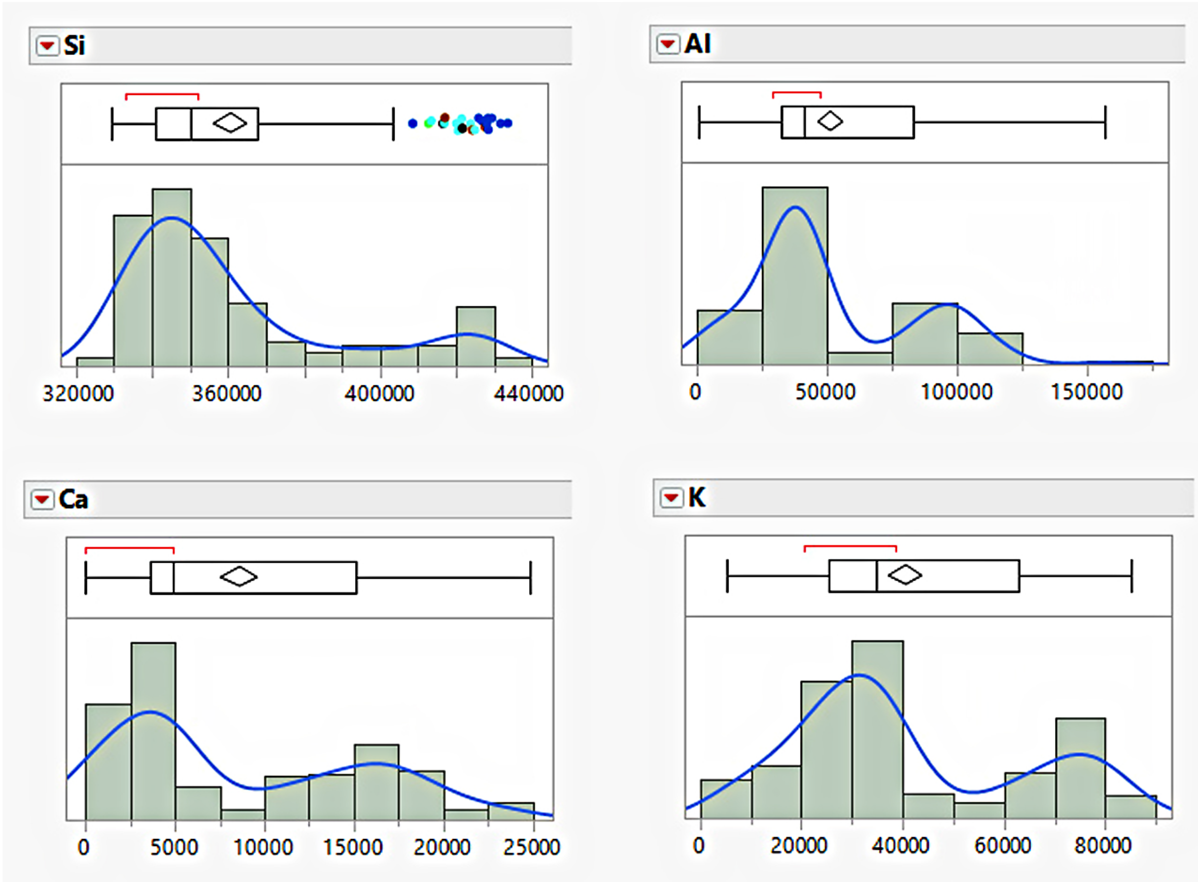

Figure 9. Histograms showing parts-per-million of Si, Al, Ca, and K. The graphs include a smooth curve fit line and horizontal box plot of distribution above each histogram.

DISCUSSION

The above analysis demonstrates that at least two and probably three chemically distinct groupings exist in the analyzed bead sample. Several possibilities can be considered to explain why these distinctions exist. Variation in raw materials occurs naturally which might reflect different raw material sources. For example, after World War II, the Bapterosses factory sold the Norwegian feldspar mine and turned to more local sources (Nourisson 2001). Additionally, deliberate addition of elements to satisfy color recipes could indicate distinct manufacturing practices of different factories and may correspond to various raw material sources. Recipes would likely vary from one company to another but may also vary within one company. Internal adjustments could occur over time as recipes were refined, as access to resources changed, or even as workers were more or less consistent in their practice.

Naturally occurring elements in feldspar exist because of variation in geological formations and are expected to represent various raw material sources as opposed to intentional variation resulting from different recipes. Ratios of various major, minor, and trace elements should be consistent in beads from the same factory using the same raw material source and recipe. The Bapterosses factory in Briare owned a feldspar mine and imposed strict quality controls on bead production (Nourisson 2001). The Redlhammer factory in Gablonz made multiple changes to factory operations (Neuwirth 2011), suggesting that quality control and raw material sourcing was less important to the final product. As a result, beads from Briare might be expected to show element relationships that are more tightly grouped, and beads from Gablonz may have more variation in the same relationships. Without examples from each of the two factories it is not possible to verify that patterns are associated with one location or another. Nevertheless, distinct groupings of elements that persist in individual beads across elemental comparisons indicate that distinction can be made.

The grouping of the same beads in different analyses reflects concordant variation that indicates these beads are chemically distinguishable. In each of three analyses, bivariate comparisons revealed elements that either had

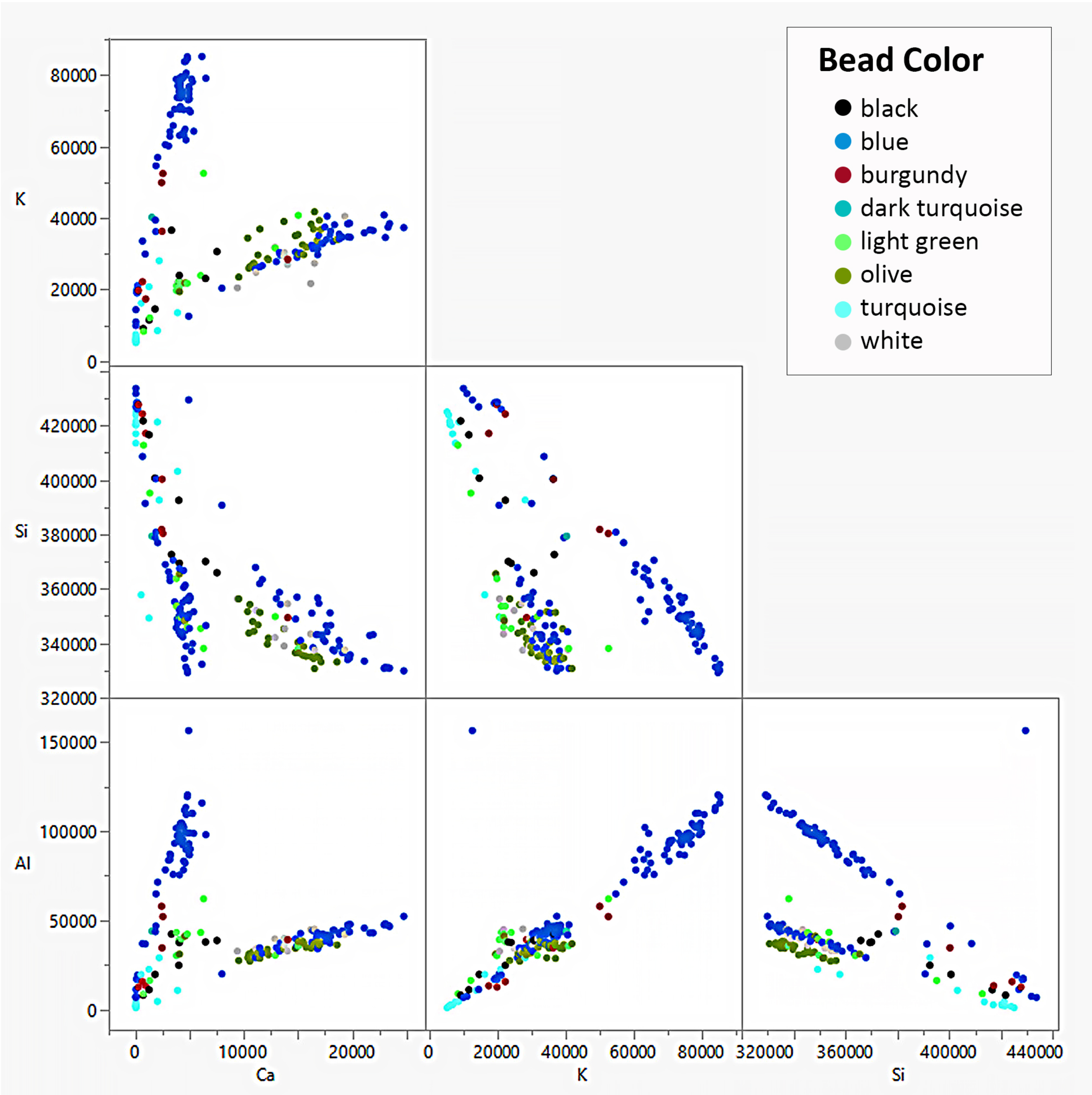

Figure 10. Scatterplot matrix showing relationships of Si, Al, Ca, and K. Dot colors represent bead colors as shown in legend.

strong linear relationships, or that varied in opposition. Potassium and aluminum were found to have a strong positive linear relationship, suggesting that their variation was linked chemically. Strontium had an opposite relationship to other trace elements analyzed. Rubidium strongly corresponded to the variation in K, while Sr and Ca were not correlated in the PCA. Blue beads colored with a wide variation of Co served to demonstrate that the variations existed independent of recipes for color.

CONCLUSION

Detailed quantitative analysis shows patterns of concordant variation in elemental composition among the 175 beads evaluated. While more than two groups seem to exist, a distinct group of 53 beads show concordant variation across multiple chemical configurations. These 53 beads retain their elemental relationships in a consistent cluster across multiple statistical analyses.

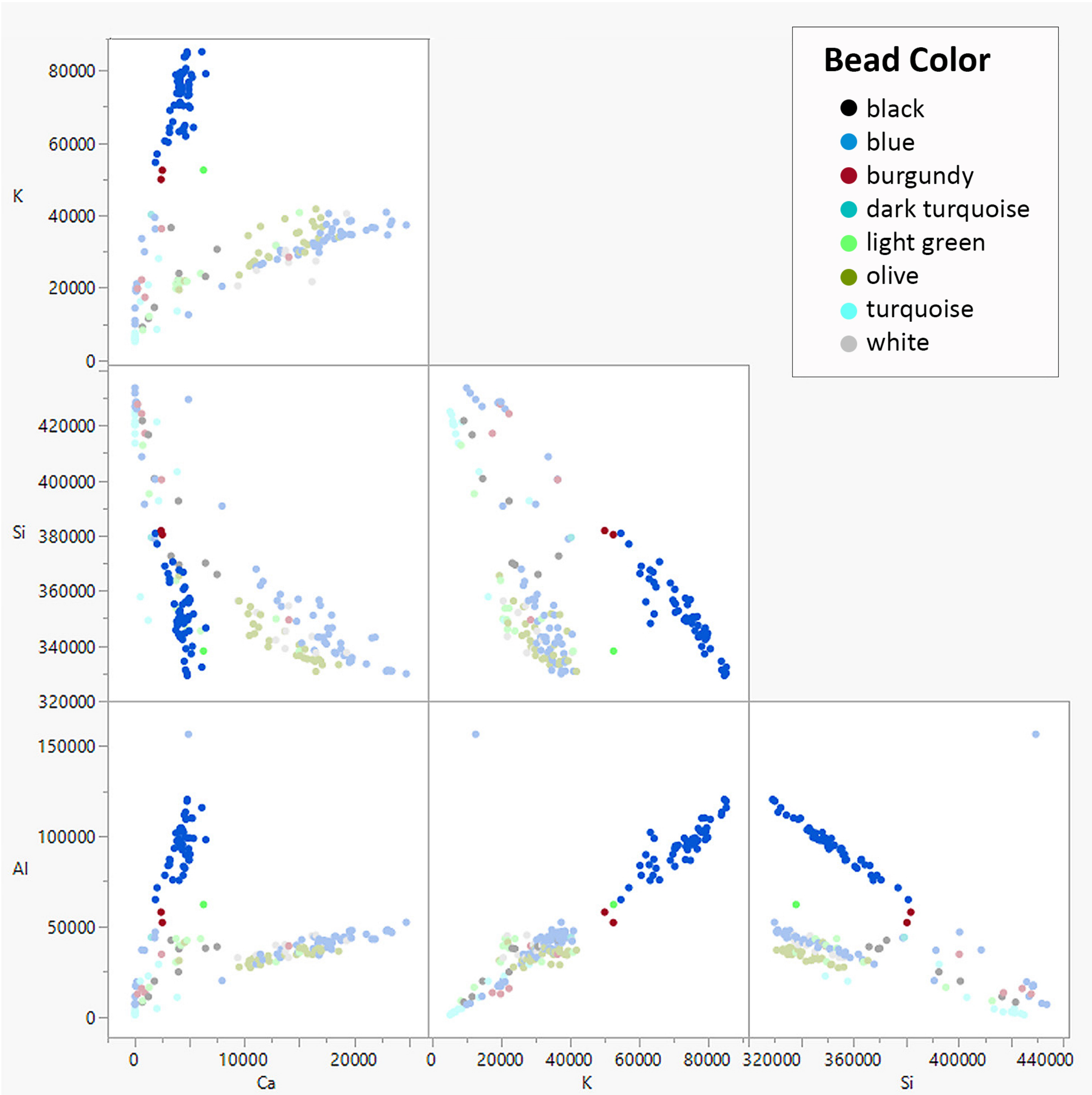

Figure 11. Scatterplot matrix showing relationships of Si, Al, Ca, and K. Highlighted dots represent high K beads (n=53) as determined by the bottom middle plot of Al and K. Dot colors represent bead colors as shown in legend.

This group of distinct beads, and other potential clusters shown in the graphs, are the result of either different raw material sources, or different manufacturing practices. Further study of Prosser molded beads using XRF with a helium flush to include detection of sodium will provide additional insight into these analyses. Additionally, beads with known provenance can be assessed to determine if variations exist at the inter-factory level, or if they are specific to each manufacturing location.

Given these results, it is a reasonable conclusion that with further study and development, elemental models may be created that will provide researchers a way to establish provenance of Prosser molded beads using XRF technology in the field. Pre- and post-WWII time periods may also be distinguished. Such models will provide valuable insight into manufacturing, material procurement, and international distribution and sales practices in the 19th and 20th centuries across three continents.

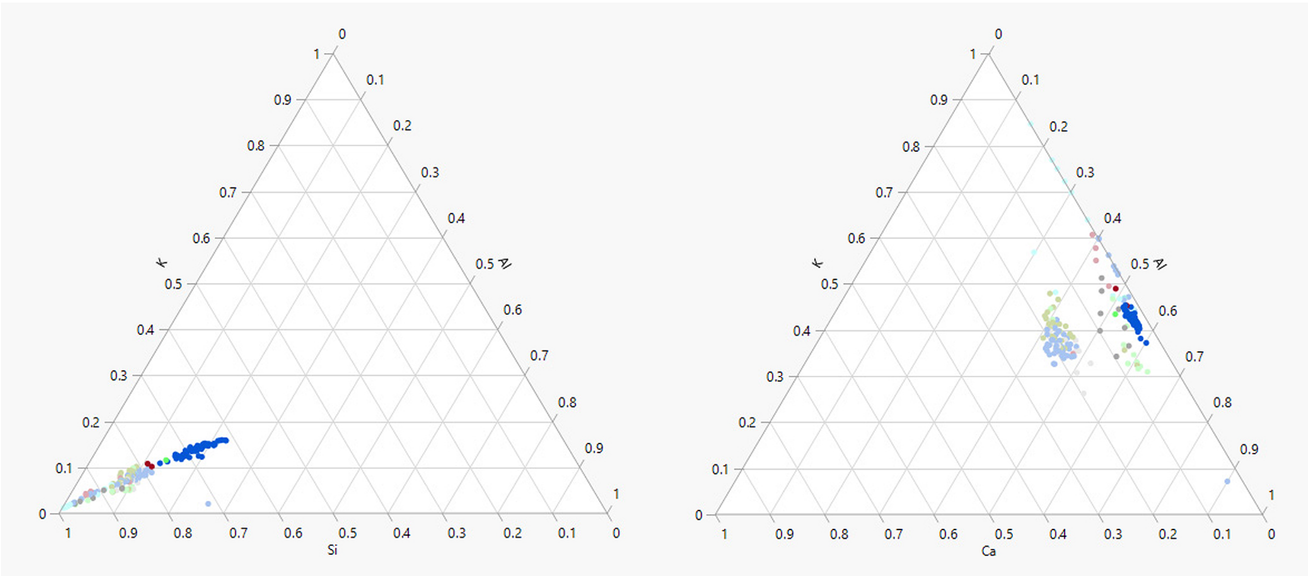

Figure 12. Ternary plot of K and Al over Si (left) showing linear relationships and ternary plot of K and Al over Ca (right) showing two distinct clusters of data. High K beads as defined previously are highlighted and dot colors represent bead colors as shown in legend in Figure 11.

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I would like to thank Dr. Bruce Kaiser for his help, training, and support and for allowing me to use his Bruker Handheld XRF instrument under his supervision. I also thank Dr. Richard Shipley for making his bead collection available for study and for cheering me on. Additionally, Dr. Elliot Blair from the University of Alabama provided support and insight in the use of the XRF, including access to standards and suggestions for research, which were greatly

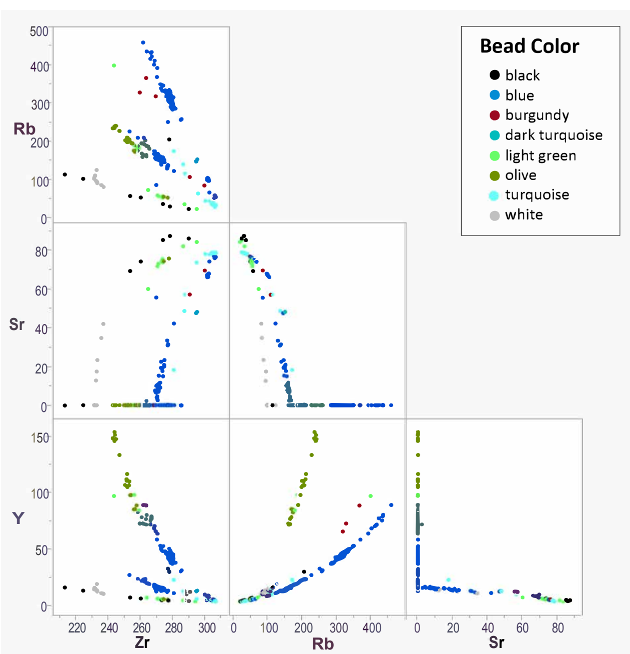

Figure 13a. Scatter plot matrix showing comparisons of trace elements Rb, Sr, Zr, and Y. Dot colors represent bead colors as shown in legend.

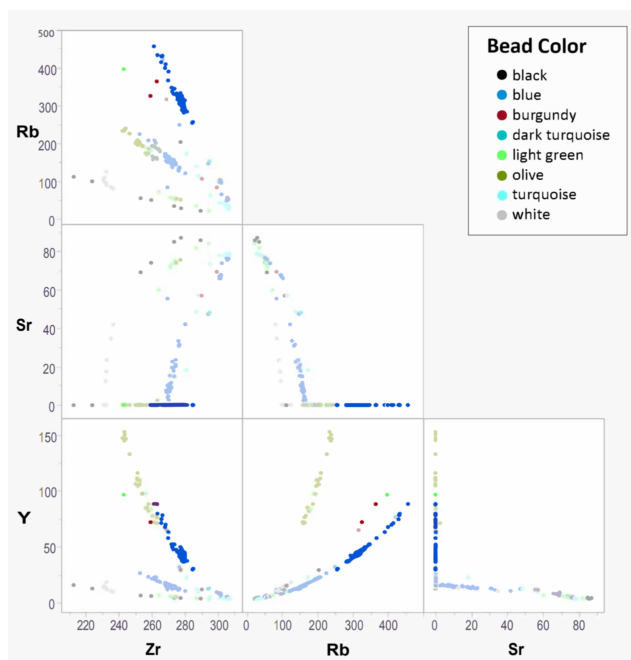

Figure 13b. Scatterplot matrix showing comparisons of trace elements Rb, Sr, Zr, and Y. High K beads as defined previously are highlighted and dot colors represent bead colors as shown in legend.

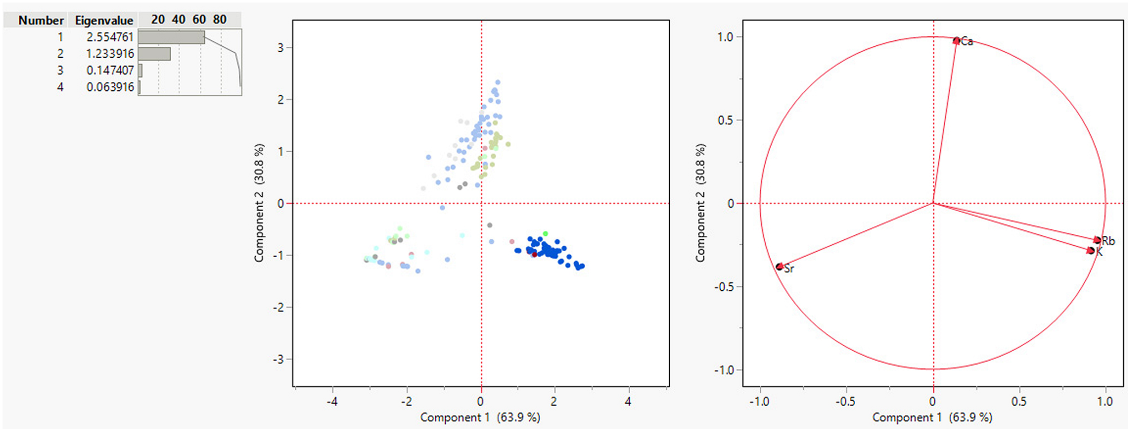

Figure 14. Principal component analysis of Rb, K, Sr, and Ca. Strong correlation is shown between Rb and K, while Sr and Ca, with vectors at approximately right angles are not correlated. Highlighted beads on the scatterplot are the same high K as previously noted and dot colors represent bead colors as shown in previous legend.

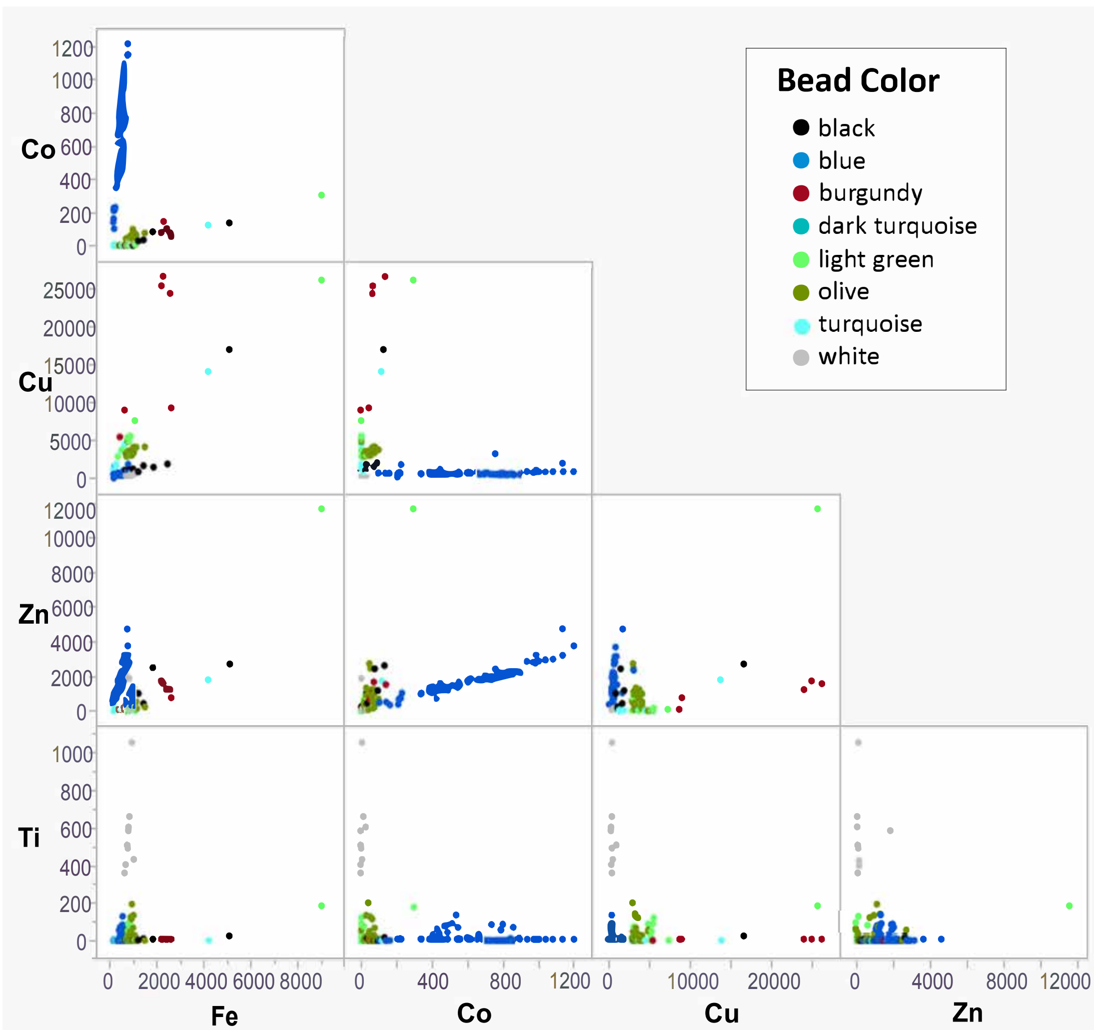

Figure 15. Scatterplot matrix of coloring elements Co, Cu, Zn, Ti, and Fe. Colors of beads are tightly grouped except for blue beads, which have high variation of cobalt. Dot colors represent bead colors as shown in legend.

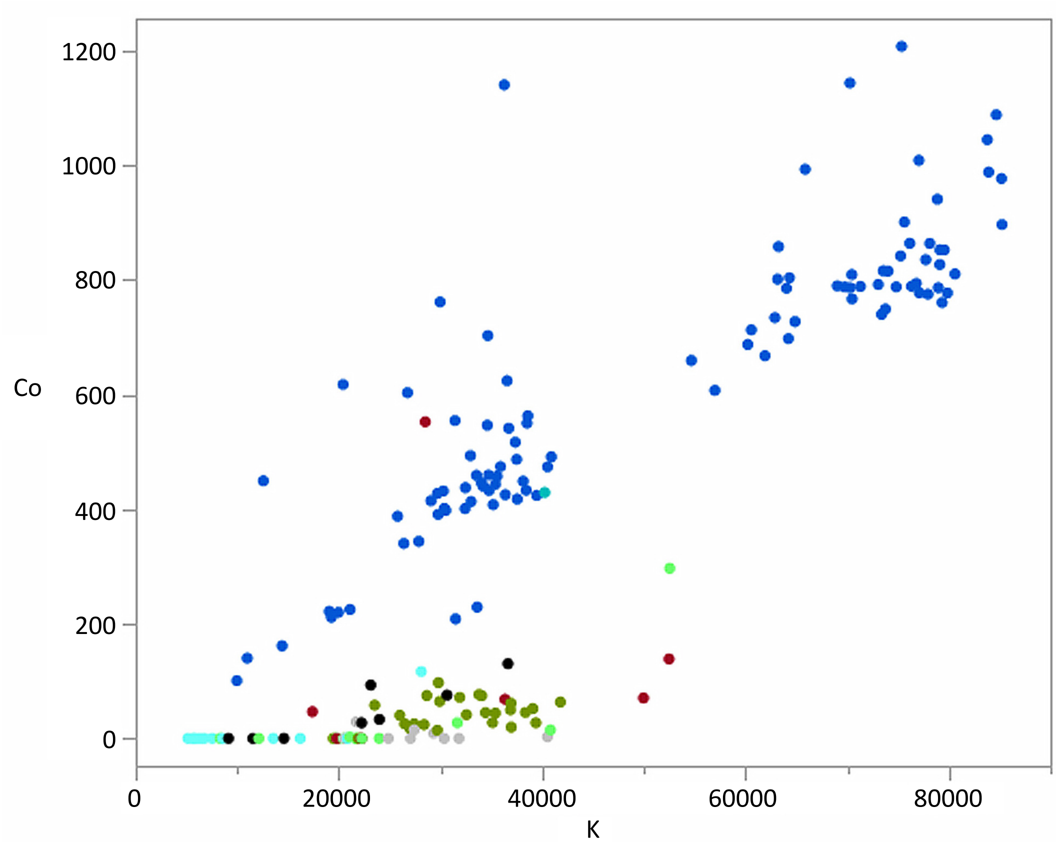

Figure 16. Bivariate plot of Co and K. The dot color corresponds to bead color. Two distinct groups of blue beads are evident, one with higher and one with lower K content.

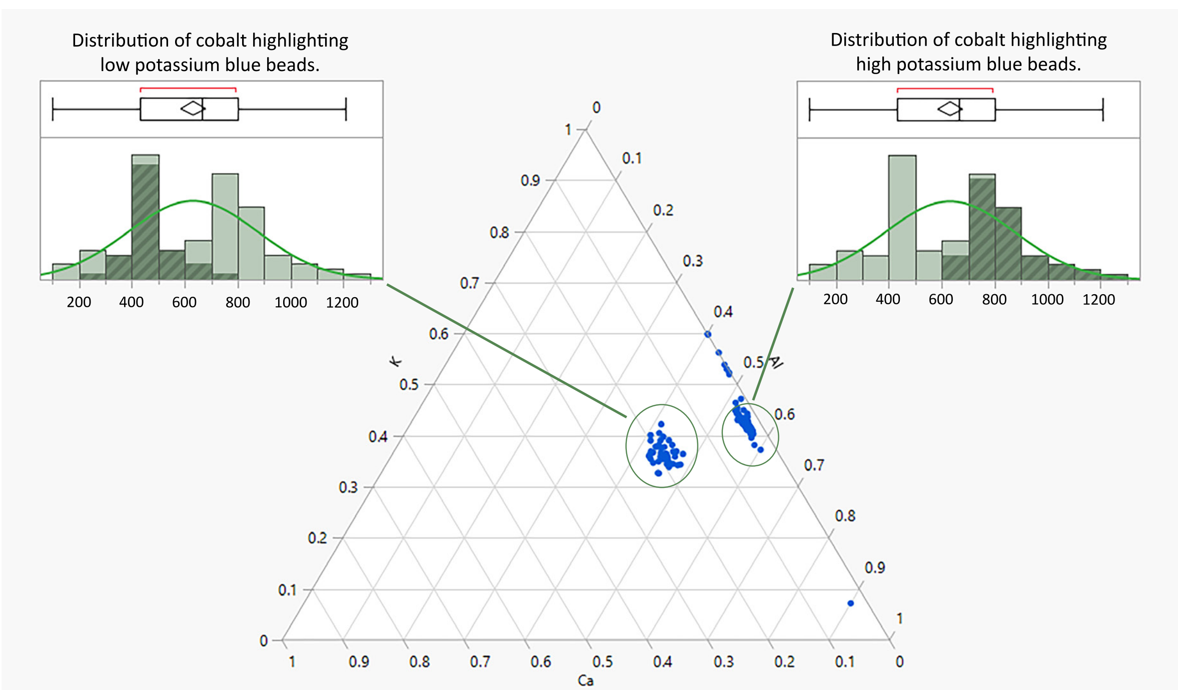

Figure 17. Ternary plot of K and Al over Ca showing variance of blue beads only with cobalt distribution. The histograms show sub-distribution (hatch-marked) of cobalt for the respective cluster of beads as indicated.

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STRONG CONTRASTS: BEADWORK FROM THE OKAVANGO

Michael Oehrl

With its black and white contrasts and interplay of positive and negative spaces, the beadwork of the Mbukushu and Yei of Botswana brings to mind the geometric designs of Op Art. In some pieces the pattern creates an almost three-dimensional effect. Because of their attractiveness and rarity, such works now fetch considerable prices on the art market. However, it is always difficult to distinguish between the works of the two peoples, whose style was also decisively influenced by a third people, the Tawana. Rudolf Pöch's Tawana collection at the Weltmuseum Wien is used to demonstrate the mutual influence of the material culture of three peoples living in close proximity at the beginning of the 20th century.

Figure 1. Mbukushu apron, Botswana, dimensions unknown, private collection (photo: Jacaranda Tribal).

INTRODUCTION

The visually striking beadwork (Figure 1) of the Kavango peoples in Botswana, Namibia, and Angola are poorly represented in literature and museum collections and only a few pieces are fully documented. Technical details and the type of glass beads, which could serve to differentiate between them, are similar in all works. The present paper aims to compile the limited facts and to show the interrelationships between the Kavango peoples and the Tawana in this area of material culture.

Historical descriptions of the Mbukushu and Yei and their beadwork

The Mbukushu and Yei[1] are two Bantu-speaking peoples who settled mainly in the area of the Okavango River and Lake Ngami, into which it flows (Figure 2). They, along with the Gciriku, Mbunza, Kwangali, and Sambyu, make-up the larger group of Kavango peoples.

The Yei migrated from the Zambezi region as early as the mid-1700s, with the Mbukushu arriving some 50 years later; both peoples initially lived and intermarried with the country's indigenous San groups. Yei and Mbukushu had separate areas of habitation. Even where they came into closer contact, they lived on different riverbanks and islands or at least had separate settlements. Despite a common origin, their languages are distinct and not mutually intelligible (Larson 2001:17). Hostilities were rare, as was intermarriage. In the 19th century, Yei and Mbukushu were subjugated by the Tawana, who conquered the region at that time (Eckl 2004:70f.). The dependence of the Mbukushu was mitigated by the fact that members of their matrilineal royal clan served the Tawana and the peoples of the neighboring regions as vital and feared "rainmakers." This protected the Mbukushu from attack, gave them political influence, and enriched their elite through tribute payments (Gibbons 1904:213; Larson 1970:32; Shiremo 2009:68).

The first written mention of the "Bayeiye" (Yei) people was in 1849 by the Scottish explorer and missionary David Livingstone (1857:64), in his descriptions of his journey to Lake Ngami, where they formed the majority of the

Figure 2. Map of the Okavango region in northwestern Botswana (map: M. Oehrl).

population. He described them as peaceful and utterly unfit for war, leading the Tawana to refer to them as "Bakoba", or "slave."[2] According to Livingstone, they subsisted mainly on fishing and the occasional hippopotamus kill. The Swedish-English explorer Charles Andersson, who traveled through the area of present-day Botswana between 1850 and 1854, described the women's short leather aprons as "richly covered with beads and all kinds of ornaments of brass, copper, and iron" (Andersson 1858 [2]:254). Andersson believed that the Yei had adopted this costume from their masters, the Tawana, and depicts a "Bayeye" couple (Figure 3) whose beaded jewelry appears very sparse (Andersson 1856:481,502).

Another account of a journey through southwest Africa was penned by the Swiss botanist Hans Schinz, who traveled in the region from 1884 to 1887. The "Bajeje" women he observed wore a fur piece around their hips and a larger cape-like one around their necks. A "narrow fringed apron decorated with glass beads covered their private parts" (Schinz 1891:378). The geographer and geologist Siegfried Passarge also believed, like Andersson, that the Yei costume was adopted from the "Betschuana" (Tawana), although the concept of leather clothing is similar throughout southern Africa. Passarge also encountered the Mbukushu on his expedition, but his description of the leather clothing of the

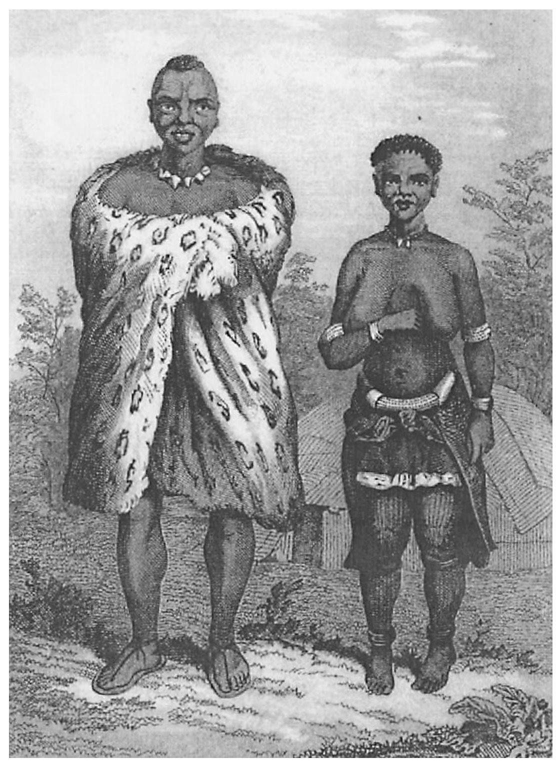

Figure 3. "Bayeye", illustration by Andersson (1856:481) (photo: M. Oehrl).

Mbukushu in 1898 is not nearly as descriptive as that of Thomas Larson seventy years later. Passarge refers mainly to the strikingly decorated hairstyles of the women but does not mention any extensive beadwork on their aprons (Wilmsen 1997:290f.).

The Tawana

No description of the region would be complete without the Tawana. They belong to the Tswana, the majority population in the area and the namesake of today's Botswana, who are closely related to the Sotho people of South Africa. The Tawana split off from the Ngwato, another Tswana sub-group, at the end of the 18th century due to succession disputes and sought new areas of settlement in the northwest of present-day Botswana (Larson 1989:25; Schinz 1891:380f.). Contemporaries described them as warlike and known for their use of firearms. By creating a centralized state, the Tawana quickly succeeded in subordinating the Yei and Mbukushu. The Tawana referred to the Yei as "dependents" or slaves who served the Tawana as cattle herders and agricultural laborers. They also had to make payments and levies and were auxiliary troops of the Tawana in the event of war. The Mbukushu enjoyed greater independence, partly because of their work as rainmakers, and partly because they lived at a greater distance from the Tawana.

The Tawana had early access to glass beads, which they used as jewelry and status symbols. Contacts with traders from the Cape Colony via eastern Botswana began around 1840. As early as 1858, Andersson quotes the Tawana chief Letcholètébe I, who lived at Lake Ngami, with the "rather crude but significant" statement that beads were no longer in demand because "the women grunt like pigs under their burden" (Andersson 1858[2]:223). The beads were brought to Lake Ngami from South Africa in large quantities and were, along with weapons, the main trade goods, mostly in exchange for ivory from supplies of neighboring tributary peoples. Small beads, in the colors of "light red, matte white, light green, brick red, light blue, dark blue, and yellow" were preferred (Andersson 1858[2]:223).

A larger number of Ngwato objects from the end of the 19th century have survived and are quite typical in their pink and blue coloration. In contrast, few examples remain from the Tawana themselves. The collection of 170 Tawana objects (of which about 27 are beadwork) compiled in 1908 by the Austrian explorer Rudolf Pöch is therefore an important source of evidence. In 1936, his estate was catalogued by Walter Hirschberg, who published a book on Pöch's expedition to the Kalahari and Ngamiland in 1907-1909. From 11 September to 13 October 1908, Pöch was with the Tawana in Tsau, their main town north of Lake Ngami, and in his travel diaries he emphasized the accuracy of the documentation of the objects collected: "[t]he name in Secwana, the method of manufacture, and the use were determined for all of them" (Hirschberg 1936:26). Hirschberg describes the clothing of the Tawana and the front aprons of the girls and women as follows:

> The women wear a front apron of leather or beads (khiba) [...]. The khiba, the women's front apron, is usually decorated with beautifully patterned beads. Leather strips are used to tie it. There is also a trapezoidal front apron made of springbok skin. The back apron (massis) is sewn together from either goat, springbok, pallah, or sheepskin. The girls' khiba consists of a strip of leather trimmed with blue and white glass beads and a leather fringe. A leather belt trimmed with white and dark blue glass beads and decorated with glass bead cords in the same colors holds the khiba in place" (Hirschberg 1936:27).[3]

One apron, with accession number 86156, is described as "with MaKuba pattern" (Inventarbuch Weltmuseum Wien). Makuba or Makoba was a derogatory Tawana term for the Yei. Pöch collected ten Tawana front aprons not illustrated in Hirschberg's publication, several undecorated leather back aprons, and a large number of other beadwork pieces, some of which are described and illustrated.[4] The front aprons range in size from 13 × 14 cm to 48 × 38 cm and are simple and restrained, with black, white, and sometimes red beads. The glass beads are not sewn onto the leather but are woven into a beaded fabric (Figure 4). The works came to what is now the Weltmuseum Wien (World Museum in Vienna) in 1909 (acc. nos. 86145-86151, 86154-86156).

In terms of coloration, the frontal aprons form a separate group within the Tawana works as a whole. Other Tawana beadwork often uses blue beads, which do not appear in the aprons collected by Pöch. On the other hand, the surviving body of work is too small to make definitive statements. Three of these aprons with black and white zigzag patterns (acc. nos. 86145, 86147, 86150) are similar in every detail to two aprons collected in the region by the Frenchman Jacques de Rohan-Chabot and the German Victor von Frankenberg. Von Frankenberg's example, with a striking zigzag pattern of red and white beads ("Koba, Yeye"), is now in the Ethnological Museum in Berlin (Figure 5). The entry in the museum's inventory book states that the piece ("*mussisse oa sifaha*") was made by a Majei woman, but that the type of work originally came from the Majambo people on the Okavango River. The identity of the Majambo cannot be further verified. In 1912 when the apron was collected, Victor von Frankenberg, who at times

Figure 4. Tawana apron, Botswana, 48 x 38 cm, before 1908 (courtesy of the Weltmuseum Wien, acc. no. 86154, photo: KHM Museumsverband Wien).

held the officia post of a "Resident" (an administrative German official who gave support to the local ruler), was engaged in surveying work in the Caprivi Strip, east of the Okavango (Moser 2006:122). The dark blue and white bead specimen now in the Musée du quai Branly (acc. no. 71.1912.15.252) was collected by the explorer Rohan-Chabot during the 1911–1914 expedition to Angola and the Zambezi River that bears his name. The attribution to "Angola" remains imprecise.

Figure 5. Yei apron, Namibia, 22.5 x 38 cm, before 1912 (courtesy of the Ethnologisches Museum Berlin, acc. no. III D 4021, photo: Myriam Perrot).

Thomas Larson's investigations among the Mbukushu in Botswana after 1950

The American ethnologist Thomas Larson produced several publications detailing the results of his research visits to Botswana, such as his monograph on the Mbukushu, whom he called "the rainmakers of the Okavango" (Larson 1970:38; 2001). He mentions that during his fieldwork in 1950, all Mbukushu women and most men were still dressed traditionally. Women wore particularly elaborate plaited hairstyles consisting of a crown bulge from which strands of artificial hair decorated with cowries and glass or ostrich eggshell beads hung (Figure 6). In later years, these headdresses were often removable and were also made for sale (Larson 2001:23). During Larson's later visit to Ngamiland in 1969, a few old women still wore hairstyles in the old form, although they were removable.

Larson emphasizes the great importance of beadwork in the matrilineal society of the Mbukushu, where a month-

Figure 6. Detachable Mbukushu hairstyle, Namibia, dimensions unknown, private collection (photo: Ezakwantu).

long initiation ceremony was held for girls at which beaded jewelry designed by the young girl's grandmothers and other female relatives was presented (Larson 1975:118). If the girl was married immediately afterwards, as was customary, the groom's family gave the bride a back apron as a gift. Women also wore a necklace called a *mande* (*mpande*) made from the disc-shaped operculum of a "large river mollusk" (Larson 1975:118) or imitations of these opercula made in Europe. Such valuable pieces, often inherited, were attached to thick strands of glass beads and were considered status symbols. Other jewelry included strands of beads (*ufa*) worn around the chest. Numerous strands of ostrich eggshell beads were also given as gifts to the bride by her relatives (Larson 1979:35f.).

Larson does not mention any decoration of the leather front apron (Larson 2001:125). He also does not explicitly mention the ostrich eggshell and glass bead belts for which the Yei were known. With regard to the Mbukushu's ceremonial jewelry, he merely states that ostrich eggshell beads were used for belts. He does, however, depict some Mbukushu women with heavily decorated back aprons (Figure 7). The leather *majambaro*[5] back apron was richly decorated with glass beads, usually in six wide bands (2001:24,119). It remains unclear from his photographs whether all the glass bead panels were attached to the apron or whether some were separate (Larson 1970:5; Larson 1975:119; Larson 2001:133). Larson points out that by 1969, the back aprons were no longer everyday wear but were only worn for his photographs. Only the numerous civil war refugees from Angola continued to dress traditionally and engage in the manufacture of leather clothing and everyday utensils (Larson 1970:40).

Figure 7. Two Mbukushu women in Shakawe, Botswana, in 1969 with back aprons and decorated hairstyles (Larson 1975:119, photo: T. Larson).

The Lambrechts' field esearch among the Yei

Early Yei back aprons are not known to have been collected. It is possible that they did not appear until the mid-twentieth century in their present form, when they were documented by Frank and Dora Lambrecht, who were working for the Botswana Health Service. In an article about their observations of the Yei, they describe the women's traditional costume worn only on special occasions and consisting of a back apron, a beaded belt, and a front apron (Lambrecht and Lambrecht 1977). The back apron was made of antelope skin using an intricate patchwork technique, and beads were attached to the middle section using animal sinew in a variety of ways (Figure 8).

Figure 8. Yei back apron made of antelope skin with additional belt, Botswana, 111 x 80 cm, private collection (photo: Alan Marcuson).

According to the Lambrechts, it was the men who decorated the skirts with beads, while the belts were decorated by women. The additional belt consists of a wide band from which one or more separate panels and individual cords hang down. It is knotted in the front and worn over the back apron (Figure 9). The oldest belts were decorated with ostrich eggshell beads. These were traded by the San and were often combined with glass beads (see also Larson 1975:118; Wilmsen 1997:290). The bead colors are limited to black, white, and red, but in some older pieces single black beads have been replaced with transparent dark blue beads. Usually only two colors were used per piece; if more are found, it usually indicates a date of manufacture in the last third of the 20th century. Larson (2001:258f.) also mentions that a greater variety of colors were chosen for pieces intended for sale. At the time of their fieldwork, the Lambrechts found no front aprons among the Yei, but older women told them that originally no costume was complete without one. At that time, the back apron was generally worn on special occasions, such as the *sembukushu* dance.

Figure 9. Yei belt with panels, Botswana, 68 x 46 cm, private collection (photo: M. Oehrl).

Glass beads, techniques, and patterns

The glass beads used in beadwork, aprons, belts, necklaces and beaded headdresses are relatively large (3 × 2 mm to 5 × 3 mm) and irregularly shaped (Figures 10a, b). This applies to the early Tawana aprons, as well as the Mbukushu examples from the 1960s. The apron collected by von Frankenberg in 1912 and now in the Ethnologisches Museum Berlin (acc. no. III D 4021) incorporates red "white heart" beads (Figures 5, 10a), as does an apron collected by Pöch in the Weltmuseum Wien (acc. no. 86154). In contrast, transparent red beads are found on other aprons.

The glass beads are woven together with animal fibers, usually bovine sinew, using the so-called brick or gourd stitch, as in the case of the Tawana. The upper edge consists of a leather band of varying width, into which the bead section is either directly woven with sinew or, probably secondarily, attached with commercial thread. Narrow leather straps are either sewn directly onto this strip or fastened with buttons.

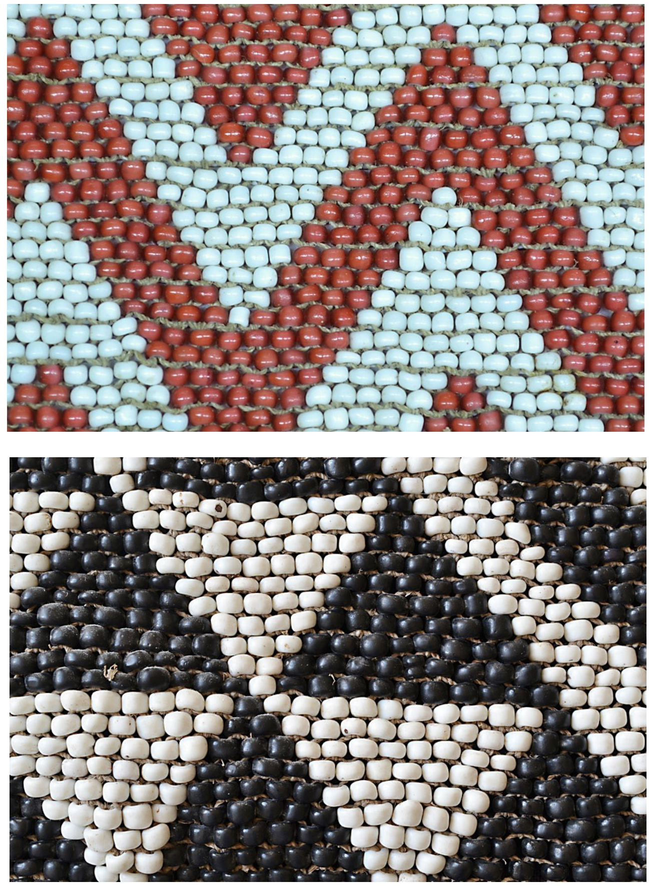

Figure 10. (a) Detail of the Yei apron in Figure 5, (b) Detail of the Mbukushu apron in Figure 13a.

At the turn of the 19th and 20th centuries, wavy lines, triangles, and diamonds were used for decoration, similar to the patterns burned into woodwork, like vessels and sieves, or painted on Tawana clay vessels (Larson 1975:113; Hirschberg 1936: plate 2, figs. 5, 6)(Figure 11). Some of the Tawana specimens collected by Pöch play with the positive and negative areas created by these pattern elements on a white background. Forty or fifty years later, Yei and Mbukushu women developed sophisticated patterns, sometimes with almost three-dimensional effects. There are similarities between the patterns on the panels of the back aprons and the front aprons.

Figure 11. Tawana clay vessels with zigzag and diamond patterns (Hirschberg 1936, plate 2, Figure 5 and 6) (photo: M. Oehrl).

Since these highly complex patterns do not occur in the early collections, it is clear that a development has taken place, suggesting local innovation following a possible cultural exchange. In addition to the abovementioned origin of the glass beads from South Africa, another route via Angola would have been possible. Scherz et al. (1981:21) mention that in the mid-20th century glass beads were obtained from Angola via Mbundu traders. However, the same trade is said to have taken place as early as 1850 via Portuguese coastal towns and detribalized Mbundu as intermediaries, enabling beadwork to emerge as an art form (Haingura 1993:31, 32).

DISCUSSION

Until now, the influence of the Tswana on the works of the Mbukushu, Yei, and other Okavango peoples has not been mentioned, although there is no shortage of literature on Tswana history. Early writers often did not consider beadwork important enough to describe in detail. In Livingstone's account of his travels, for example, glass beads are mentioned frequently only in the context of goods for trading in encounters with the Tawana and Yei at Lake Ngami in 1849. Andersson limits himself to summary descriptions of the Tawana's clothing.

There is much to suggest that the Yei and Mbukushu borrowed beadwork designs from the Tawana at the turn of the nineteenth and twentieth centuries. In the early 20th century, the Tawana began to settle in the wider region, outside their main town of Tsau, to be in closer contact with the peoples who traditionally depended on them. "Wherever they settled, the inhabitants began to adopt Tawana culture," writes A. C. Campbell (1976:167). Tawana men also married Yei women, while the reverse was not possible due to the Tawana's sense of superiority over the Yei (Larson 1989:26).

From these exchanges, local styles evolved in the material culture, although the exact sequence cannot be traced in each case. Andersson and Passarge believe that the Yei adopted their dress style from the Tawana, but they describe only sparse embellishments with beads on the Yei garments. In general, beadwork for various items such as belts or pendants was common amongst all Tswana peoples. The Ngwato sub-group, living farther east, did not wear beaded aprons, only fringed aprons or leather aprons sparsely decorated with glass beads. One exception was a small triangular glass bead apron for male youths (Brighton Museum, acc. no. R4007/21) (Figure 12).

Figure 12. Ngwato apron for boys, Botswana, 28 x 18 cm, before 1899 (courtesy of the Brighton Museum, acc. no. R4007/21, photo: Brighton Museum).

Pöch's accounts and collections are the main evidence of Tawana influence. Pöch used his one-month stay in Tsau to assemble a substantial collection of Tawana material culture. The collection numbered 170 items and included "fur coats, [...] women's aprons made of beads in various patterns, painted clay pots, wooden pots, baskets and bowls woven from palm leaves, various objects of daily use and household items, and jewelry" (Hirschberg 1936:26). He inquired about the history of the Tawana and the reason for the unrest at that time, which was based on succession disputes. This led the British colonial administration to depose the regent, Sekguma, who was considered illegitimate (Hirschberg 1936:26). Pöch described Tawana's clothing and jewelry, including much beadwork. He also mentioned that fur ornaments were provided by the San, while wooden bowls were made by the Mbukushu (Hirschberg 1936:27). Whether Pöch's reference to a "Makuba" (Makoba or Yei) pattern on the Tawana apron in Vienna (acc. no. 86156) being an indication of such borrowing from these groups must be left open here and suggests a fruitful avenue for additional research.

After the establishment of the British protectorate in Ngamiland in 1890, the Tawana were impacted by the missions, as the associated trade and subsequently Western clothing elements became established. It is not clear whether the ready availability of glass beads and Western influence also held true for the less affluent Kavango people, especially the Mbukushu who lived in the remote and undeveloped central Okavango region. Authors differ on the amount of available barter goods, such as ivory. In any case, the area was rarely visited by traders (Eckl 2004:109f; Haingura 1993:31, 33).

After the establishment of two Catholic missions and a German police station at Nkure-Nkuru on the Okavango between 1910 and 1913, trade may have increased. Large numbers of the Mbukushu, Gciriku, Kwangali, and Mbunza populations had also moved to the German colony south of the Okavango due to disputes with the Portuguese colonial power. The fifth Kavango people, the Sambyu, had fled into the interior of Angola. Glass beads were among the gifts exchanged at meetings with the colonial officials of German South West Africa (Eckl 2004:115). The mostly German missionaries of the 'Missionarii Oblati Mariae Immaculatae,' rewarded services with glass beads, but their influence in the remote and economically insignificant area remained limited.

After the local surrender of the Germans in the First World War in 1915, the British largely prevented trade in the region for years (Eckl 2004:143f.). It was only between 1925 and 1929 that further stations of various missionary societies were founded among the Kavango peoples in Namibia, and in 1959 a mission was added in Angola. Some of the population returned to Angola after the reform of Portuguese colonial policy in 1930, because conditions there were more favorable for agriculture and cattle breeding (Fisch 2005:13).

According to Larson (2001:24), the Mbukushu names for traditional clothing are borrowed from the Siyei, suggesting that the Yei, who lived in closer contact with the Tawana, provided the model. Clothing and jewelry seem to have developed in parallel for both peoples. Unfortunately, there are no known photographs of the Mbukushu or the Yei wearing front aprons. It is therefore possible that the Mbukushu did not decorate front aprons with glass beads until the mid-20th century, while among the Yei there exists at least one early example that can be attributed with certainty. Yei and Mbukushu back aprons do not appear to have been decorated until the 1930s and '40s, respectively. There is little evidence from the years between the First and Second World Wars, despite a fairly extensive literature. The earliest published photographs of women with beaded back aprons date from the 1950s by Larson, and from the late 1960s and '70s by Lambrecht.

It was therefore a surprise when a large number of aprons from Angolan civil war refugees came to light, causing a sensation because of their striking appearance (Figure 13a-c). The struggle for independence and the ensuing decades-long civil war in Angola led to the flight of about 4,000 Mbukushu from Angola to neighboring Botswana in 1968 and '69 (Larson 1970:32; Fisch 2005:74). Between 1975 and '78 another 8,000 Mbukushu fled to Namibia (Fisch 2005:78f.). According to trade sources, a group of about 15-20 Mbukushu aprons were acquired by a Peace Corps volunteer directly from a UN refugee camp in Botswana and brought to the United States. From there, some found their way to the Museum of International Folk

Figure 13. Three Mbukushu aprons, Botswana: (a) 43 × 46 cm, private collection (photo: M. Oehrl), (b) Dimensions unknown, private collection (photo: Jacaranda Tribal), (c) 46 × 43 cm, private collection (photo: Peter Liaunig).

Art in Santa Fe, New Mexico, while others ended up on the international art market. In 1978, the exhibition "Traditional and Contemporary Crafts from Botswana" at the National Museum of African Art in Washington, DC, featured a smaller number of front aprons.[7] Most, if not all, of these pieces were made by Mbukushu who originally lived in Angola. They date most probably from the 1940s to the '70s.

Overall, the number of surviving examples is not very large. Beaded back aprons were also collected around 1950 from other Kavango peoples living in the immediate western vicinity of the Mbukushu, such as the Sambyu, Gciriku, and Kwangali (Kwangari).[8] The bead panels were often smaller and of an irregular shape, while the design is usually freer, and the patterns are less elaborate. However, there are no clear characteristics that can be used to differentiate between the works of the various makers, and only the information provided by the collectors can be used as a reference. From the second half of the 20th century, the San, who have lived in the area for thousands of years, also began to produce headbands, bracelets, and necklaces with black and white triangular patterns. However, individual pieces in other colors, especially shades of blue, existed as early as 1900, as documented in museum collections (Weltmuseum Wien: Au-Nin-San, acc. no. 85464).

CONCLUSION

There are few field observations of the beadwork of the Okavango peoples. In particular, no author has seen thefrontal aprons used in situ. Nevertheless, Pöch collected aprons from the Tawana in 1908 and Frankenberg from the Yei in 1912. In 1950 Larson photographed Mbukushu women who still wore the more elaborate back aprons with many glass beads in everyday life. The Lambrechts took similar photos of the Yei's back aprons in the 1960s and '70s. This makes it possible to place these works in a rough chronological order. The body of beadwork collected in the 1970s and '80s differs in the complexity of the designs and can be attributed to the Mbukushu who left Angola as refugees to Namibia and Botswana because of the civil war. Due to the lack of data, the assumption of mutual influence between the Tawana, Yei, Mbukushu, and other Kavango peoples is rather *prima facie* and leaves room for further investigation. However, this is suggested by the similarity of materials and techniques, and the type and color of glass beads, which have barely changed since the beginning of the 20th century.

ENDNOTES

1. Mbukushu—alternatively: Hambukushu.
   Yei—alternatively: Bayei, Bayeye, Bayeiye, Bayeyi, Bajeje, Yeye, Mayeye, Mayei, Maiye, Majei, Yeyi, Yeyei, Jei.

2. Siegfried Passarge does not translate the term as "slave" but as "boat people/canoe men" (Wilmsen 1997:89).

3. Some of the aprons (e.g. acc. no. 86145) are additionally labeled "Segomo" in the catalogue, which is translated as "string of beads" for other objects.

4. Pöch describes various other Tawana beadwork, such as neck rings worked on a leather core with triangular patterns reminiscent of the Sotho and the *mathato* necklace made of blue beads with two circular pendants in red and white ("elephant eyes") (Hirschberg 1936: plates 1-3). He also collected fertility dolls decorated with beads in a checkered pattern (plate 3, 11). These are in the Weltmuseum Wien. Another Tswana collection, mainly from the Ngwato, is in the Brighton Museum. It comes from the British missionary William Willoughby and was compiled at the mission base in Palapye in the years 1893–1898. It contains no aprons in the same style, but very similar bags, as well as a triangular apron for boys (Royal Pavilion & Museums Trust, Brighton & Hove, acc. nos. R4007/19-R4007/21).

5. Larson uses different spellings in his publications.

6. *mojamboroo* in Siyei (Larson 1970:38), *kuan-dura mapi* in Simbukushu (Larson 1979:35).

7. https://africa.si.edu/50years/.

8. The American Museum of Natural History has a collection of back aprons and other beadwork of the Sambyu. They come from the William Morden Expedition of 1953 (acc. nos 90.2/995 etc.). According to Cecilia McGurk (Gibson et al. 1981:110) and Larson (2001), the Sambyu (Sambiu, Wasambiu, Shambyu) make similar back aprons. The same applies to the Gciriku (Gibson et al. 1981:173) and the Kwangari or Kwangali (Shiremo 2009).

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Signature of Pöch's letters: WMVK_VA_NA_Pöch_B.

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TOOTH BEADS IN TWO HUNTER-FISHER-GATHERER SOCIETIES OF NORTHERN EUROPE

Lars Larsson

Beads made from animal teeth were an important form of decoration among hunter-gatherer societies in Northern Europe. The analyses presented in this paper are based on questions regarding the design of the beads, the choice of animal teeth, their placement on the costume, and the exchange of beads. For these analyses, two sites with partly different conditions have been selected, one located in northern Latvia (Zvejnieki), and the other in southernmost Sweden (Skateholm). The former covers a long period of use with a large number of graves, while the latter has a smaller number of graves, but these have been studied using new methods of analysis.

INTRODUCTION

In most societies where hunting makes the most important economic contribution, beads made of animal teeth are common as decorative objects (Rigaud 2011). Tooth beads can be perceived to have various meanings. A number of studies of tooth pendants have considered social factors (d'Errico and Vanhaeren 2002; Cristian and Borić 2017; Macāne et al. 2019; Mannermaa et al. 2017; Rigaud et al. 2015; Vanhaeren and d'Errico 2002) as well as other factors, such as the ritual perspective (Laporte and Dupont 2019). They can be a purely decorative element of the costume, but they can also be a kind of abstraction of the wild environment (Larsson 2012).

The animal teeth, in being extracted and reshaped, are transferred to the human sphere of hunter-fisher-gatherers (Larsson 2006). Here, carnivorous and herbivorous animals, and animals from marine and terrestrial environments, are mixed together in an artificial world completely ruled by humans. However, they remain part of the wild and their special qualities might be transferred to the wearer. The use of teeth from particular animals may generally be taken to reflect norms and values accepted by individuals living in a shared physical and social environment. For example, members of a society can be related to a particular animal through heredity or special characteristics, or a large number of tooth beads on a woman's costume can mark her status and relationship to that of a skilled hunter.

One aim of the current study was to obtain an understanding of how the teeth were modified by identifying the techniques of bead manufacture. A further goal was to identify and classify whether and in what ways the beads might have been affected through use by conducting a use-wear analysis. This analysis should give an indication of how the pendants were fastened, as well as how different sets of garments were handled, and whether beads differing in use-wear were combined.

Throughout life, a person's dress, adornments and gear would change, being replaced and supplemented. The number and combination of beads might change due to transitions in age and gender roles. Other reasons for a change in the embellishment of dress might be developments in competences and special social relationships. For example, a person who left their previous place of residence may change their dress and ornament in order to be accepted into a new society. These transitions ought to shape the number of items, species composition, and wear patterns in the assemblage of pendants associated with an individual. In the archaeology of hunter-gatherer societies, such features might be reconstructed based on the study of tooth beads and pendants of other materials associated with burials. Further insight would be obtained, if these combinations could be followed diachronically, shedding light on the survival of tradition and acceptance of innovations. Changes in the climate and composition of local game can also have consequences for the choice of tooth beads.

To illustrate different aspects of these phenomena, two different sites have been selected. A site permitting both synchronic and diachronic analysis is the cemetery at Zvejnieki, northern Latvia (Zagorska 2006a; Zagorskis 2004). At the time of its prehistoric occupation, lasting from about 7500 to 2600 cal BCE, it was an island in the middle of the lake, which was three times larger than at present (Eberhards 2006). The other site included in the study, Skateholm, is located on the opposite shore of the Baltic, on the southern coast of Scania, the southernmost part of Sweden (Figure 1). The Skateholm excavation project revealed two cemeteries with associated settlements on former islands in a now completely dry bay, dated to the Late Mesolithic, around 5000 cal BCE (Larsson 2006, 2012, 2020). The two burial sites, Skateholm I with 22 and Skateholm II with 65 graves, appear to be chronologically sequential, which relates to a rise in sea level.

How beads were shaped and used

At least three major modes of shaping the teeth into beads have been identified (Larsson 2006). The first mode is drilling in order to obtain a round perforation. In most cases the perforation has been made from both sides (Figure 2). A second mode involved perforation achieved by carving on opposite sides of the root using a tool with a sharp edge, until a perforation or crater was obtained. The third mode was by cutting a groove in order to facilitate the fixing of the tooth to a thread.

It is possible to evaluate how long a tooth bead was used by studying use-wear on the perforation. Use-wear consists of wear on the edge of the hole so that it becomes more or less rounded. In cases with extremely heavy use wear, it can include the smoothness of the entire tooth root. On most tooth beads, traces of wear are limited, which may indicate that they were securely fixed to the clothing. In some cases, distinct wear can be traced (Figure 2e-f). One such example is a red deer tooth where the original suspension hole was broken and a new one added (Figure 2a). The traces of wear are found around the perforation, but are mainly visible in the area in the direction of the root of the tooth. Experiments have further shown that wear on the perforation will be limited, even if the tooth was allowed to hang free. For example, wearing a bracelet of teeth daily for just over six months resulted in limited traces of use.

Traces of use-wear suggest that beads were individually sewn to some surface or combined into

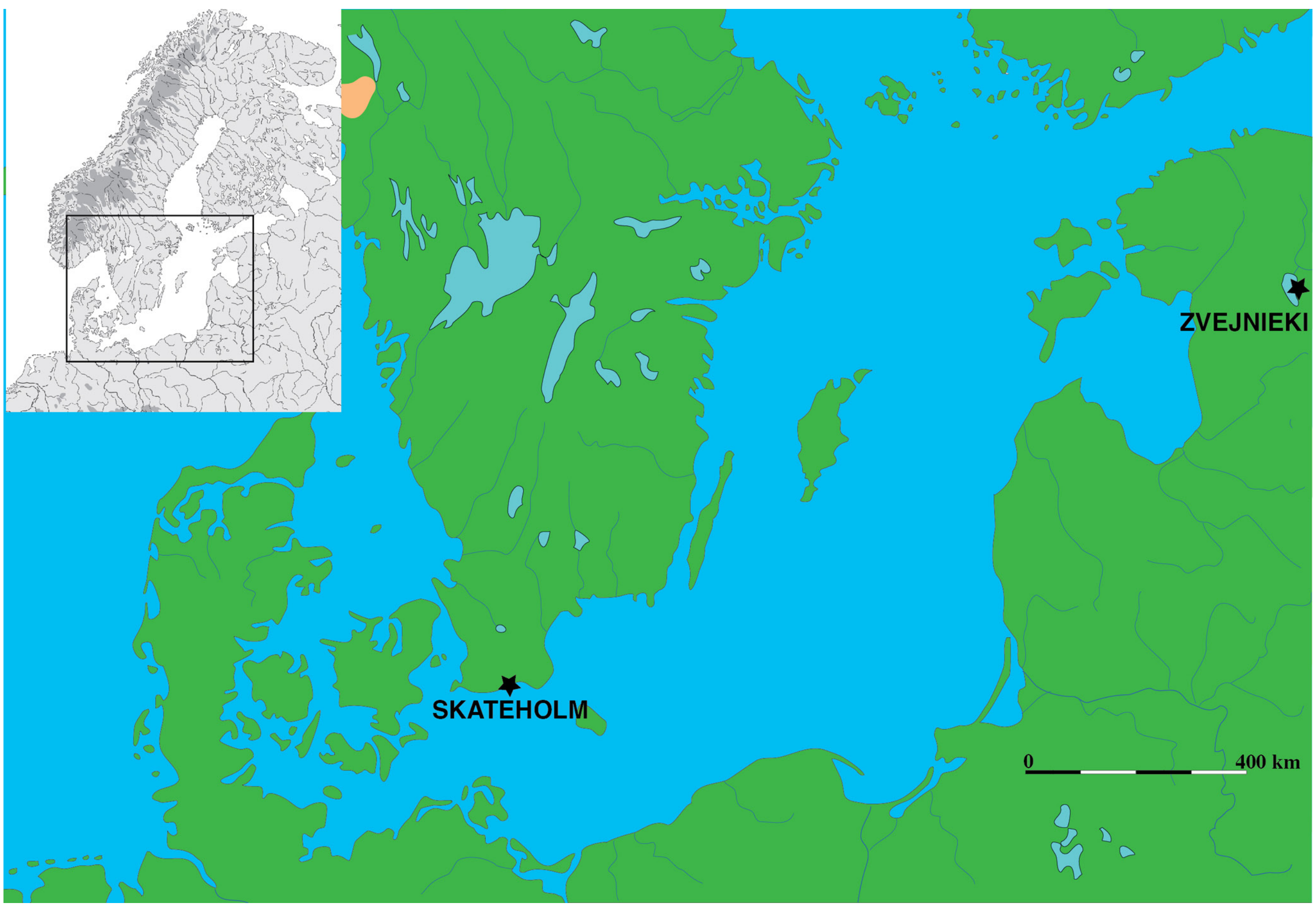

Figure 1. Northern Europe with the find sites of Zvejnieki, northern Latvia, and Skateholm, southern Sweden. (Drawing by the author, 2005).

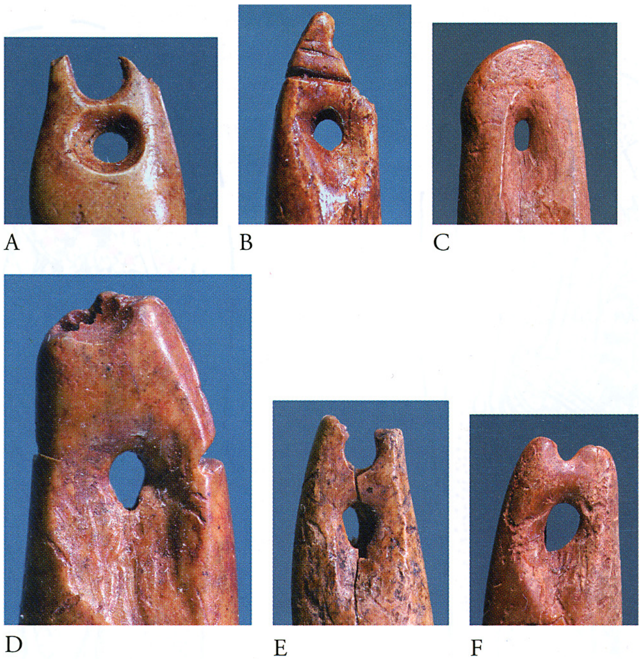

Figure 2. Tooth beads displaying different techniques for altering the root and use-wear. A. Root drilled twice, with heavy use-wear, B. Combined grooves and drilled perforation, C. Carved perforation with heavy use-wear, D. Carving of the perforation, and E-F. Twice cut perforations with light and heavy use-wear. (Photo Bengt Almgren, 2004).

smaller or larger sets. There is no obvious evidence of wear from secondary fastening, such as a second string or multiple loops of leather. Observation of the beads' positions on the burials suggests that both modes of use – sewing to a surface and stringing beads together – were common. The fairly common occurrence of use-wear indicates some movement of the beads along the string or fastening loop. Beads firmly tied to a surface would not be so mobile and would not display as much use-wear. My own experimental study shows that a considerable time of use is needed before physical traces of the kind observed in this study can develop on the beads. The use-wear might appear earlier, if they were worn during energetic activities, such as dancing.

In several instances, tooth sets include beads with wear varying from light to heavy, as well as teeth without any use-wear at all. Although teeth in the same group could have become differentially worn according to their position on the substratum (hide, etc.), it is likely that in at least some cases, sets were arranged by recycling old beads and adding new ones. A small number of beads have no traces of wear at all and appear to be in mint condition. They seem to have been made shortly before or after the individual's death, possibly added to the gear or clothing at the time of interment.

BEADS FROM A LARGE CEMETERY

A site permitting both synchronic and diachronic analysis is the cemetery at Zvejnieki, northern Latvia (Zagorska 2006a; Zagorskis 2004). In Latvia, the Middle Mesolithic period dates to 8300–5400 cal BCE, Early Neolithic to 5400–4100 cal BCE, Middle Neolithic 4100–2900 cal BCE and Late Neolithic to 2900–1800 cal BCE. Altogether, 330 registered structures have been excavated including single, double and group burials, which are divided into two clusters (Zagorska 2006b; Larsson et al. 2017; Meadows et al. 2018). Several graves contain grave goods other than tooth beads, while many burials are lacking personal ornaments.

The long period of use, from the Early Mesolithic to the Late Neolithic (lasting approx. 7500 to 2600 cal BCE) provides possibilities for studying the design and selection of tooth beads. The study included all 46 graves containing tooth beads from different periods, examining all the available tooth beads, more than 2000, at 10x magnification. The tooth beads are very well preserved, which provides the opportunity to study them in detail.

The range of species used for the beads seems to be smaller during the early stage of the cemetery, with moose (*Alces alces*), wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), and aurochs (*Bos primigenius*) as the most common (Lougas 2006). A much wider spectrum is present during the later stage. In addition to those species present in the Middle Mesolithic, the following species were used: brown bear (*Ursus arctos*), wolf (*Canis lupus*), dog (*Canis lupus familiaris*), badger (*Meles meles*), otter (*Lutra lutra*), marten (*Martes martes*), fox (*Vulpes vulpes*), ringed seal (*Phoca hispida*), beaver (*Castor fiber*), wild horse (*Equus caballus*), and human. Most of the tooth beads are incisors from herbivores and omnivores in contrast to canines from carnivores.

No burial was found containing beads from just one species; most included three or more species. The dating of the graves shows a clear change from beads made by drilling holes to beads with holes produced by carving already took place at the end of the Middle Mesolithic (Larsson 2006, Fig. 21). To give an insight into how tooth beads were used, a small selection of the graves with tooth beads from the Zvejnieki site are presented.

The application of tooth beads

Grave 170 (a young adult male from the Middle Mesolithic) is one of the oldest burials in the cemetery, dating to 8150±80 BP (7380–7021 cal BCE, Ox-5969) (Figure 3a). All of the beads were perforated using the drilling technique. There is a marked spatial distribution of beads within the burial according to species. The largest number are incisors from wild boar, and these are associated with the chest area, forming vertical as well as horizontal lines. Tooth beads form a regular cluster in two vertical rows in the pelvic region and on the extremities (Figure 3b). The remaining pendants occur as smaller clusters, including a group of red deer beads at the lower right side of the chest and a mixed group of wild boar and moose tooth pendants at the right upper chest. There was a necklace consisting mainly of beads from moose, with a bead from aurochs placed in the middle. Beads from moose, wild boar, and red deer were found close to the feet.

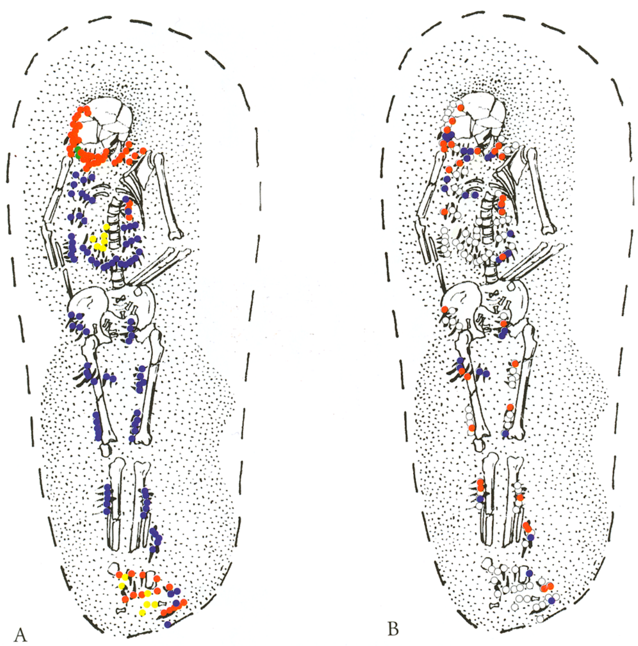

Figure 3. Grave 170, Zvejnieki. A. The distribution of beads according to species: red – moose, blue – wild boar, yellow – red deer, green – aurochs. B. Pendants with light use-wear (blue) and heavy use-wear (red). (Drawing by the author, 2005)

Most of the beads with identified use-wear are associated with the neck region of the buried individual (Figure 3b). Among the sets of beads from wild boar, the wear varies from clusters showing no use-wear to those in which all beads display use-related polish. Because teeth within clusters of beads tend to show similar amounts of wear or lack of wear, the different groups of beads may be interpreted as having been obtained at different stages during the individual's lifetime. One third of the beads from moose teeth, the two beads from aurochs, and just one of the beads from red deer show use-wear.

A different group of burials are dated to the Late Mesolithic in accordance with the Latvian chronology. Among these is grave 57, an elderly adult female dated to 6825±60 BP (5839–5628 cal BCE, Ua-3636) (Figure 4). The burial includes some 52 beads, none of which have traces of use-wear. Of the eleven beads with perforations, only one shows signs of drilling. The remaining beads were made by carving. Just one set of beads from moose is directly associated with the interred individual, occurring in the lower pelvic region. The other beads were found close to the body or a small distance away. Six deer teeth without traces of alteration were found close to a stone axe behind the head of the interred. Four separate sets of beads were found on the left side of the individual. Because of their positions, they cannot have been part of the clothing in which the person might have been dressed when interred. They may have been part of a shroud of, for example, an animal skin that surrounded the body. Only three teeth showed use-wear. The teeth next to the body, including the set in association with the stone axe, indicate that the beads were used not just for bodily adornment or application to clothing.

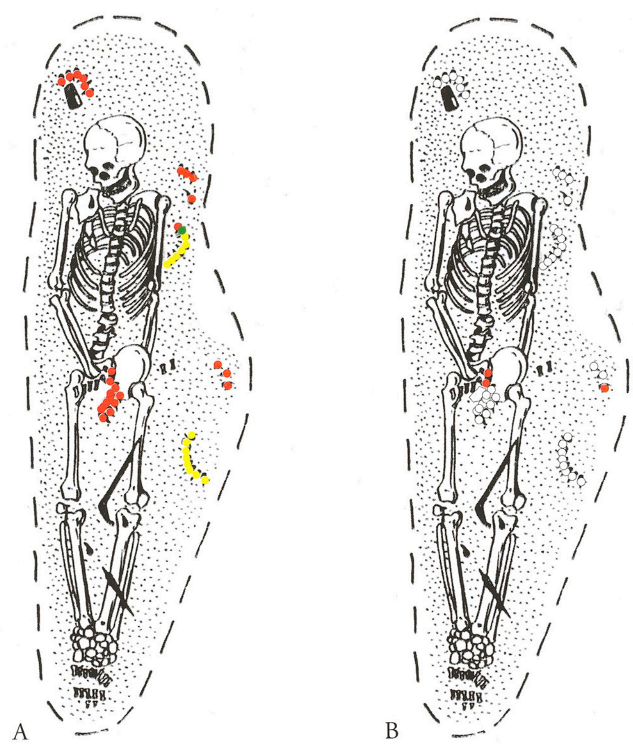

Figure 4. Grave 57, Zvejnieki. For legend see Figure 3. (Drawing by the author, 2005).

Grave 122–123 is a double grave from the Early Neolithic, consisting of a young adult male with a child arranged on top. The male has been dated to 6395±75

BP (5481–5214 cal BCE, OxA-5967). More than three hundred pendants were found, representing twelve species altogether (Figure 5a). This grave also holds the most tooth beads from aurochs, elk, wild boar, red deer, brown bear, dog, badger, otter, marten, ringed seal, beaver and wild horse (Macāne 2022).

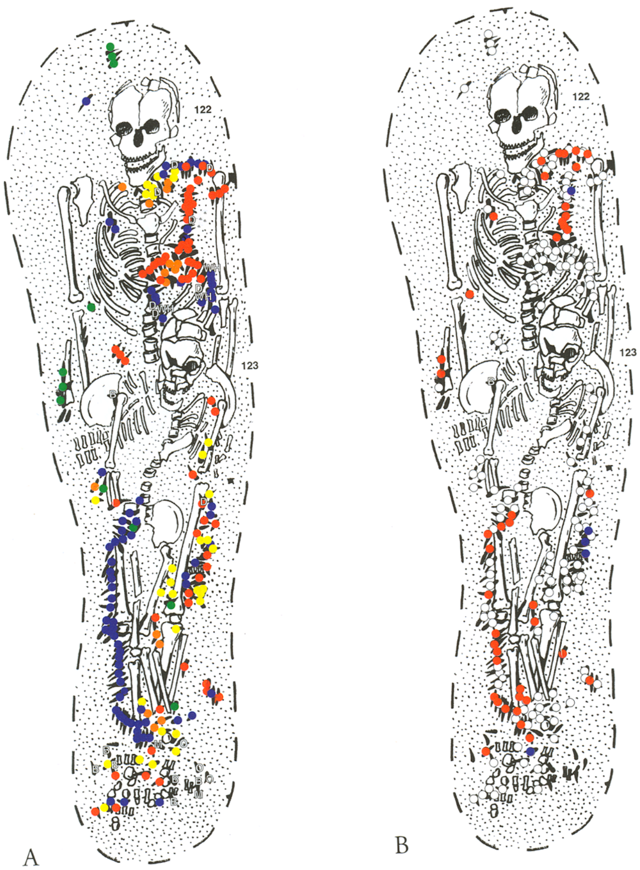

Figure 5. Graves 122–123, Zvejnieki. **A.** The distribution of beads according to species: red – moose, blue – wild boar, yellow – red deer, green – aurochs, orange – brown bear, B – badger, D – dog, M – marten, O – otter, WH – wild horse. **B.** Pendants with light use-wear (blue) and heavy use-wear (red). (Drawing by the author, 2005).

It is problematic to associate many of the teeth specifically with the adult male or the child. Two small sets of teeth were found behind the skull and to the left of the legs of the adult (Figure 5a). Rows of teeth at the neck, the left shoulder and along the upper chest of the male can be assigned to this individual. A fan-shaped arrangement behind the child can be associated with it, along with some pendants at the left margin of the chest. The sets of pendants along the extremities belong to the adult, including teeth close to the feet. A clear difference is seen in terms of wear and type of alteration of the tooth. The tooth beads embellishing the man's dress exhibit various forms of use-wear, whereas the tooth beads that belong to the child do not show any use-wear (Figure 5b).

Tooth beads for children

As noted above, a person's dress, adornments, and gear would change, being replaced and supplemented, throughout their life. Also of special interest is the question of how and when a new member of society received their outfit and gear. Two contrasting scenarios are expected. One is that the dress outfit and adornments were specially made for a child entering the society. Alternatively, the child inherited the outfit – or parts of it – from relatives or other members of the society. In the former situation, the beads would be newly made, with little or no use-wear. In the latter scenario, one would expect to find use-wear among the beads for the child. Moreover, because it is unlikely that children's beads could have developed substantial use-wear, worn beads in juvenile burials likely represent gifts including used beads.

Grave 27, that of a child, was part of a collective burial of five individuals from the Late Mesolithic period. However, the child's skeleton was found at a certain distance from the other interred individuals and was not disturbed when these were buried (Figure 6a). Beads were found all over the child's body. A drilled perforation was observed on just one bead, an incisor from aurochs with heavy wear. Moderate wear was identified on beads from moose, wild boar, and red deer (Figure 6b).

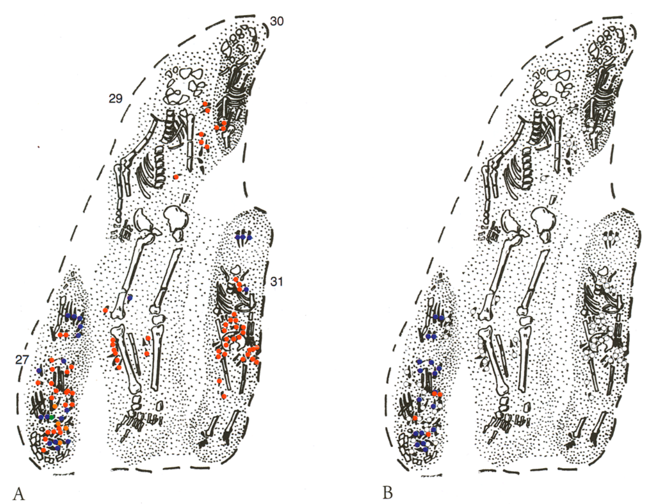

Figure 6. Graves 27–31, Zvejnieki. For legend see Figure 3 (Drawing by the author, 2005).

Burial 31, another child in the same mass burial, had three beads from wild boar around the head, plus a small number at the neck, along with a number of beads from the same species at the right leg and foot (Figure 6a). In the pelvic region, a subgroup within the concentration appeared to have been arranged in a fan shape. No use-wear was identified on the beads.

Both of the above-described patterns are represented in child graves at Zvejnieki. In the case of burial 27, a young child, a considerable number of the beads exhibit use-wear (Figure 6b). Grave 31 had no beads exhibiting use-wear (Figure 6b). In the case of grave 122–123, there is a spatial distinction between beads associated with the adult individual and those associated with the child (Figure 6a). The adult bead assemblage includes worn teeth, whereas the child's assemblage includes no specimens with use-wear (Figure 6b).

One might expect that the social roles of children changed rapidly with age. If a child died at a very young age, he or she would not yet have been fully initiated as a true member of the society and would not have received their personal dress, including adornments. As in the case of burial 27, such a child would have been wearing parts of their dress from adult relatives. However, as a child grew older, he or she would have been presented with a new dress or gear, as a full member of society. It seems difficult to determine at what age this initiation took place. The child burial 31 seems to have a new dress, as the beads show no use-wear. Full acceptance may have occurred at about the age of two. Child grave 190 could exemplify this change, where the interred individual was buried in a new dress, while the old one, having been given after birth, was deposited to the left of the body (Larsson *et al*. 2017).

Most adult burials include beads with wear. Yet, in a small number of cases, such as grave 57, beads associated with the interred person show no wear. One does not need to be a child in order to enter society. Women and men might have been given, or expected to furnish for themselves, a new dress with newly-made ornaments when they were integrated into new families or obtained a new status among their own relatives. At death, a completely new dress might even have been made for use as a covering for the dead, while the old dress or parts of it could have been deposited in the grave beside the body.

Of particular interest is a couple of individuals who had decoration on their heads consisting of a combination of beads from dogs and seals (Figure 7). The seal originates from the coast, reached by following a watercourse about 60 km downstream. Analysis of the dog teeth has shown that they ate marine food (Ericsson and Zagorska 2000). It is likely that special decorated headgear was made at the coast and brought inland as an example of trade.

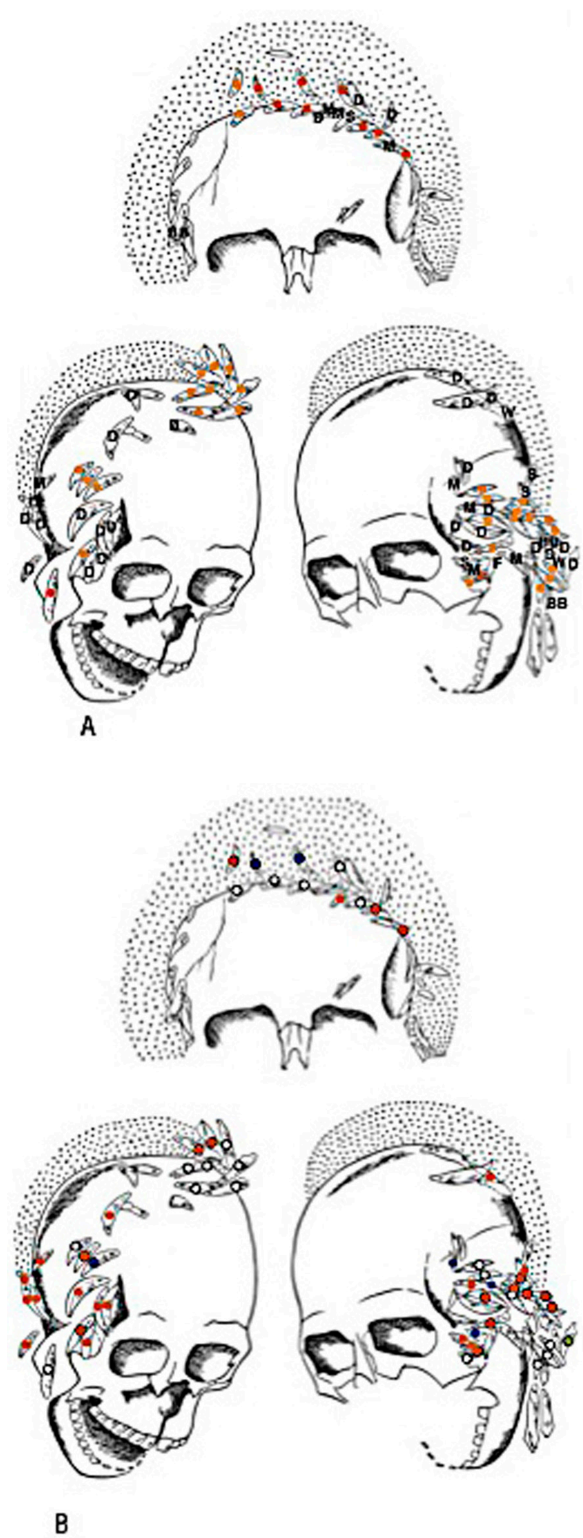

Figure 7. The skull of the individual in grave 153. For legend see Figure 3. Additionally: D – dog, S – seal, BB – brown bear, M – marten, W – wolf. (Drawing by the author, 2005).

The distribution of beads on the embellished clothing

One important aspect of the study of the Zvejnieki beads is to obtain an understanding of how the teeth were combined and distributed in relation to the body of the buried person. In order to study the variability in the position of beads on the interred individual with respect to chronological period, age, and sex, the bead distribution is projected onto a schematic representation of the body. Despite the unequal sample sizes, it is obvious that in the case of the Mesolithic burials, beads are distributed mostly around the central part of the body (Larsson 2006). For the Neolithic sample, beads are related to the extremities and head. In both periods, a number of beads were found outside the interred body. In several burials, beads occur in association with the feet (Figure 3a). Most commonly in such cases, a range of different animals are represented. From around 4000 cal BCE, tooth beads were replaced with beads, rings, and pendants in amber as exchange objects from a region further south (Larson 2020).

TOOTH BEADS FROM TWO MINOR CEMETERIES

The other site included in the study, Skateholm, consisted of two cemeteries 200 meters from one another, and is located on the opposite shore of the Baltic, on the southern coast of Scania, the southernmost part of Sweden. Thirteen of the human graves contained objects that may have embellished clothing. Due to the relatively poor state of preservation, it was not possible to determine in detail the use-wear for all the teeth from the burial grounds, but here it was possible to use a completely new method of analysis, namely strontium isotopes analysis.

Teeth from red deer predominate; while less frequent, teeth from wild boar are also present. A few beads were made from the teeth of moose and aurochs. There are also beads from porpoise (*Phocoena phocoena*), bear, and wolf. By contrast, there are no beads from roe deer (*Capreolus capreolus*) or grey seal (*Halichoerus grypus*), even though these are well represented among the bones found at the settlement sites (Jonsson 1988). However, deer hooves have been used as ornaments on the costume, while the grey seal fur or skin was perhaps represented in parts of the costume for its special texture.

Likewise, teeth from smaller fur-bearing animals, such as fox, marten, and badger, common as beads at Zvejnieki, were not used either. These animals provided soft, colorful furs for clothing, and their exclusion from embellishments of this kind was probably not because it was difficult to pierce the small teeth, but instead probably due to norms within the society.

Most of the teeth were perforated from both sides of the root by drilling; but not all teeth were perforated to serve as ornaments. They could also be cut out from the jaw in such a way that the gums were preserved around the roots, and some of the teeth from graves at Skateholm were held together in this way. In a few instances, parts of the jaw adjacent to the teeth were cut loose, and both the bone and the dried gums served to hold the tooth.

Tooth beads in male and female graves

There seems to be a certain gender distribution regarding where the tooth beads were located in the grave in relation to the clothing. In women's graves, Grave XXII in Skateholm II, the tooth beads occur in one or more rows around the upper part of the pelvic area. It has been suggested that they were attached to a belt placed immediately above the hip. In one grave, Grave VII at Skateholm II, this decoration comprised a total of 121 beads from about 30 red deer (Figure 8). Only front teeth were used, and only teeth from the left part of the jaw were mounted on the left side of the band, while teeth from the right half of the jaw were placed on the right-hand side, matching the position in the animal's jaw. This distinct distribution is also found in other tooth sets, not just from red deer but also from wild boar. On the other hand, there are no restrictive patterns concerning the sex or age of the animal. Both sexes are represented, and the teeth come from young animals as well as older individuals (Jonsson 1988). No major variation can be discerned in terms of wear on the perforation, which suggests that the entire set of teeth was processed at the same time. Where several red deer teeth have been combined, one or two teeth from some other animal appear.

Figure 8. Around a woman's hip in Grave VIII, Skateholm II, more than a hundred tooth beads were found, deriving from about 30 deer. (Photo by the author, 1983).

One woman, Grave 6 at Skateholm I, like several others, had been placed in a sitting position, had on her hip about 20 tooth beads from wild boar and one from moose, arranged in several rows (Figure 9). On top of these teeth, the skeleton of a new-born child was found. Most likely, the woman died in childbirth, and the baby was placed on her hip. Although the tooth beads are in the hip region, it is not certain that they belonged to her clothing. Ethnographic parallels show that teeth and other objects might be attached to a pouch for carrying an infant, sometimes referred to as a papoose (Vang Petersen 2016). It may be a richly decorated pouch like this that the baby lay on. The teeth on the pouch could also have made a rattling sound, perhaps to lull the baby to sleep, or may have served as amulets to protect the baby (Rainio and Tamboer 2018).

Figure 9. Grave 6, Skateholm I, a woman in a sitting position. Several tooth beads of wild boar were found on her hip. On top of these was the skeleton of a new-born child or an almost full-term fetus. The baby may have lain in a richly decorated pouch. (Photo by the author, 1982).

As for the men, tooth beads were used in a less systematic way. One buried man, Grave XV at Skateholm II, had red deer teeth placed across his head, perhaps attached to some kind of headdress or fastened to the man's hair (Figure 10). The same man also had some wild boar tooth beads at his left thigh.

As stated above, a band of tooth beads placed at the hip is interpreted as a typical female clothing item in other graves from Southern Scandinavia (Brinch Petersen 2016). However, in two cases, such an ornament also appears in graves identified as containing males. One young man in Grave 53 at Skateholm I, had tooth beads placed at the elbow and next to his hands and feet, as well as around the hip, (Figure 11). This is the only person with decoration at the arms and feet. These beads were probably attached to the sleeves of the clothing and to the footwear. When the man moved, perhaps in dance, the teeth may have given a rattling sound (Larsson 2006; Rainio and Mannermaa 2014; Rainio et al. 2021).

In this situation, it is interesting to consider the finds in terms of gender rather than sex (Deaux 1985), and the possibility that some items could have been worn by both

Figure 10. Grave XV, Skateholm II, a man in a sitting position with red deer tooth beads across the skull. (Photo by Lovisa Dal, 2022).

Figure 11. An accumulation of tooth beads from red deer and wild boar and an unperforated porpoise tooth lay next to the left hand of a man in Grave 53, Skateholm I. (Photo by the author, 1983).

genders. As for children, the Skateholm graves provide little evidence of embellished clothing for individuals under the age of 20. A double grave, Grave 41 at Skateholm I, with an adult male and a four-year-old child contained two canine teeth of brown bear and pendants of amber (Figure 12a-b). In other graves, a small number of amber pendants were found in combination with tooth beads. Amber has been found on the beach in the vicinity of the site.

Figure 12. A-B. Grave 41, containing an adult male and a four-year-old child with two canine teeth of brown bear and pendants of amber. (Photo by the author, 1983).

Tooth beads from near and far

Identifying the ratio of strontium isotopes $^{87}Sr/^{86}Sr$ in the tooth enamel has proven to be an appropriate method for determining where an individual spent the first years of life. The isotopic ratio varies depending on soil composition (Price *et al*. 2002). This value is transmitted through the diet into the enamel during dental development. By comparing the strontium value of tooth enamel and the value at different sample points in the landscape, it is possible to establish where an individual grew up.

Extensive analyses have been performed on teeth from the humans buried in Skateholm and on teeth from other animal species, both tooth beads and teeth found in occupation layers (Price et al. 2021; Larsson and Price 2022). Results show that the humans buried at Skateholm were born in this area and spent their first years of life there (Boethius et al. 2022). Not one person born in other parts of southernmost Sweden settled in Skateholm later in life.

Most of the animals whose teeth have ended up in the occupation layer or were used for bead production were likewise born in the surrounding area. However, in contrast to the human teeth, there are tooth beads that exhibit slightly or markedly anomalous values. This applies to teeth from red deer, wild boar, moose, and bear. That the values for moose, wolf, and bear differ slightly from the local signature is not so strange. These are species that inhabit large territories and move great distances. Some tooth beads from red deer, wild boar, and moose, on the other hand, show values that are more comparable to the ratios in northern Scania and even further north, at least 100 km away. This is an indication of contact with tribal areas in northern Scania or possibly even further away, with the teeth of red deer and wild boar constituting a major item of exchange. (Boethius *et al*. 2022). These animal species did occur in the immediate area, so the reason why they were traded over considerable distances was probably to maintain contact routes. Notably, the tooth beads forming part of the papoose found with the woman and child in Grave 6 (Figure 9) were exchange items. It is likely that the entire papoose was an object brought from the north.

A small number of beads were made from aurochs with a strontium isotope content showing that these individuals were born and lived in the Skateholm area. There are, on the other hand, no skeletal remains of aurochs in the occupation layers (Jonsson 1988). This seems to be contradictory, but the extremely heavy wear around the perforation and on the entire tooth root shows that the tooth beads had been worn for a very long time before finally ending up in graves. They were made several generations earlier, at a time when aurochs were still hunted in the area. Hence, these tooth beads may have been perceived as valuable heirlooms that were only applied to special persons.

CONCLUSION

When comparing the sites in northern Latvia and southern Sweden, there are significant differences in how beads and pendants were worked, but similarities in the types of beads chosen for use. For both sites, the teeth used as beads come from the most important hunted animals. At Zvejnieki, the teeth deemed appropriate for adorning the costume were mainly from moose, while at Skateholm it was the red deer that contributed to the decoration. This is mainly due to ecological differences. When it comes to other animal teeth, the variety of tooth beads is significantly greater at Zvejnieki than at Skateholm. This may in some cases be due to ecological factors, but is also related to norms and rules within the communities.

When it comes to how these tooth beads were worn on the clothing, there are significant differences. Some of the differences between the sites may have chronological significance, as the overall time span of the burials at Zvejnieki when tooth beads were used as decoration is much longer than in the case of Skateholm, but there was also a significant difference in traditions and associated norms. At Zvejnieki, tooth beads were used as neck and chest decoration as well as along the extremities, but less commonly in connection with the pelvic area. Arranging teeth in rows of various lengths was also common. Tooth beads also adorned the footwear and were attached to grave gifts. However, wearing of decorated headgear by some richly furnished individuals is similar at both Zvejnieki und Skateholm. At Skateholm, tooth beads were attached to some form of girdle in the pelvic area, an item common to women and men. There is one example of a necklace, and the same is true of foot decoration.

At Zvejnieki it seems that people were given tooth beads at different times in their lives. Young children were buried with an adult's embellished dress. At about two years of age, they were given newly made tooth beads to wear on a costume of their own, probably a mark of their acceptance as real members of society. For the rest of a person's life, the jewelry on the costume was augmented with new tooth beads, which may be due to membership of different groups within society combined with the person's own special efforts. Certain tooth beads, for example from aurochs, were heirlooms that after several generations of transmission finally ended up as grave gifts. Tooth beads were also bartered. In some cases, these came from special animals that did not occur in the settlement area, but in several cases beads from familiar animals hunted in the area seem to have been exchanged over significant distances. Here, the explanation may be offered that the bead trade was one of several ways to maintain contact between different tribes. Ornaments on individual outfits reflected not only the community's environment and subsistence strategies, but also personal information: male and female, infant, juvenile, prime and old age and different status.

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REPORT ON THE STONE BEADS, DEBITAGE AND RAW MATERIALS FROM THE 2007 AND 2008 EXCAVATION SEASONS AT PATTANAM, KERALA

Gwendolyn Kelly

This article examines stone beads and production debris from the 2007-2008 excavations at the site of Pattanam in South India. An analysis of finished beads and debitage indicates that the bead assemblage at Pattanam is distinct from other bead production sites in southern India, namely Arikamedu and Kodumanal. Bead producers at Pattanam focused largely on agate, carnelian, and chalcedony materials, with beads having been manufactured using the "pecking" method. Scholar Peter Francis, Jr., had previously argued that there were two technological traditions of stone bead production in South India, which were associated with two different cultural/ethnic groups. Evidence from Pattanam challenges this assertion, arguing that different ethnic groups did not exclusively work with particular raw materials or manufacturing methods.

INTRODUCTION

Stone ornament production and trade were important aspects of economic life during the Early Historic period in South India (300 BCE – 400 CE). Stone beads and many other varieties of ornaments were important as expressions of social status and cultural identity during this period (e.g., Selvakumar 2021). Pattanam, identified with the literary and historical site of Muziris, was one of the most important port sites of the Indian Ocean trade, and as such, it most likely played a role both in bringing together various products from South India for trade and export, as well as in importing goods from around the Indian Ocean (Cherian et al. 2009a; Cherian et al. 2007, 2009b; Cherian et al. 2010, 2011; Shajan et al. 2005) (Figure 1).

Pattanam was not only a center for trade, but also for production of stone beads and other ornaments (Abraham 2021; Cherian and Menon 2014). Analysis of the stone beads, bead roughouts and blanks, as well as some of the stone raw material and debitage that was recovered during the 2007 and 2008 excavation seasons at Pattanam, indicates bead production at this site was distinct from that found elsewhere in South Asia. In contrast to workshops at Arikamedu and Kodumanal, the craftspeople of Pattanam primarily focused on the production of carnelian and agate beads as opposed to locally available semi-precious stones such as quartz, citrine, and garnet, which were found in lesser quantities.

The bead scholar Peter Francis, Jr., had previously argued that South Indian bead production was divided into two different bead-making communities that used different technological traditions: the pecking, polishing, drilling school associated with the local "Pandukal" people who worked local materials, and the grinding, drilling, polishing technique linked to migrants from Gujarat who used non-local carnelian and agate (Francis 2004: 490-1).

I argue that evidence from Pattanam, as well as Kodumanal and Arikamedu does not support Francis' hypothesis. Different bead manufacturing techniques were not exclusive to specific raw material types nor different cultural traditions or ethnic groups. In this article, I first present a background on this topic and discuss the importance of the gem trade at Pattanam based on literary sources. I then examine previous work by Peter Francis, Jr., on bead production in South India at the site of Arikamedu and my own work at the site of Kodumanal. Following this, I present my analysis of the *chaîne opératoire*, or operational sequence, of bead production at Pattanam.

Non-local influence at Pattanam

The connection between Rome and ancient India has been of longstanding interest to both archaeologists and historians (c.f. Aiyappan 1941; Begley 1983; Begley and DePuma 1991; Begley et al. 1996, Begley et al. 2004; Casson 1989; Ray 1986, 1987, 1989, 1994, 1996a, 1996b; Wheeler 1948, 1951, 1954; Wheeler et al. 1946). The debate has mainly centered on the question of exactly how much

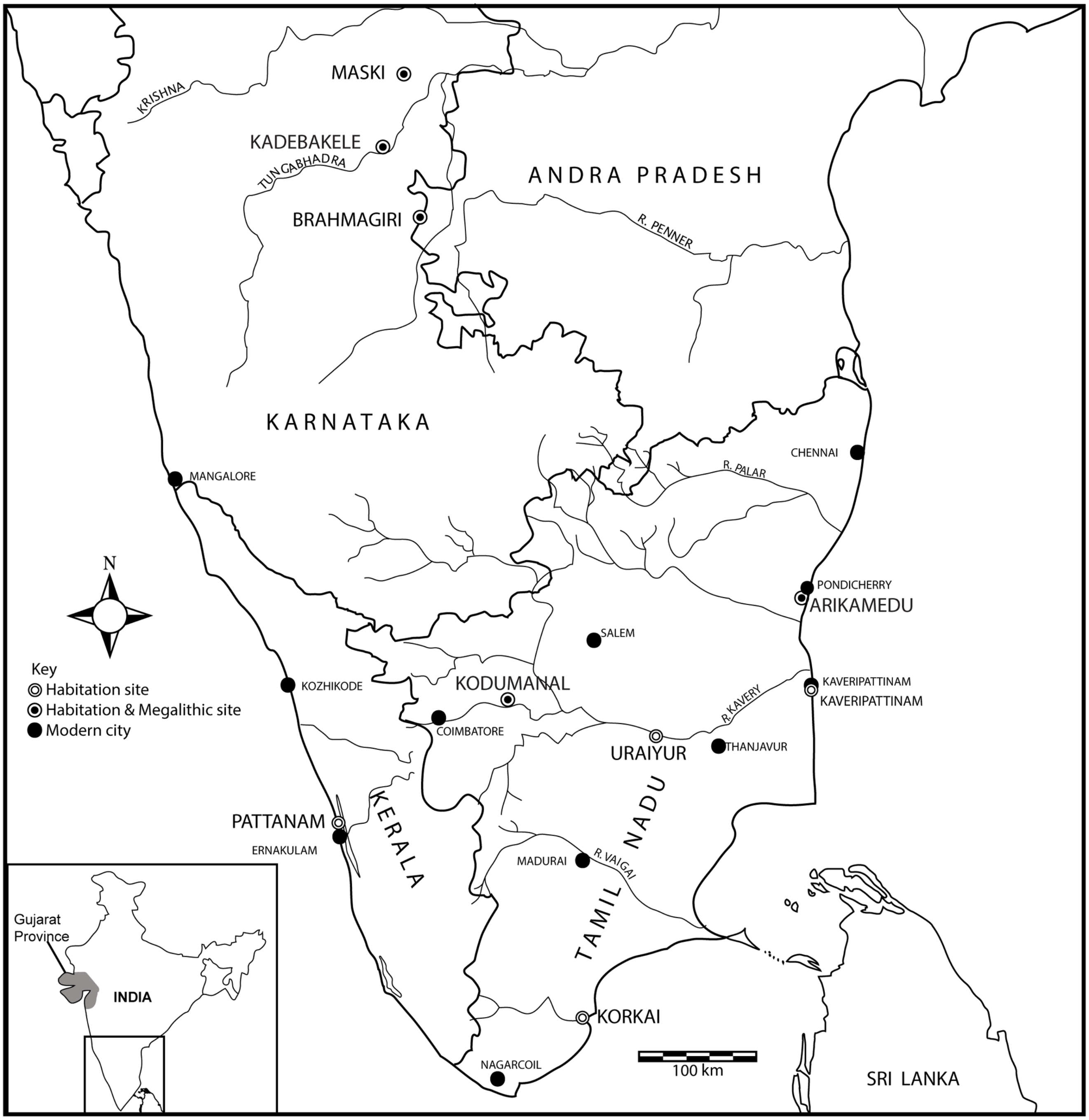

Figure 1. Map of Key Early Historic Sites in South India. Inset map shows location of Gujarat Province.

Roman or foreign presence and influence there was in South India during this period. Beyond the question of presence is the complex question of the impacts of such a presence and influence on the economy, trade, and political developments in South India during this period. Early scholars such as Wheeler argued, for instance, that Arikamedu was a Roman settlement in India (Wheeler 1948, 1951, 1954).

Recently the pendulum has swung significantly in the other direction, with scholars arguing that there was likely very little settlement or long-term presence of foreigners, but rather emphasizing the importance of Indian traders and ships, and the movement of Roman and Mediterranean goods through numerous hands, to finally reach South Indian ports (Ray 1986, 1994).

Exactly how many "Romans" ever set foot on the shores at Muziris or Arikamedu is impossible to know, but it is clear that Mediterranean goods were consumed there, and that Indian goods were consumed in the Roman world. In terms of actual connections of trade, chemical analysis of beads, cameos and other ornaments from Pattanam and sites in the Roman world could help to demonstrate actual connections between specific sites in both regions.

There are also questions of trade, social connections and potential migrations within South Asia. South Asia was clearly connected; there are no major geographic boundaries, and cultural areas, to the extent to which such areas are defined, blend into one another. As coastal ports of trade, Arikamedu and Pattanam likely received finished goods and raw materials via overland and sea routes (see Abraham 2002; Verma 2022).

Scholars have wondered whether all the carnelian in India came from the region of Gujarat (there are no known sources of carnelian or agate in South India) (Figure 1), and if stone bead makers from Gujarat may have migrated south and settled at sites like Arikamedu (Francis 1991, 2004). Francis argued that the *chaînes opératoires* of bead production evident at Arikamedu supported his migration hypothesis, while craftspeople also maintained trade contacts with Gujarat for agate and carnelian raw materials (Francis 1991, 2004).

Notably, the patterns Francis found at Arikamedu are not borne out by the material at Pattanam. There are several possible conclusions that may be drawn from this. First, it is possible that Francis was correct that beadmakers from Gujarat settled at Arikamedu, but that the same was not true at Pattanam. Second, it's possible that the different techniques and *chaînes opératoires* of bead production belonged to different technological traditions, perhaps originally of different regional affiliation, but which came to be shared and transmitted by other means (such as imitation and/or apprenticeship and training) across these geographic and cultural boundaries. Thirdly, it is possible that the material found at Pattanam derives from multiple sources. Being an active port of trade, it is possible that some of both the finished and partially worked bead roughouts and blanks could have arrived at the site in the state in which they were found, having been made or partially worked elsewhere. This article examines some of the questions related to the techniques of production. Further research will be necessary to clarify the picture with regards to the nature and impact of long-distance trade connections around the Indian Ocean and Mediterranean worlds.

Literary References to Muziris and Trade in Semi-Precious Stones

The ancient port of Muziris, with which Pattanam is identified, has been mentioned numerous times in both ancient Tamil Sangam literature and foreign sources such as the *Periplus Maris Erythræi*[1] and Ptolemy's *Geography*. The *Periplus Maris Erythræi* mentions the export of numerous varieties of semi- precious stones from India in general and Tamilakam[2] or the Tamil region, although only the stones and other materials are listed, not their forms. From Muziris in particular, the *Periplus* mentions *lithia diaphanes*, meaning diaphanous or translucent stones, which may include a wide variety of colors and gems. Diamonds, (*adamas*) are listed separately from other translucent stones. Other varieties of stone of dubious identification are also mentioned, such as *yakinthos* meaning perhaps either ruby or amethyst, according to McCrindle (1879:33-37), or possibly sapphire or lapis, since the color it refers to is interpreted as blue in most translations. Pliny, in his 'Natural History', mentioned a large variety of stones, including beryl, rock crystal, amethyst, garnets, prase, onyx and sardonyx. But only in the case of beryl, does he describe the forms in which it was worn, used and presumably traded:

> The people of India are marvelously fond of beryls of an elongated form, and say that these are the only precious stones they prefer wearing without the addition of gold: hence it is that, after piercing them, they string them upon the bristles of the elephant. It is generally agreed, however, that those stones should not be perforated which are of the finest quality; and in this case they only enclose the extremities of them in studs of gold. They prefer, too, cutting the beryls in a cylindrical form, instead of setting them as precious stones; an elongated shape being the one that is most highly esteemed. Some are of opinion that beryls are naturally angular, and that when pierced they become improved in colour; the white substance being thus removed that lies within, and their brilliancy heightened by the reflection of the gold in which they are set; or, at all events, their transparency being increased by this diminution in their thickness. … In our own part of the world it is thought that they are sometimes found in the vicinity of Pontus. The people of India, by coulouring crystal, have found a method of imitating various precious stones, beryls in particular (Pliny translated by Bostock and Riley 1857:415).

Excepting the above description, the fact that most such stones seem to primarily have been categorized by the authors as "semi-precious stones" without further enumeration of their forms (such as beads, ornaments, cut gems, etc.) can be taken to mean several things. First, it could be that the forms these items took, whether raw materials or finished beads and ornaments, were irrelevant to the traders and others reading such documents. It could also mean that the category included multiple forms of finished and unfinished beads and ornaments as well as raw materials. Such vagueness in the literature suggests that trade may not have taken place only in finished products, but also in items and materials at various stages in their processing and manufacture.

The Sangam literature also refers to Muziris (as Muciṟi), and it is similarly described as an important port of trade. According to these sources, the most important items of export were paddy (rice), pepper, and fish. The passage below is likely representative of the kinds of items that were traded in the largest volumes and presents a vibrant and evocative picture of this port site:

> In Muciṟi with its drums, where the ocean roars, where the paddy traded for fish and stacked high on the boats makes the boats and houses look the same and the sacks of pepper raised up beside them make the houses look the same as the tumultuous shore and the golden wares brought by the ships are carried to land in the servicing boats,
>
> Kuṭṭuvaṉ its king to whom toddy [a type of fermented palm sap or palm wine] is no more valuable than water, who wears a shining garland, gives out gifts of goods from the mountains along with goods from the sea to those who have come to him. (from *Puranāṉūṟū* 343 Translated by Hart and Heifetz 1999:195-6).

This account of the loading and unloading of ships using smaller boats accords well with that of Pliny, who also mentions that the ships were moored out from the coastline:

> For from thence, and with the West Wind called Hypalus, they have a passage of forty Days' Sailing to the first Town of Merchandise in India, called Muziris. However, this port is not to be ventured in, because of the neighboring pirates, which keep ordinarily about a place called Hydrae; and it is not richly stored with Merchandise. And moreover, the Station of the Ships is far from the Land, so that they must convey their Wares in little boats which they use for the purpose. At the time in which this Account was written, the King that reigned there was named Celebothras [Keralaputras](Pliny the elder, translated by Holland 1849: 135).

Stone beads were not mentioned with regard to Muziris, or, in fact, any other place in the Sangam literary corpus. The lack of mention of beads and semi-precious stones in these sources suggests that the trade or production of beads and semi-precious stone ornaments was not considered particularly noteworthy, or perhaps not sufficiently poetic to Sangam authors. Considering their repeated mention in foreign sources, we might infer that such products had more significance to the foreigners importing them than the Indians who produced and exported them. Though "diaphanous stones" may not have been the prime economic force driving trade, it is certainly likely that the growing trade in grain, pepper, spices and textiles created economic opportunities for bead and ornament production.

PREVIOUS RESEARCH ON STONE BEADS, TECHNIQUES, AND TECHNOLOGIES IN SOUTH INDIA

Stone beads were produced at many sites in South India during the late Iron Age and Early Historic periods. Arikamedu and Kodumanal have been studied in the greatest detail, while excavation reports from other sites note the presence of stone beads and bead production without detailed information (Francis 1991, 2002a, 2002b, 2004; Kelly 2009; Rajan 1998). The beads and production debris from the site of Arikamedu (identified with the emporia of Podukê mentioned in the *Periplus Maris Erythræi*), were studied in detail by Peter Francis, Jr., (1991, 2002a, 2002b, 2004). Gwinett and Gorelick (1986, 1987, 1988) examined the drilling technology of stone beads in India and Sri Lanka. Additionally, I have examined the stone beads and manufacturing techniques of bead production from Kodumanal, Erode district, Tamil Nadu (Kelly 2009, 2016).

Bead production at Arikamedu

Francis' (1991, 2002a, 2002b, 2004) investigations of the Arikamedu collection produced several important conclusions about the techniques of lapidary production. There was a roughly 2:1 proportion of quartz and macrocrystalline materials to agate and carnelian and other microcrystalline varieties of bead blanks and unfinished beads in various stages of the production process. From the beads he examined, which had been excavated at different times by different excavators, he found that there were two predominant and distinctive *chaînes opératoires* of bead manufacture. One sequence of steps is:

0) procurement of raw materials;
1) chipping the stone to produce a roughout of the bead shape and removing cortex;

2) heating to intensify color and facilitate further chipping;
3) chipping to rough out a shape;
4) grinding the roughout into a bead blank;
5) drilling of the perforation; and
6) polishing the surface.

This sequence or *chaîne opératoire* is associated more strongly with agate and carnelian bead manufacture at Arikamedu (Francis 2004:479-491) and at Khambhat in Gujarat (Kenoyer, Vidale and Bhan 1991). The alternative *chaîne opératoire* was associated with quartz and other macrocrystalline materials at Arikamedu and involved:

0) procurement of raw materials;
1) chipping the stone into a roughout of the bead shape;
2) pecking the roughout into a bead blank;
3) polishing the surface; and
4) drilling of the perforation.

Francis argued that these two different *chaînes opératoires* were strongly associated with two different categories of raw material at Arikamedu. The grinding technique and associated sequence of drilling before polishing is mostly found with the agate, carnelian and chalcedony materials that were not locally available, and thus with non-local or migrant bead makers. In contrast, he argues that the pecking technique and alternative sequence of polishing, then drilling, was associated with the macrocrystalline stones such as quartz, and thus associated with the "Pandukal people," a "people" or culture identified with the construction of megalithic burials in South India (Francis 2004:490-491; Leshnik 1974). Francis also mentions that this pecking technique is known from Kodumanal in Tamil Nadu (citing Rajan 1990), and Mahurjhari in Maharashtra, (citing Deo 1973, and Mohanty 1999).

Though Francis argues that these two *chaînes opératoires* are associated with two different categories of material and therefore two different groups of producers, there is not an exact correlation between material and technique of manufacture. His own data from Arikamedu, (including both the Pondicherry Museum collections and materials excavated in the 1989-1992 excavations) show that both techniques were used for both categories of raw material – what he calls "crystalline", (meaning macrocrystalline varieties such as quartz, amethyst, citrine, etc.) and what he calls "chalcedonic" (meaning microcrystalline varieties of agate, carnelian, chalcedony, jasper, etc.). (Table 1). One might say that the correlation is strongest for the microcrystalline varieties, shown in both the Pondicherry Museum collections and excavated materials. The association for the local, and more readily available macrocrystalline stone varieties is weaker in both assemblages. Using a chi-square test, we can see that the proportions of pecked versus ground blanks in the Arikamedu sample are not random ($x2 = 60.758$, $p < .01$).

Though we can say with statistical certainty that the proportions of pecked and ground bead blanks are the result of patterned human action, we must still explain why it is that the assemblage of local macrocrystalline materials is split roughly in half, while a much larger proportion of microcrystalline agate, carnelian, jasper, etc., was predominantly made by the "grinding" method.

Francis examined three possible hypotheses to explain the differential use of "pecking" with crystalline raw materials (quartz, amethyst, etc.), and grinding with microcrystalline raw materials (agate, carnelian, chalcedony, etc.). He considered whether the techniques were related to the materials, that is whether pecking might be easier with crystalline materials and grinding with microcrystalline materials. He rejected this hypothesis on the basis that it does not explain why these techniques also reverse the steps of drilling and polishing. He then examined whether there was any chronological trend to the use of these different techniques and *chaînes opératoires*, and found none, at least within the Arikamedu data set.

Table 1: Pecked Versus Ground Bead Making Techniques at Arikamedu (Francis 2004:488).

Material Type	Pondicherry Museum Pecked v. Ground		Total from Pondicherry Museum	1989-1992 Excavations Pecked v. Ground		Total from 1989-1992 Excavations
Macrocrystalline varieties	172 (50.4%)	169 (49.6%)	341 (100%)	21 (65.5%)	11 (34.4%)	32 (100%)
Microcrystalline varieties	61 (20.2%)	241 (79.8%)	302 (100%)	13 (81.2%)	3 (18.8%)	16 (100%)
Total	233 (36%)	410 (64%)	643 (100%)	34 (71%)	14 (29%)	48 (100%)

He concluded that two different schools or traditions of technology were practiced by two different bead making communities: the pecking, polishing, drilling school associated with the local "Pandukal" people, and the grinding, drilling, polishing technique linked to migrants from Gujarat (Francis 2004: 490-1).

Bead Production at Kodumanal

My analysis of bead production at Kodumanal shows that both pecking and grinding were techniques used, though in both cases the order of the *chaîne opératoire* appears to have been the same as that which Francis associates with the 'pecking' complex (either pecked or ground, and then polished, prior to drilling). There is only one example of a bead that was pecked and then drilled before polishing. This assemblage is also almost entirely made up of clear, colorless crystalline quartz, with a ratio of approximately 2000:1 (including debitage), for quartz and macrocrystalline raw materials versus agate and other microcrystalline stones. The proportion of pecked and ground materials at Kodumanal is also about 1:1 (28 pecked: 29 ground), a ratio similar to that at Arikamedu for quartz and related materials (Kelly 2009, 2016.).

Gwinnett and Gorelick (1986, 1987, 1988) have examined the impressions of drill holes from Arikamedu and sites in Sri Lanka, demonstrating the predominance of double-diamond drill bits at these sites. Francis (2004:482) notes that all the beads he examined appeared to have been drilled by the double-diamond drill bit. However, analysis of the material from Kodumanal suggests that there were a wider variety of drill types in use at the time, or the continuing circulation and trade of beads that had been drilled with a wide variety of drill types (Kelly 2009, 2016.). These drill types include stone drills (possible materials include chert, jasper or ernestite c.f., Kenoyer 2005), single-diamond tipped, double-diamond tipped, copper/bronze rod with abrasive, and copper tube with abrasive. At Kodumanal the methods of drilling seem to have predominantly been both double-diamond drills, and copper/bronze rod with abrasive for beads, and copper tube drills with abrasive for rings (Kelly 2009). Considering the myriad ways in which the Pattanam stone bead material defies expectations, a study of the drilling techniques would be a useful and productive line of inquiry for future research.

PATTANAM LAPIDARY PRODUCTION

Pattanam bead making techniques appear to be exceptional, especially when compared with Arikamedu and Kodumanal. First, it is significant that Pattanam lapidary workers seem to have focused primarily on agate, carnelian, and chalcedony materials, producing beads, and cameos (or perhaps more likely, cameo blanks), inlays and pendants. Further, at Pattanam, and in contrast to Francis' conclusions from Arikamedu, it appears that the carnelian and agate beads were primarily being manufactured using the 'pecking' method.

The sample from these two seasons is small compared with Kodumanal and Arikamedu, and therefore some of the differences between these assemblages may result from the effect of sampling. Even so, the Pattanam assemblage is composed of different proportions of both stone raw materials and production techniques. In terms of production, microcrystalline materials (agate, carnelian and onyx) were the most common (n=50, 71%), with a ratio of 6:1 carnelian/microcrystalline materials to quartz/macrocrystalline materials. The macrocrystalline materials (quartz and citrine) made up only 23% of the assemblage (n=16, 23%), and garnet only 6% of the assemblage (n=4) (Figure 2 and 3 and Tables 2 and 3).

Figure 2. Agate and carnelian roughouts and pecked bead blank (lower left) from the 2007-'08 excavations at Pattanam.

Figure 3. Agate and carnelian beads from the 2007-'08 excavations at Pattanam.

With regard to the question of pecking versus grinding, there is only one roughout in this assemblage, and it is pecked (Table 4). The rest of the unfinished and waste material comes from stages prior to either the pecking or grinding stage. Of the finished beads I examined, a large proportion (74%) still show the marks of their methods of manufacture, despite polishing. The remainder (26%) is so highly polished as to have obliterated any marks of pecking or grinding.

The assemblage at Pattanam seems therefore to be the opposite of that from Arikamedu in that it contains predominantly microcrystalline material (agates of various colors including carnelian) and it is also largely pecked, rather than ground: 79% of the microcrystalline beads are pecked and 14% ground; the remaining 7% were indeterminate. In contrast, at Arikamedu 80% of the microcrystalline material was made by grinding (Francis 2002).

The Pattanam material is also noteworthy regarding the order of the stages in production. According to Francis (2002:479-491), beads made by grinding would be drilled before polishing, and beads made by pecking would be drilled after polishing. To determine the order of drilling and polishing, I examined the drill holes from the finished Pattanam beads to note whether the area around the perforation was polished or not. From this analysis, I determined that 67% of the finished beads were drilled before polishing, and 25% were

Table 2: Proportion of Finished and Unfinished Beads and Worked Material by Material, from Pattanam 2007-08 Excavations.

Pattanam 2007-'08 Excavations			
Material Type (% of Assemblage)	**Finished Bead (Row%)**	**Total Unfinished/Worked (Row%)**	**Total**
Garnet	2	**4**	6
(6%)	(33%)	(67%)	(100%)
Macrocrystalline	7	16	23
(21%)	(30%)	(70%)	(100%)
Microcrystalline	13	50	63
(58%)	(21%)	(79%)	(100%)
Serpentine	9	0	9
(8%)	(100%)		(100%)
Steatite	3	0	3
(3%)	(100%)		(100%)
Other/Unknown	3	1	4
(4%)	(75%)	(25%)	(100%)
Total (100%)	37 (34%)	71 (66%)	108 (100%)

Table 3: Sample of Stone Beads and Production Materials from Pattanam 2007-'08 Excavations.

Pattanam 2007-'08 Excavations						
Material Type	**Bead (Row%)**	**Blade (Row%)**	**Flake (Row%)**	**Raw material (Row%)**	**Roughout (Row%)**	**Bead blank (Row%)**
Garnet	2 (33%)			4 (66%)		
Macrocrystalline	7 (30%)		2 (9%)	13 (57%)	1 (4%)	
Microcrystalline	13 (21%)	1 (2%)	18 (29%)	12 (19%)	18 (29%)	1 (2%)
Serpentine	9 (100%)					
Steatite	3 (100%)					
Other/Unknown	3 (75%)			1 (25%)		
Total	37 (34%)	1 (1%)	20 (19%)	30 (28%)	19 (18%)	1 (1%)

drilled after (Table 5). All eight of the microcrystalline beads that were drilled before polishing, were also pecked. This contradicts not only the idea that pecking should be associated with macrocrystalline materials, but also that pecked materials should be drilled after polishing.

In addition, the range of colors in the microcrystalline materials suggest that heat treating of raw material was a possible, but not necessary, step in the *chaîne opératoire* for these materials as Francis suggested. Microcrystalline materials naturally vary quite significantly in their color from white, tan, brown, gray, light orange to dark orange, to dark red-orange, where heating or heat-treating the stone tends to darken and intensify the color. It would appear from the blanks and roughouts that only a small fraction (approximately 25%) of the microcrystalline materials were likely to have been heated. It is much more difficult to say with any certainty whether the orange, perhaps best described as "Fanta orange," was heated or not. The evidence here is not conclusive, but it does suggest that heating was perhaps an optional step in production when using microcrystalline materials.

Table 4: Proportion of Pecked Versus Ground Materials from Pattanam 2007-'08 Excavations.

Pattanam 2007-'08 Excavations			
Material Type	**Pecked (Row%)**	**Ground (Row%)**	**Finished (Indeterminate) (Row%)**
Garnet	1 (50%)	0	1 (50%)
Macrocrystalline	3 (43%)	0	4 (57%)
Microcrystalline	11* (79%)	2 (14%)	1 (7%)
Total	15 (65%)	2 (9%)	6 (26%)
*Includes one unfinished pecked blank, the rest are finished.			

Table 5: Beads Drilled Before and After Polishing from the 2007-'08 Excavations at Pattanam.

Pattanam 2007-'08 Excavations			
Material	**Drilled After**	**Drilled Before**	**Indeterminate**
Macrocrystalline	2 (29%)	1 (14%)	4 (57%)
Microcrystalline	3 (25%)	8 (67%)	1 (8%)
Total	5 (26%)	9 (47%)	5 (26%)

The *chaînes opératoires* for both micro- and macrocrystalline materials at this point are difficult to untangle, but can be summed up as:

0) procurement of raw materials;
1) chipping/flaking the stone to remove cortex and produce a rudimentary roughout;
2) —> OPTIONAL for microcrystalline materials—> heating to intensify color;
3) chipping to rough out a shape nearer the dimensions of the finished object;
4) shaping from roughout to blank, either by
   a) pecking to shape a "blank,"
   OR
   b) grinding to shape a "blank,"
   OR
   c) pecking then grinding to shape a blank; and
5) finishing by
   a) drilling the perforation THEN polishing the surface,
   OR
   b) polishing the surface and THEN drilling the performation.

Such variation in both the techniques of manufacture and in the order of steps in the *chaînes opératoires* suggests that the picture of distinct techniques and cultural traditions is far more complicated than Francis supposed.

Based on depths and stratigraphic associations, most of this material may belong to the latter part of the Early Historic or Early Medieval period, approximately from 2nd century CE to the 5th century CE or later (Table 6). Of the sample I have examined here, four finished beads and six roughouts can be dated with some confidence to the Early Historic (approximately 2nd century BCE – 2nd century CE). However, this dating is tentative, and a larger sample would be needed to establish any significant chronological trends. Instead, this assemblage can be treated as a palimpsest of the occupation at Pattanam and can be assumed to represent the composite of its history of bead production. Considering the overall consistency in the techniques of manufacture in the sample examined here, the technological traditions remained more or less constant over the course of the occupation. A more complete analysis would be necessary to look at the variation between different areas of the site, and over time.

There is little evidence for bead production from macrocrystalline material (quartz), which is in evidence in finished beads (shown in Figure 4). There are a total of 16 pieces of a worked macrocrystalline yellow-tinged stone that appears to be citrine (14.8% of the total sample) from the two seasons of excavation. None of these pieces are roughouts or bead blanks, and instead appear likely to have been waste material, though they are mostly pieces of shatter, rather than flakes. This contrasts with the debitage of microcrystalline production, which is a mixture of roughouts, cortex removal and core-reduction flakes. Likely these finished quartz beads were not made at Pattanam. However, the semi-opaque material does not match that of Kodumanal either. Only the smaller clear and colorless faceted crystal beads match the kinds of beads produced at Kodumanal (Kelly 2009, 2016.).

There appear to be two distinct categories of quartz beads. The beads in the top row of Figure 4 are made from a pure and transparent colorless quartz, similar to the quality and material found and produced at Kodumanal. Those in the second row are made of milky quartz, significantly less translucent, and almost white rather than clear. This quartz occurs under somewhat different geological conditions, resulting from the occurrence of gas bubbles that are trapped during the formation of the crystal, which increase the opacity of the stone. These bead forms (Figure 5), and perhaps also the material, are like those found at other coastal sites, such as Arikamedu, and Tissamaharama in Sri Lanka (Hannibal-Deriyanagala 2001:220)

In addition to the macrocrystalline and microcrystalline beads and debitage, there was a distinctive set of several

Table 6: Finished and Unfinished Beads and Production Evidence from 2007-'08 Excavations at Pattanam.

Pattanam 2007-'08 Excavations									
Excavation Unit	**Finished**			**Unfinished & Production Evidence**			**Grand Total**		
	Col%		**Row%**	**Col%**		**Row%**	**Col%**		**Row%**
Near Trial Trench 1	3%	1	100%	0%	0	0%	1%	1	100%
PT07-I	22%	8	73%	4%	3	27%	10%	11	100%
PT07-II	43%	16	89%	3%	2	11%	17%	18	100%
PT07-III	14%	5	20%	28%	20	80%	23%	25	100%
PT07-IV	3%	1	50%	1%	1	50%	2%	2	100%
PT08-IV	5%	2	25%	8%	6	75%	7%	8	100%
PT08-VII	5%	2	15%	15%	11	85%	12%	13	100%
PT08-VIII	0%	0	0%	17%	12	100%	11%	12	100%
PT08-IX	0%	0	0%	1%	1	100%	1%	1	100%
PT08-X	5%	2	20%	11%	8	80%	9%	10	100%
PT08-XI	0%	0	0%	10%	7	100%	6%	7	100%
Total	100%	37	34%	100%	71	66%	100%	108	100%

Figure 4. Quartz beads from 2007-'08 excavations at Pattanam.

varieties of green stone (Figure 6). The beads in the bottom row are all made of serpentine, a relatively soft stone. The four on the bottom right are all decorated with sawn incised marks around the surface. Of these, the three on the right are scored in a rough, spiraling pattern around the circumference of the beads. The fourth from the right is decorated with sawn collar marks and the middle is decorated by a cross-hatching pattern. These lines might have been filled with a paste or other colorant, without which the lines are not particularly visible. Though the serpentine beads on the bottom row are all relatively rough in shape, they can generally be identified

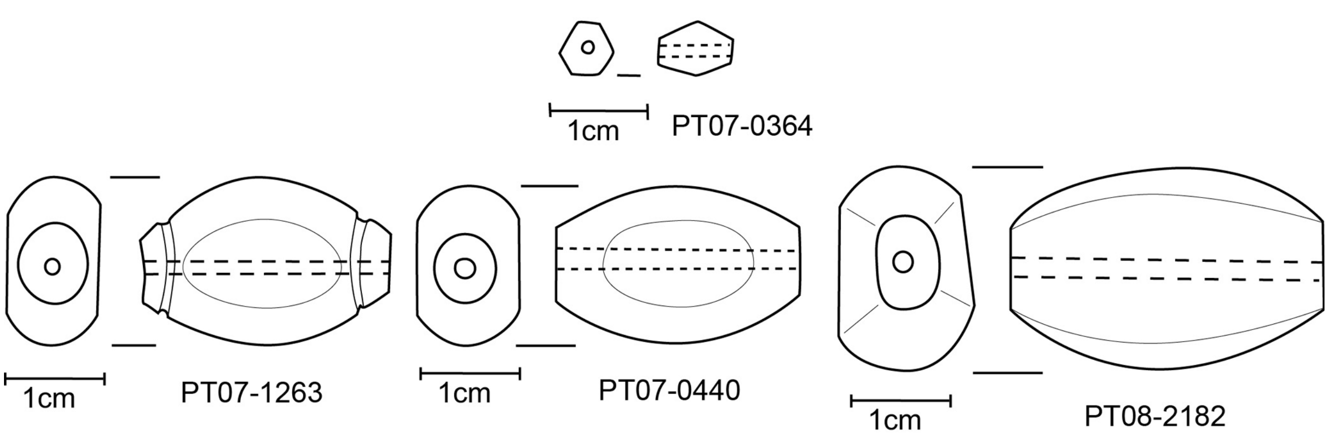

Figure 5. Quartz beads showing transverse section from 2007-'08 excavations at Pattanam.

Figure 6. Serpentine and other green stone beads from 2007-'08 excavations at Pattanam.

as having a barrel shape longitudinally and being roughly triangular in transverse section. This type of bead appears similar to those reported by Francis at Arikamedu, which he identified as a type of steatite. According to Francis, beads of this type, which he also describes as triangular in section and decorated with incisions over the surface, have been found at Kaveripattinam and Kodumanal in Tamil Nadu, Óc Eo in Vietnam, and Khlong Thom, Thailand (Francis 2004:506).

CONCLUSIONS

Francis argued that there were two technological traditions of stone bead production in South India that were associated with two different cultural/ethnic groups. However, I argue that the overlap of pecking and grinding, the variability in the *chaîne opératoire*, and the distribution of these techniques within areas of Kodumanal, Arikamedu and Pattanam suggests that pecking and grinding were not exclusively associated with particular raw materials, and were not the intellectual property, or exclusive cultural practices of different ethnic groups. As Francis argued, some bead makers may have migrated from other regions of India to take advantage of economic opportunities within these southern ports. However, there is currently not sufficient evidence in the bead making techniques, or the presence of ceramics or other material culture from Gujarat or other regions outside South India, to suggest a large-scale migration.

Although the absence of evidence should not always be taken as evidence of absence, it seems most likely that bead makers, regardless of regional affiliations, were using both pecking and grinding techniques. I do, however, agree with Francis' claim that the difference between pecking and grinding cannot simply be explained by function or application, such as the difference between rounded bead forms and faceted ones. Pecked faceted forms have been found, as well as rounded forms that have been ground. Without going back to re-analyze all the Arikamedu material first-hand, I cannot evaluate Francis' claims about the differential ordering or sequence of the *chaînes opératoires*. However, if his observations were true at Arikamedu, that may be an exception, as the same pattern does not hold at either Kodumanal or Pattanam.

Some material and ornament types are lacking from these two excavation seasons. There is neither lapis nor steatite stone beads and apparently no shell or glass, rings, or ear-spool ornaments. Small numbers of glass bangles and ornaments made from gold and terracotta have been identified (Cherian et al. 2016). Some of these idiosyncrasies may be the result of a small sample size. On the other hand, another explanation may lie in the chronology of the site, and the particular trenches and layers excavated in the 2007-'08 season.

As an important port of trade, it is difficult to establish whether the finished and unfinished products were loaded onto the boats mentioned in Pliny's text and the Sangam poem (Puranāṉūṟū 343) for trade. Or they may have also been used and worn by the inhabitants of Muziris. Bangles and anklets are the ornaments mentioned most frequently in the Sangam corpus, and yet only 51 bangle fragments were identified in excavations from 2007-2015 (Cherian et al. 2016). Does this sample and assemblage therefore represent purely trading activities, and not the ornaments of daily wear? Further excavation and analysis of these materials will help answer these and other questions, about the production and trade of stone beads in South India.

Considering the question of migrants from Gujarat or other parts of India, there is currently a lack of evidence for other forms of material culture distinctive to those regions of India found at Pattanam. The more likely interpretation is that the two regionally affiliated technical traditions and *chaînes opératoires* ultimately came to be transmitted not through the migration of people, but through the transmission of knowledge and training in those techniques. Since both Arikamedu and Pattanam were important ports of trade, it is also possible that the materials, including both finished and unfinished products that may have originated elsewhere, and that partially finished beads and ornaments may have themselves been traded. This would result in a much more muddled view. According to Cherian et al. (2010, 2011), a local lapidary workshop has been discovered. Analysis of the remains to look for micro-debitage and reconstruct the reduction sequence from that area may help to clarify these issues.

Furthermore, analyses such as LA-ICP-MS (Laser Ablation-Inductively Coupled-Mass Spectrometry) or INAA (Instrumental Neutron Activation Analysis) of some of the finished and unfinished stone beads and materials from Pattanam would be extremely useful to compare to the increasingly large database of sources of carnelian and agate in Gujarat and elsewhere (e.g., Carter and Dussubieux 2016; Law et al. 2013; Theunissen et al. 2000). By examining the Pattanam material using these methods, we may find that the material can be positively identified with sources in Gujarat, but it is also possible that these beads and raw materials might match other sources in Iran and Southeast Asia, or perhaps even belong to an as yet undiscovered South Indian agate source. The combination of information about the geologic sources, the beads, and their techniques of manufacture may also contribute to our understanding of the regional association of different techniques, such as pecking and grinding, and the different *chaînes opératoires* and order of drilling and polishing. Much more research remains to be done to improve our understanding of the locations and organization of bead production, and the nature of the trade in raw materials, unfinished and finished beads in South India, and the wider Indian Ocean, and Mediterranean spheres.

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ENDNOTES

1. The *Periplus Maris Erythræi* is a navigational guide to the Indian Ocean, written in Greek, by an anonymous Roman-Egyptian, in approximately the 1st century CE (Casson 1984).

2. The terms in these documents are *damirike* and *limurike*. The term *damirike* appears to be the Greek rendering of *Tamilakam* (meaning Tamil country), and *limurike* the result of a transcription error in Greek where Δ (i.e. D/delta) seems to have been mis-transcribed as Λ (i.e. L/lambda) (Caldwell 1856[1875:14]). The "ri" probably results from a misinterpretation of the retroflex L of Tamil, heard by foreigners unused to the sound of retroflex consonants.

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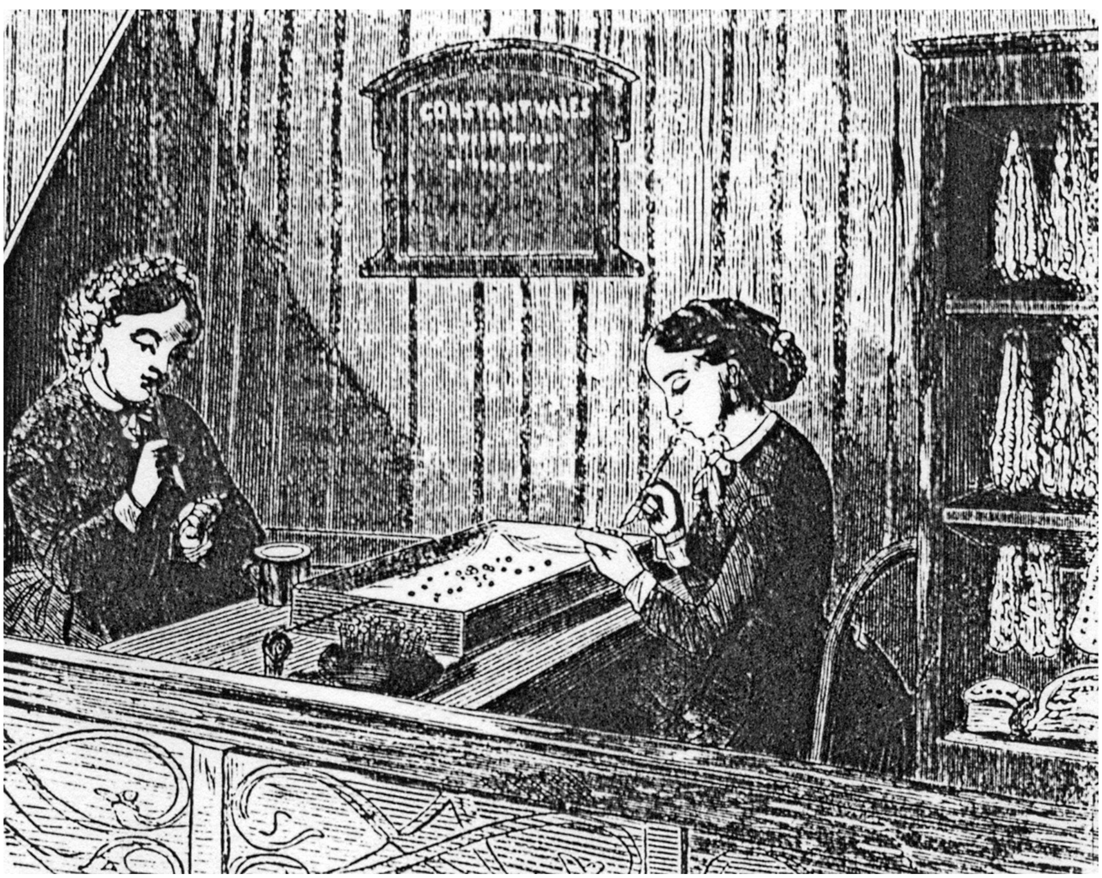
ARTIFICIAL PEARL MAKING: EMPLOYMENT FOR WOMEN

[This item appeared in the January 1871 issue of *Godey's Lady's Book and Magazine* (Vol. 82, No. 487, pp. 65-67), published in Philadelphia. It provides a relatively detailed description of the production of faux pearls as practiced in France, highlighting the role women played in their creation. The plaque on the wall in the illustration mentions Constant Vales, possibly a familial member of the M. Valez & Co. mentioned below.]

A considerable portion of the various operations of pearl-blowing, as of fan making, is carried out by women. Although this work is but poorly remunerated, yet, as affording employment to many hundreds of women, it would be a useful introduction into America.

The first mention of artificial pearls is found in 1318. M. Lazari, in his "Notizie delle opere, d'arte e d'antichità," tells us that the makers of them, called "chaplet makers" and pearl makers," were established at Vienna and Murano, and formed a sufficiently numerous body to require an express statute for their regulation. Although even at that time the large export of pearls to the East brought large sums of money to the Venetian republic, it would appear that it had not yet reached its apogee for the same author adds: "The fabrication of artificial pearls, by means of the glassblower's lamp, confers immortality on the name of Andrea Vidoare, to whom we owe, if not the inventing, at least the perfecting, of this process in 1528." The manufacture is now carried on chiefly in Rome, Venice, and Paris, and in those cities it



BEADS: Journal of the Society of Bead Researchers 36:63-65 (2024)

has reached a dangerous excellence. So perfect beyond all others are the French imitation pearls that it is difficult for the practiced eye of a jeweller to distinguish the true from the false. The French are very happy in the production of black pearls. The perfection of these imitations renders them all but indistinguishable from the real pearls. The process of the manufacture of these charming little articles is carried out in the following manner: –

The pearl-blower's workshop is of the simplest character. It is composed of a little table almost a yard long, on which is placed a lamp with a thick wick, which, fed either with oil or lard, gives forth a long jet of flame – this flame being regulated by a bellows arranged under the table, and moved by the foot of the operator. On this table are placed some hollow glass tubes of different kinds. Some of ordinary glass, which are used to make the common kinds of pearls; others of a slightly iridescent tint are only employed for the best description, known commercially as "Oriental pearls." The secret of the composition of the latter kind of glass, due to the researches of the chemist, M. Pierrelot, who died some years ago, now belongs to the house of M. Valez & Co.

We will now describe how the pearl-maker, with the aid only of a tube of hollow glass (precisely the same as a child's peashooter), is enabled to produce pearls of all kinds, some of which, by the beauty of their form and their opaline lustre, can with difficulty be distinguishcd from the finest Oriental variety. The pearl-blower, seated at the table, has the lamp before him. On the right are placed tubes of very small dimensions; the size of the tube employed naturally is in proportion to the size of the pearls required. Thc first operation of the workman is to draw out the tube–that is to say, to increase its length, to diminish its diameter. The tube being drawn out to the required dimensions, he breaks it into minute fragments; he then takes up one of these fragments, and presents one end of it to the lamp. As soon as the glass begins to liquefy, he blows softly into the tube, which, though drawn out, retains the internal passage, and the air dilating the warmed end, a globule is formed. This globule will eventually be the perfect pearl; at present it is incomplete, for in order that it should assume a faultless form three operations are indispensable – firstly, the piercing, which consists of two holes if the blower is making round pearls for necklaces or of one hole only if he is making round or pear-shaped pearls for ear-rings, buttons, etc.; secondly, the required form, whether round or pear-shaped; thirdly, the coloring of the interior of the pearl.

The double piercing necessary to admit the string, which is to unite the pearls, and form them into a necklace, is done at the moment when the glass, still of a spheroidal form, and adherent to the tube, is yet ductile. The first hole is made in the lower half of the pearl by the breath only of the blower, and the second is the natural result of the hollow of the tube at the point where the pearl is separated from it by means of a sharp tap.

All artificial pearls are made in the manner here described; but what are termed "Oriental pearls," being the most exact imitation possible of the real article, require a still further application of the pearl blower's art. Although the method of manufacture is precisely similar in both cases, the so-called Oriental pearls are distinguished from the commoner kinds, not only by their being made of an opalescent glass, but by the care the blower bestows on their form, as well as on their varied internal tints.

Every pearl buyer knows the difficulty of finding a pearl without defect, not in the material of which it is composed, but in shape and color. The art of the pearl blower, then, consists in the production of the best possible imitation of Nature; his talent is evinced not only by his neutralizing the exact regularity obtained by blowing the pearl, but he must produce on it the effects usually found in natural specimens. The work requires 1ong practice, and is the fruit of careful and patient observation. An artist in pearl blowing ought to be sufficiently acquainted with the appearance of real pearls, only to place on his own productions such defects as shall, by the aid of skilfully devised reflected lights, enhance the beauty of the work he has completed. In order to obtain this important result, the blower, taking advantage of the instant while the pearl yet adheres to the tube, takes a small iron instrument, with which he strikes lightly on certain portions of the pearl that are yet malleable. It is this last labor which, producing on it here an elevation, there an almost imperceptible depression, ends by forming a pearl which, losing its mathematical regularity, becomes a perfect imitation of nature. At this point the blower has finished his work. The pearls, which as yet are only morsels of colorless glass, will now pass into the hands of workmen whose business it is to give them the requisite coloring.

Although the work of coloring which will now be described is the same in all pearls, yet as the manufactured pearls are divided into two categories neutralizing–neutralizing ordinary pearls and oriental pearls neutralizing–neutralizing it is evident that two kinds of workwomen are necessary to finish them off. One undertakes the coloring of the ordinary ones; the other of the finer kinds. We shall only detail the method of coloring the latter sort; it merely differs from the other process by requiring a larger amount of finish. Our illustration exhibits the process of finishing. It will be observed that each workwoman has before her a series of small compartments, containing altogether several millions of pearls, so arranged that the side with the hole left by the blower is on its upper surface. Before introducing into it the coloring matter, which would be too easily detached from the glass if it were not consolidated by some fixing medium, each pearl receives inside it a very thin layer of a quite colorless glue made from parchment. This layer being spread over the internal cavity of each pearl, the workwoman takes advantage of the moment while it is yet wet to commence the real coloring operation.

The workwoman, taking up her slender hollow tube of glass, dips it into a paste composed of the scales of a tiny fish called bleak, of which she blows a certain small quantity into each of the pearls. Reference to the illustration will show the figure on the left hand in the act of performing this operation. The pearls are now finished, and have to be sorted and packed for the purpose of commerce. The fish-scale paste now used in filling the pearls is said to be the discovery of a Parisian chaplet maker, named Maître Jacquin, in 1686. It was a most useful and fortunate discovery for up to that period artificial pearls were colored by quicksilver, and its emanations proved most deleterious to the health of the workpeople employed in the manufacture.

Colored pearls are made in precisely the same manner as the white varieties, except that instead of the bleak-scale paste a compound of the color desired in the pearl is blown into it.

It has already been stated that the women practisers of this art gain but a poor livelihood; in order to earn from three and a half francs to four francs per diem, they must color forty thousand pearls. Still, even this rate of pay contrasts favorably with that obtained by needlewomen, and induces us to wish for the introduction of this branch of industry, into our own fields of labor.

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BOOK REVIEWS

Bead Talk: Indigenous Knowledge and Aesthetics from the Flatlands

Carmen Robertson, Judy Anderson, and Katherine Boyer (eds.). University of Manitoba Press. 2024. 240 pp. 62 figs. $22.50 Canadian (ePub or PDF) $27.96 Canadian (paper)

For many Indigenous peoples, beads are capable of communication, of telling stories, of carrying cosmologies, and of signifying networks of human and more-than-human relationships. Editors Carmen Robertson (Scots Lakota), Judy Anderson (Gordon First Nation), and Katherine Boyer (Métis and settler) use their positionalities to convene Flatland-born or -based Indigenous scholars, bead workers, artists, and curators for the creation of an edited book. Their contribution centers the power of beading traditions, relations, and visual aesthetics in storying a multiplicity of Indigenous worlds and temporalities. To take the bait of the title's idiom, that which must also be read beyond the figurative, *Bead Talk* lets beads and their beaders talk. So, what are they saying?

The introduction reminds us of the history of certain subfields that continue to fetishize beads or suck their souls by framing them as sterile, antiquated, and artifactual. Rather than dwell on that particular theme, this book intervenes by focusing on the contemporary Indigenous art/media of beading praxis and the specific colonial and decolonial histories — past, present, and future — that they respond to. Careful attention is given to introduce all contributors and to detail how their kinship networks formed through in-person, Zoom, and other virtual beading circles, particularly in the midst of the COVID-19 pandemic.

Bead Talk is organized in two parts, the first containing conversations and the second, essays. Part I is valuable in providing behind-the-scenes looks at beading processes, underscoring themes such as the value of mentorship, queer visual cultures, mental health, and institutional (museum, gallery, university) politics that impact Indigenous expression. Two standout chapters in this section are dialogues with Ruth Cuthand (Plains Cree and Scottish), a paradigm shifting beader. Cuthand details her work in *Trading Series* (2009), which represents viruses such as Smallpox through teeny tiny glass beads. By rendering the microbial through colorful beads, she interprets the realities of colonialism, particularly biological warfare enacted by European settler-invaders, but also those of survivance and resistant creativity.

While I appreciate the transcribed conversations and attention to Indigenous methodologies of talking circles and beading circles, Part II feels more polished and is where the magic happens. Theoretical dives into the agency and animation of beads, along with felt stories of place, ceremony, and the more-than-human world find a home in this second part of the book. Sherry Ferrel Racette's (Métis) essay interprets work from Indigenous artists and theorists of many backgrounds such as Cree, Anishinaabe, and Métis to demonstrate how beadwork is "language, speech, and coded knowledge" (p. 158). Particularly powerful is her storying of Rosalie LaPlante Laroque's (Métis) wallpocket (c. 1870), which features a whooping crane, fish, and river. It invites viewers to feel the ecology of the Qu'Appelle River in Saskatchewan and decode the beaded imagery thereof, based on their degrees of connection to the place.

Readers will also appreciate the book's visual delights: plentiful full-color images of prismatic beads strung together in patterns, textures, and shapes that show just how beads are an Indigenous worldmaking technology. Beading is affective and multisensory, but it is strikingly visual; thus, the book would not have the same impact if the images were in black and white. A respirator mask, tea bag, moccasins, toilet paper, regalia, and a goalie helmet are among the objects, belongings, and ideas adorned by beads and depicted in the images throughout the book. Somewhat comparable to atoms, Legos, and binary digits, beads allure us in their singular form, but transform into limitless mediations, be they mundane, playful, political, horrific, or joyful pieces. While beading has been a part of Indigenous cultures and technologies since time immemorial, many beads were brought through globalized trading networks and Indigenous Peoples have adapted and used what they see fit in the ways they see fit. Anderson offers a reminder that Indigenous beading is expansive and need not always reflect an assertive aesthetic of decolonization, particularly one that is comprehensible by non-Indigenous eyes. Anderson states, "While my work is about decolonizing, I don't centre decolonization. I believe that decolonizing is at the core of all of our work" (p. 58).

The strength of the edited collection lies in its meticulous curation of voices and beadwork that present Flatland beadworking on its own terms, framing it rightfully as leading-edge. Though I appreciated the authors' honesty and intentionality in the scope and locality of the work, the Flatlands, the book left me wanting for a more comprehensive collection that engages with beadworking across diverse Indigenous communities. However, this limitation in scope creates space for other Indigenous editors and authors to take up similar methods in future research. Readers looking to supplement this book with others on Native beading could consider *Painful Beauty: Tlingit Women, Beadwork, and the Art of Resistance* by Megan A. Smetzer. While those gripped by the brilliance of contemporary Indigenous art could also pair it with Jeffrey Gibson's *An Indigenous Present*.

Bead Talk ultimately affords beads and Indigenous Peoples the agency to transport us into textured relations with Land (prairie, plains, and flatlands), Indigenous knowledge systems, and community. This book is an essential read and citation for scholars interested in the intersections of current beadwork, Indigenous Studies, and Art or Visual Studies. Moreover, the book is certain to gain an audience via word of mouth in Indigenous culture and education committees, beading circles, and intergenerational art collectives that exist within and across Tribal and First Nations communities.

[Editor's Note: A version of this review also appeared in the *K'wen 'Inish-Ha* tribal newspaper for the Coquille Indian Tribe on the Oregon Coast.]

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Glass Trade Beads in California

Clement W. Meighan and Elliot H. Blair (ed.). BAR Publishing, Oxford. 2024. 107 pp. Black & white and color illustrations. £38.00 (paper)

Anyone with even a passing familiarity with the archaeology of colonial California has undoubtedly seen reference to Clement Meighan's glass bead type collection. Meighan began his work on the project some 75 years ago, drawing on the extensive archaeological and ethnographic collections at the Phoebe A. Hearst Museum of Anthropology (what was then known as the Robert H. Lowie Museum) at the University of California, Berkeley. With periodic updates and expansions, Meighan eventually included beads from nearly all corners of the state, identifying some 440 different bead types. These included beads of essentially all known manufacturing techniques—drawn, wound, blown, mold-pressed, and Prosser-molded—not to mention a wide range of colors and finishes. Yet, Meighan passed away in 1997 without ever publishing his typology. And for most archaeologists and bead researchers—especially those who came of age in the new millennium—his bead project has existed primarily in the realm of shadow and rumor, taking on an almost mythical status. Many knew of it, but few had seen the actual manuscript. That is, until now.

With the blessing of Joan Meighan (Clement's widow, herself now deceased), Elliot Blair has put in countless hours of work to bring this important manuscript to press. Indeed, there will be great satisfaction among archaeologists and scholars of a certain age in simply—finally—having a physical copy to reference. This is especially important for the ability to decode early publications that relied on Meighan's typology to present bead findings. That said, the world of bead research has in many ways passed Meighan by. Meighan was a self-professed "splitter" and organized the beads in his type collection primarily by color, shape, and size. Today, however, most bead researchers use the typology developed by Kenneth Kidd and Martha Ann Kidd, and refined by Karlis Karklins (2012), that instead relies on manufacturing technique for the first order classification (hereafter Kidd/Karklins). While Blair identifies some areas where Meighan's system does capture potentially meaningful variation missed by the Kidd/Karklins system, few if any archaeologists are likely to adopt Meighan's typology wholesale. Similarly, significant time has elapsed since Meighan wrote the explanatory text that accompanies his typology. While it is interesting as a window into the history of California bead research, more recent studies have rendered Meighan's interpretations of certain topics—such as his discussion of the origins of the various beads brought to the region—outdated and factually incorrect.

But this project goes much further than simply publishing Meighan's system and accompanying text. As the editor, Blair makes use of extensive footnoting to point out where current understandings conflict with Meighan's original text, providing a range of references to more recent archaeological studies from both academia and cultural resource management. While Blair relies on footnotes for most of his edits, he does offer a substantive introductory chapter that situates Meighan's work both historically and in the context of contemporary bead research. For the uninitiated, this chapter alone offers a useful introduction to California glass bead studies. Particularly useful here is his short discussion of likely manufacturing centers, which included not only Venice, but also France, Bohemia, and perhaps even China.

Blair is also credited as a coauthor on Chapter 6, which presents Meighan's original descriptive typology with key updates including each bead's corresponding placement in the Kidd/Karklins system. Though Blair does not exhaustively expand Meighan's tabulation of the geographic distribution for each bead type, the textual descriptions for many beads contain additional information about manufacturing location and dating, drawn from Blair's extensive research on the glass beads of colonial North America. Especially important in this chapter are two concordance tables. Table 5, for example, organizes Meighan's types by Kidd/Karklins type in a clearly legible manner. The other, Table 6, is presented according to Meighan's type numbers but also includes each bead's corresponding Kidd/Karklins type along with information on manufacturing method, construction, color, opacity, and size. Taken together, these tables are nothing short of a Rosetta Stone for the early historical archaeology of California.

It is also worth reiterating that nearly all of the beads in the type collection were collected from Native Californian ancestral sites. Perhaps ironically given Meighan's vocal opposition to repatriation, the published volume is sensitive to this fact and to the contemporary cultural and political contexts in which these beads exist. As Blair explains in his introduction, many of the beads in Meighan's type collection lack robust provenience information, and given the history of California archaeology it is likely that at least some were originally associated with burials. Accordingly, Blair consulted with representatives of multiple Native Californian communities, who asked that photographs of the physical beads not be included. Instead, the volume contains color plates with composite drawings of all 440 of Meighan's original bead types, showing each one along both axes. These drawings are a necessary compromise and the utility of the illustrations is not diminished in any meaningful way—especially given the long reliance of bead researchers on the drawings presented in the Kidd/Karklins typology.

Overall, the publication of Meighan's *Glass Trade Beads of California* will be immensely satisfying for a subset of archaeologists and other bead researchers who have waited for this volume in some cases for decades. But the final version of the book is more than simply the long-overdue printing of Meighan's original typology. Blair has done a commendable job of maintaining the flavor of the original while simultaneously offering updates that will greatly enhance the impact of this publication. By contextualizing Meighan's original work within the current state of the art of bead studies, Blair has positioned this volume to help breathe life into older collections and to bring broader awareness to the fascinating range of glass beads that circulated across the complex social interactions between Native communities and various newcomers in colonial California.

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The Elemental Analysis of Glass Beads: Technology, Chronology and Exchange.

Laure Dussubieux and Heather Walder (eds.). Studies in Archaeological Sciences 8. Leuven University Press, Leuven. 2022. 392 pp., 81 figs. ISBN: 9789462703384, 9789461664662, 9789461664655. 80 € (hardback); free (PDF).

Dr. Laure Dussubieux and Dr. Heather Walder have edited a comprehensive and detailed book on the elemental analyses of glass beads. Dr. Dussubieux is a senior research scientist at the Negaunee Integrative Research Center of the Field Museum in Chicago, Illinois. She has considerable experience in the analysis of glass beads from a global perspective, utilizing LA-ICP-MS (Laser Ablation-Inductively Coupled Plasma – Mass Spectrometer). Dr. Heather Walder is an assistant teaching professor in the Department of Archaeology and Anthropology at the University of Wisconsin–La Crosse. Her research interests include the study of colonial and prehistoric material culture, with a particular focus on glass beads.

This publication represents the outcome of a workshop convened at the Elemental Analysis Facility (EAF) of the Field Museum, organized by Dussubieux and Walder. Regrettably, the necessity to comply with the prevailing health protocols necessitated that the event be conducted in an online format. The book brings together more than twenty archaeologists and scientists from various geographical areas to provide insights into the current state of research on the chemical analysis of glass beads. All chemical analyses presented in this book were conducted at the EAF with LA-ICP-MS. Additionally, some chapters include data previously obtained with instrumental neutron activation analysis (INAA), a method that predated analyses with LA-ICP-MS for glass objects. Indeed, prior to the enhancements made to mass spectroscopy instruments and their integration with laser ablation, INAA was the sole non-destructive approach for elemental analysis of glass artifacts.

The book is divided into four sections, in addition to an introduction (two chapters) and a conclusion. The initial two chapters provide an overview of the history of chemical analysis conducted on glass beads (Chapter 1) and of the research questions associated with glass beads worldwide and through time (Chapter 2). Part I is comprised of five chapters on European glass beads found in North America, excavated on sites spanning from the 17th to the 19th century. Part II comprises four chapters on beads manufactured in South and Southeast Asia between the Protohistoric period and the 17th century. The five chapters of Part III are dedicated to the examination of glass beads excavated in Africa and in the western part of the Indian Ocean, with a focus on the precolonial and colonial periods. Finally, Part IV comprises two chapters on glass beads from Israel and Iraq, with a temporal scope spanning from the Neolithic/Antiquity period to the Medieval period (6000 BCE to 13th century CE).

The book presents a comprehensive and compelling case study in the integration of archaeological and chemical data to address archaeological questions and enhance our understanding of human behavior. Indeed, the examination of manufacturing techniques, trade networks, and questions regarding their chronologies are typically challenging when relying solely on observations, even when utilizing advanced optical and electronic microscopies. The undertaking of a chemical analysis can facilitate the acquisition of such information, provided that the specific data pertinent to the analysis are available. The book's diverse chapters allow readers to explore the different methods to process elemental analysis, including binary and ternary diagrams with relevant chemical elements, as well as multi-component analysis methods such as principal components analysis (PCA). The various contributions, which encompass sites from around the globe, illustrate the diversity of glass bead production and the necessity of considering glass recipes to accurately assign them to the appropriate period and culture. Indeed, several chapters demonstrate the existence of long-distance networks even during the early periods, as well as the striking similarity of the beads manufactured over time and across different geographical regions. The numerous colored plates of beads are of significant value for those engaged in research on beads.

The online supplementary materials are of significant interest to archaeologists seeking to expand their knowledge of the chemical analysis of glass objects with LA-ICP-MS, as well as to more advanced users of chemical analysis data who require comparison materials.

LA-ICP-MS is currently the only non-destructive and micro-invasive elemental method that provides such a wealth of information on glass beads. This book offers a comprehensive overview of the insights that can be gained from such data. Its open access is a valuable contribution to the scientific community and is likely to encourage further exploration of this approach in the study of glass beads.

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https://www.beadresearch.org/resources/guidelines-for-bead-research/

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