THESIS

METHODS OF DATING GLASS BEADS FROM PROTOHISTORIC SITES IN THE SOUTH PLATTE RIVER BASIN, COLORADO

Submitted by

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ABSTRACT

METHODS OF DATING GLASS BEADS FROM PROTOHISTORIC SITES IN THE SOUTH PLATTE RIVER BASIN, COLORADO

Morphological characteristics and chemical trace elements counts acquired using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry analyses were documented for glass trade beads from 24 protohistoric archaeological assemblages in the South Platte River Basin. The resulting database was used to provide quantitative descriptions of each recorded assemblage and to characterize the types of glass beads currently reported in the region. Statistical analyses were then conducted to determine if and to what extent morphological and chemical traits change through time. Characteristics of beads in dated contexts were then used to develop a linear regression model in an attempt to determine if it is possible to estimate the age of beads from undated contexts.

It is concluded that morphological and chemical characteristics of glass beads in dated contexts can be used to estimate the age of glass beads in undated contexts using linear regression. The results of this thesis demonstrate that morphological characteristics are currently more accurate and precise than chemistry although both methods hold potential for revision and improvement as more dated sites become available to supplement the statistical models.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

> *At this time, dating estimates derived from experience-based subjective evaluation of bead samples seems to be at least as reliable as laborious quantitative analysis. Very little money should be wagered on either technique if there is any possibility of using some direct dating method…* Galloway (1978:7)

Glass trade beads are one of the most commonly discovered, yet widely under-analyzed artifact types of the protohistoric period in the Great Plains region. Attempts to determine glass bead age based upon morphological characteristics have shown moderate success (Davis 1973; Karklins and Barka 1989; Reher and Scheiber 1993; Scheiber 1994) but are often underutilized or overlooked by researchers. More recently archaeologists have explored the use of chemical trace element analysis as a possible avenue for answering the same questions as morphological analysts but with more accurate and cost effective results (Billeck and Dussubieux 2005; Popelka et al. 2005; Robertshaw et al. 2003; Robertshaw et al. 2006). These studies have also shown moderate success while remaining underutilized tools for understanding the protohistoric period. This thesis addresses the validity and importance of archaeological glass trade bead analysis using a series of glass bead sites and assemblages in the South Platte River Basin of northeastern Colorado. Morphological analysis and analysis of chemical trace element counts acquired from Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) tests are used to answer the following questions:

1) Is it possible to use morphological patterns in dated archaeological glass trade bead sites/assemblages in order to establish a technique for dating beads (i.e. a statistical regression model) from undated contexts?

2) Is it possible to use mean trace element similarities between dated archaeological glass trade bead sites/assemblages to establish a technique for dating undated beads (i.e. a statistical regression model)?

3) Assuming that morphological and/or trace element mean counts produce statistically significant evidence that dated archaeological glass trade bead sites/assemblages can be used to estimate the ages of undated archaeological glass bead sites/assemblages, which method produces the most reliable and accurate results?

Statement of Purpose

The specific hypotheses tested in this thesis are outlined in the introductory paragraph of this chapter; however, the purpose of this thesis extends beyond these questions. My interest in dating archaeological glass trades beads is the result of an observed misunderstanding of the method by archaeologists who are interested in protohistoric archaeology. When I began the research for this thesis I encountered many archaeologists (e.g. contract archaeologists, museum curators, college professors, etc.) who believed that a simple method existed for dating glass bead sites and assemblages. This is not entirely untrue as long as interested parties are capable of investing the time and resources necessary to become proficient in bead analysis and analytical techniques. Whenever untrained researchers are relied upon to analyze bead assemblages the end result is limited to a description of color and the use of non-standardized terms for shape and size. Subsequently, the data describing such bead assemblages is difficult to apply to other studies, thus prohibiting the identification of similarities between two or more assemblages.

Consistency in the documentation of glass bead assemblages is essential as glass bead researchers have demonstrated that it is possible to use *terminus post quem* and *terminus ante quem* dates to estimate the age of archaeological glass bead sites and assemblages using seriation techniques. Brain (1979), Davis (1973), Karlins and Barka (1989), and others have used such methods effectively, providing bead dates for protohistoric assemblages with an accuracy of 15-30 years. Although three decades is quite a narrow time estimate in most archaeological studies, many regions of the Great Plains experienced culture change at a much faster rate. The South Platte River Basin (the focus region of this study), for example, provides archaeological and ethnographic data which shows limited interactions between Native Americans and Euroamericans between 1805 and 1832. Between 1833 and 1850 Native Americans in the area witnessed the construction and demise of four trade forts along the South Platte River and had direct contact with Euroamerican traders. During the latter half of the 19th Century American cities were built, the United States military and Native American groups engaged in the Plains Indian Wars, and Native Americans were removed to reservations. Therefore, the assumption that a 30 year time frame is adequate for interpreting that nature and extent of cultural relations in this region during the 19th Century should be viewed with skepticism. Furthermore, the time and experience necessary to establish date estimates for archaeological glass bead assemblages is difficult and expensive to acquire.

Another, more recent method for dating archaeological glass beads is the statistical analysis of chemical trace elements (Hancock et al. 1994; Popelka et al. 2005; Robertshaw et al. 2006). This approach is cost effective and the appropriate interpretation of the data can be performed by any researcher with a limited understanding of statistical modeling. The drawback is the time it takes to have materials analyzed in a laboratory and the currently small sample of published comparative data (i.e., less than a dozen articles published in international journals). These two issues have prevented chemical analyses of glass beads from surpassing morphological analyses when attempting to acquire accurate glass bead dates. The current most accurate models place beads within predefined age groups that span 30 years or more (Hancock et al. 1994; Kenyon et al. 1995).

I hypothesize that statistical modeling of morphological and chemical characteristics acquired from dated archaeological contexts can be used to estimate the age of undated sites. It is also the goal of this thesis to create a method by which beads can be recorded, interpreted, and dated in an expedient, replicable, and cost effective manner. I also hope that this method will prove to be more accurate than previous models so that it will eventually be possible to place glass bead assemblages into a historical context and help to determine the nature and extent of Native American and Euroamerican interactions in the South Platte River Basin and other regions.

Organization of Thesis

Chapter 2 of this thesis provides a history of glass bead origins and trade as well as a historical outline of events that conclusively or hypothetically resulted in the introduction of glass beads in the South Platte River Basin in northeastern Colorado. The period of time in which glass beads and other items of Euroamerican manufacture is widely referred to as the protohistoric period. For the sake of this thesis the protohistoric period is defined as beginning with the first introduction of Euroamerican goods in the South Platte River Basin (i.e., sometime after 1540 but likely not after 1775) and ending with the complete removal of Native Americans to reservations outside of the South Platte River Basin in 1880. Chapter 2 will focus on direct and indirect instances of interaction between Native American and Euroamerican groups which contributed to the introduction and increased frequency of trade items in the South Platte River Basin. Particular attention is given to historic records and archaeological evidence which convey the nature and extent of contact, trade, and conflict between these two groups. The use of historic phases, developed for this thesis from historical events and influences, are used to better define this contact. These include the Indirect Contact Phase (AD 1540-1802), the Transitional Contact Phase (AD 1803-1820), the Direct Contact Phase (AD 1821-1832), the Trade Fort Phase (AD 1833-1850), the Expansion and Conflict Phase (AD 1851-1869), and the Native American Relocation Phase (AD 1869-1880).

Chapter 3 presents the methodology by which archaeological glass beads sites and assemblages were located, documented, and analyzed. This chapter provides detailed summaries of each step of the analytical process as well as the reason why each step was undertaken and its use in previous glass bead analyses.

Chapter 4 provides information on each glass bead site and assemblage included in this thesis. The chapter begins with a description of the sites which were available for analysis and concludes with a discussion of other archaeological glass beads sites which are currently known but were unavailable for inclusion in this study. In addition to a description of each site/assemblage the chapter provides information on discovery locations, locations of curated assemblages, and information on any additional artifacts associated with the glass bead assemblages.

The results of statistical analysis are presented in Chapter 5. Independent Samples t-Tests are used to identify statistically significant variables within sites. Tests of Correlation are used to determine which bead characteristics correlate with ages of known bead sites, identify whether these correlations are positive or negative, and develop a point from which linear regression models could be calculated. Finally, linear regression is used to develop formulas by which age could be estimated for unknown archaeological sites using the morphological and chemical characteristics of glass beads from dated contexts.

Chapter 6 presents a discussion of the results of this thesis and a conclusion of my findings. Discussions focus on answering the three thesis research questions outlined at the beginning of this chapter, the applicability of morphological and chemical analyses in protohistoric studies in the Great Plains, the possible integration of morphological and chemical characteristics in glass bead dating, the limitations of this study, and future research goals.

CHAPTER 2: HISTORICAL AND ARCHAEOLOGICAL CONTEXT

The primary goal of this thesis is the development of a method for determining when Native Americans acquired the glass beads that have been recovered from archaeological sites in the South Platte River Basin. Because glass beads signify primary and secondary episodes of Native and European American culture contact, successful spatio-temporal analyses must be viewed in a larger historical and archaeological context, constructed from multiple lines of evidence (e.g., ethnographic accounts, trade fort inventories, historic diaries, and the archaeological record). Using the extant data for the study region, this chapter outlines the protohistoric and early historic human occupation of the South Platte Basin, paying particular attention to documented instances of direct and indirect culture contact between Native American and European American groups.

Many summaries document the history and archaeology of the protohistoric and early historic periods in the South Platte River Basin and its sub-regions (see Boyles 1967; Brown 1972; Burris 2006; Cassells 1999; Gilmore et al. 1999; McMechen 1948; Mehls 1984; Newton 2008; Swanson 1975). These researchers are limited by the availability and accuracy of existing archival data, often resulting in the development of two distinct records which separate the Native American and Euroamerian occupational histories of the region. Seeing this result as problematic, the following pages attempt to provide an integrated record of the South Platte Basin using historical and archaeological data to outline a chronological context in which glass beads would have been distributed, used, and discarded by Native American groups in the region. When available, archaeological data is incorporated into historical discussions. More detailed discussions of archaeological studies relevant to the topic of this thesis are presented in Chapter 4.

Glass Bead Origins and Trade

Beads made of stone, bone, hematite, and other materials have been traded between cultural groups and individuals for at least the last 30,000 years and on nearly every continent in the world (Dubin 2009). Beads represent a simple and inexpensive form of ornamentation that can be used for individual expression, symbols of status and power, and representation of cultural affiliation. The introduction of glass beads, for many cultural groups, expanded not only the number of beads available for ornamentations, but also the frequency of style and color variations. Table 2.1 provides an example of color preferences for tribes known to have occupied and/or visited the South Platte River Bain.

The level of cultural influence of glass beads worldwide makes it not only necessary to understand their origins, but also where they originated and how they were traded/distributed. Although glass production has been traced back thousands of years, the trade did not become prominent until approximately AD 100 when Romans began to experiment widely with architectural applications of the material (Dillon 1907:182). The fall of the Roman Empire did little to impede the development of newer and more modern glass manufacturing techniques and by the 13th century Venice, Italy, was recognized as the preeminent glass production center of Europe. By the 14th century, the city was producing and exporting glass beads in large frequencies (Dillon 1907:183).

Table 2.1. Description of glass bead colors used by Native Americans that occupied or visited the South Platte River Basin during the protohistoric period (adapted from Koch 1977:65, Table 3). Table combines all time periods.

Bead Color	Kiowa and Comanche	Cheyenne	Arapaho	Western Sioux
Light red	X	X	X	X
Rose underwhite	X	X	X	X
Oxblood			X	X
Orange			?	
Pale yellow				X
Lemon yellow	X	X	X	X
Light green		X		X
Medium green			?	X
Dark green	X		X	X
Light blue		X		X
Turquoise blue			?	X
Dark blue	X	X	X	X
Lilac pink	X		?	X
Chalk white	X	X	X	X
Black		X		
Pearl white	X			X

After the start of the 16th century, the first destination of most Venetian beads was the western European countries of England, France, and Spain, who used the beads as gifts for developing relationships with indigenous populations as each country sought to expand their empire and acquire lands on other continents. Later, these countries used glass beads to barter for resources from newly encountered groups. This practice proved particularly effective during the early and later European colonization of North America where Caucasian entrepreneurs traded glass beads and other items of Euroamerican manufacture to Native American groups in exchange for animal furs. Other Euroamerican items also played prominent roles in the development of treaties for peace, land, and alliances in warfare.

The North American Fur Trade era began in the 16th century and continued until the late 19th Century when Native Americans were relocated to reservations and bison populations had dwindled to near extinction. During this period, shipments of glass beads and other manufactured goods left ports in eastern Europe and were transported to

English, French, and Spanish controlled regions of North America where they were purchased by fur trade companies and transported to a variety of forts which lined the fringes of each countries' respectively growing areas of expansion and political influence. Glass seed beads (i.e. small, torus-shaped beads) were the dominate type of bead exchanged with Native Americans and were often sold by the pound or hank (i.e., multiple strings of beads sold as a single unit). Other, larger bead styles and shapes were highly desired and demanded a significantly higher cost than seed beads. Because unique specimens were rare and valued, they are less common in the archaeological record, often being discovered in mortuary contexts or within the trade forts from which they were distributed.

The formation of the United States of America in 1776 impacted the interior of the North American continent as the newly formed country expanded westward. Native American tribes which had once been limited in their encounters with Euroamericans witnessed the construction of numerous trade forts (i.e., central locations for Native Americans to visit as opposed to the earlier practice of fur traders traveling to tribal villages). The forts were supplied with glass beads and other trade items from Europe and eastern American factories which were first transported to warehouses in St. Louis before being shipped west in boats that traveled up the Missouri River or by wagon train into the Great Plains region.

Size and color were the most important stylistic elements of beads for Native Americans and numerous historic documents recount issues resulting from the acquisition of undesired bead types. In the mid 1830s, for example, Pratte, Chouteau, and Company of St. Louis wrote to their New York City distributors that, "With regard to the Glass

Beads, blue and white pound Beads, all those received last year and this year . . . were entirely too large and unsaleable" (American Fur Company Papers, Orders Inward, Book1, p. 164, cited in Ewers 1968:96). Nearly two decades later a Fort Union trader reported the following after his annual bead shipment arrived: "the white beads ordered arrived *all* blue . . . This is a serious mistake as to its effect upon the trade" (Thompson 1968:44). The importance of color and size of beads were recognized to be such that the director of the Company of Explorers of the Upper Missouri wrote the following to Jean Baptiste Truteau in 1794, "instruct us in regard to the favorite colors of each nation, as well as those that are disagreeable to them, and [do not] fail to inform us if neighboring nations have the same taste" (Nasatir 1952: 246).

Although the central Great Plains fur trade occurred between the 18th and 19th centuries, the period in which trade forts were operated in significant numbers was between 1800 and 1850. It was during this time that Euroamerican fur interests shifted towards bison robes. Because bison was a prevalent species in the region it was easily obtained and exploited. Native Americans who had relied on the animal for subsistence prior to the arrival of Euroamericans were proficient in the task of acquiring large numbers of hides that could be traded in order to acquire desired items such as horses, firearms, glass beads, and other goods. After 1850, trade forts were replaced by military forts and small towns began to appear in the region. Although Native Americans continued to have access to trade goods in the following decades, the American concept of Manifest Destiny ultimately resulted in their relocation to reservations where Euroamerican goods were provided in the form of government subsidies.

South Platte River Basin Historical Context

Indirect Contact Phase (AD 1540-1802)

Although Spain was the first Euroamerican government to claim land ownership in the Colorado region, it is unlikely that any Spanish military or exploratory expeditions, settlers, or traders entered the South Platte River Basin in the more than 100 years prior to its acquisition by the United States beginning in 1803. By the time the Spanish formally laid claim to Colorado territory (around the year 1600) only two tribes, the Ute and Apache, were residents of the area with the Pawnee and Comanche tribes visiting the area periodically for hunting, trade, and/or warfare (Baker et. al 2007; McMechan 1948). Other, less frequent visitors to the area included the Arapahoe, Cheyenne, Kiowa, and Sioux (Figure 2.1).

By the 18th Century, France was actively engaging the Pawnee for trade, with their trade parties penetrating as far south as the modern Nebraska-Kansas state border and perhaps into southeastern Wyoming and northeastern Colorado. Seeing the French alliances with the Pawnee as a threat and in anticipation of a war over Spanish-controlled lands, the Spanish government viewed Native American tribes to the north and east as "buffers" against French colonial expansion. As a result, interactions between the Spanish and Native American occupants of Colorado Territory were relatively peaceful although a number of isolated conflicts and small-scale military actions by either group are well documented in Spanish records (McMechan 1948).

Trade records for the period of Spanish influence in Colorado are extremely limited, although their settlement in Taos, New Mexico, quickly became an epicenter for Euroamerican and Native American interactions throughout the 19th Century (Garrad

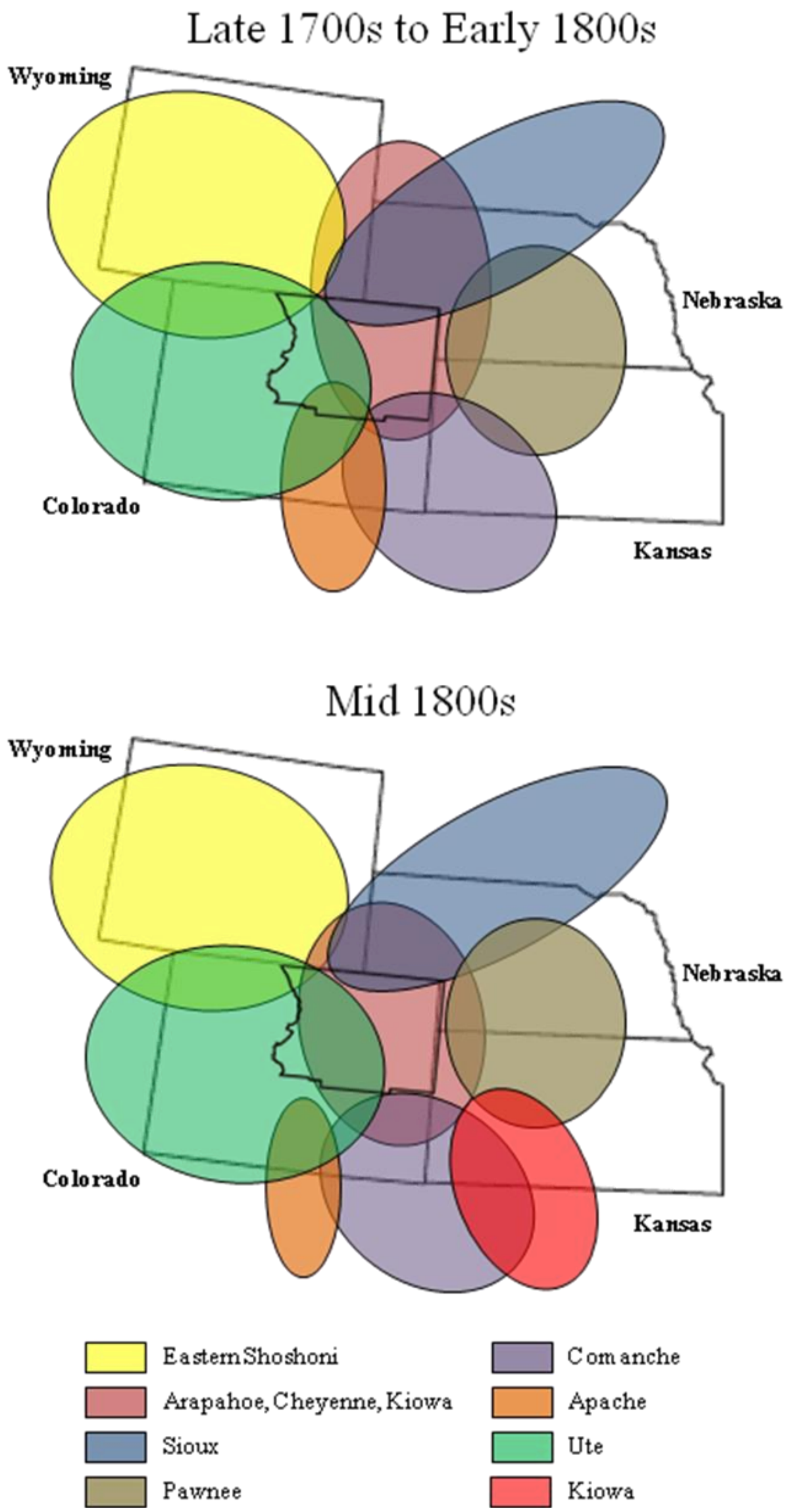

Figure 2. 1. Changes in Native American tribal distribution for the South Platte River Basin and surrounding areas during the Fur Trade Era. Map adapted from McMechan (1948) and Baker et al. (2007).

1938). Spanish exploratory parties were able to launch campaigns into Colorado and its surrounding areas from this location. While these explorations were multi-faceted in purpose, they universally encountered and documented the Native American presence/absence and mood. Although it is presumed that the earliest of these expeditions, Francisco Vásquez de Coronado in 1540, Juan de Archuleta in 1664, Governor Don Diego de Vargas in 1694, Juan de Ulibarri in 1706, Governor Antonio de Valverde in 1719, and Pedro de Villasur in 1720, carried items suitable for trade with Native Americans, it was not until the expedition by Fathers Francisco Atanasio Dominguez and Silvestre Vélez de Escalante in 1776 that a historic record of these items exists. A single record of the Dominguez-Escalante expedition documents the presentation of hunting knives, an iron axe, strings of white glass beads, tobacco, and food, to the Utes (Baker et al. 2007:66). To date, however, no artifactual evidence of this early Spanish trade has arisen in Colorado's archaeological record.

At the turn of the 18th Century the horse, originally traded or stolen from the Spanish, became a driving factor in the reorganization of Native American tribes in eastern Colorado. Driven by a desire to obtain horses, the Comanche crossed the extent of southern Wyoming Colorado and northern Colorado moving south across the Plains, and into Apache homelands. The ensuing attacks on Apache tribes led to their nearly complete displacement from Colorado and into Spanish populated areas by 1748. The successful acquisition of horses and land, however, did not stop the Comanche's southern advance which threatened Spanish control of New Mexico in the late 1770s. It was only when Governor Juan Bautista de Anza, in AD 1779-1786, was able to thwart the Comanche advance and establish a treaty providing joint military action against the southern and eastern bands of the Apache and provided an annual trading fair in Pecos (McMechen 1948:55-57).

Archaeological evidence indicates that French and Native American trade relations on the central and northern Plains began as early as the last quarter of the 17th Century (Holen 1991). To the north, this trade originated from Canadian trading posts and primarily took place amongst the Mandan and Hidatsa tribes who were living in semi-permanent earth-lodge villages along the Upper Missouri River in present day North Dakota and was directed by the independently-owned Northwest Trading Company. Further south, French trade was based out of St. Louis and spread east across the central Great Plains. Archaeological evidence reveals that French trade goods were in use by Native Americans before direct trade was established in the region no later than the 1730s (Ahler and Drybred 1993; Holen and Watson 1995:211).

Following the establishment of French and Native American trade relations, several notable French explorers/traders sought to expand their economic base by increasing the number of tribes reached through primary trade means. The first of these expeditions was by Charles Claude du Tisne, who in 1719 moved into present day Osage County, Kansas, to establish trade (Holen and Watson 1995:212; Nasatir 1990:19). That same year, Bénard de la Harpe surveyed parts of eastern Oklahoma for a potential trading post. Five years after Tisne and Harpe, Étienne Veniard, Sieur de Bourgmont returned to Kansas in 1724, possibly venturing as far west as present day Lyons County, following the Saline River (Norall 1988:57-80). A more notable expedition, led by the Mallet Brothers (1738-1741), reached Santa Fe by crossing parts of Nebraska and Kansas where the expedition may have visited and/or traded with the Pawnee at Stabaco and other sites

(Holen and Peterson 1995:219). Further north, Pierre Gaultier de Varennes, Sieur de La Vérendrye and his sons explored southward from the French trade posts along the Red River in Canada, into North Dakota and South Dakota, and possibly west into Wyoming and Montana in 1738, 1741, and 1742-1743 (Wood and Thiessen 1985: 22-23).

Although the French made very few attempts to establish permanent trade forts in the Great Plains, their economic success was amplified by their incorporation of pre-existing intertribal trade systems, originating from the Mandan-Hidatsa villages (Ewers 1968:14-33; Wood 1980). These systems, which pre-date Euroamerican arrival in the area by at least a century, were primarily responsible dispersing Euroamerican trade items. The trade systems were only later replaced with the establishment of trade forts along the Platte and Arkansas Rivers, east of the Rocky Mountains and within the Central Plains. As such, the French were constantly competing with English-based Hudson's Bay and Northwest Trading Companies whom also visited the Mandan and Hidatsa villages. French involvement in the Western American Fur Trade would end with the United States' purchase of Louisiana Territory in 1803, however, without any direct or indirect evidence of influence on Colorado's Native American tribes.

English involvement in the Western Fur Trade was limited to trade in what is now present day Canada and the Northern United States and facilitated by the Hudson's Bay and Northwest Trading Companies. With no recorded instances of exploration or other notable contact with Native American groups in or near Colorado, a discussion of English fur trade activities is omitted here although it is not presumed that English manufactured trade items did not reach Colorado through direct or indirect trade with its Native American occupants and visitors.

Transitional Contact Phase (AD 1803-1820)

This phase arises with the increase of Euroamerican and American traders entering into or passing through the South Platte River Basin and surrounding regions. A greater frequency of traders meant that Native American groups in the region could trade directly with a trade good supplier unlike the Indirect Contact Phase where goods had to be obtained secondhand from other Native American groups that had direct contact with traders in other regions such as along the Upper Missouri River. Along with the increased frequency of trade items, particularly glass beads, many Native American groups engaged in their first contact with Caucasians.

In 1820, Major Stephen H. Long led an American expedition which was the first to historically document the lands and tribes of the South Platte River Basin. At the time of the expedition, the Arapaho, Cheyenne, Apache, Kiowas, Kiowa-Apache, Comanche, Ute, Pawnee, Sioux, and other tribes, were all living in or periodically visiting the area (McMechen 1948). This occupation was the result of the basin being a particularly rich area for bison hunting, an activity which translated into a highly profitable relationship with Euroamerican fur traders who could have been visiting the area as early as the mid 18^{th} Century.

While providing primary documentation of their own encounters with Native Americans in the South Platte Basin, member of the Long expedition also provide the earliest accounts of Euroamerican activities in the area. DeMunn and Chouteau trappers reported to have been trading with the Kiowas, Arapahoes, and Kaskaias (probably Kiowa-Apaches) south of present day Denver in 1816 (Clark 1999; McMechen 1948:59). This instance of trade was likely not the first.

Very little is known about activities within the South Platte River Basin during the first two decades of the 19th century that preceded Long's Expedition; however, several scattered records provide evidence that American-affiliated trappers and traders had slowly begun to exploit the region's resources and were likely introducing Euroamerican trade items. Mehls (1984:21) and Goetzman (1975:40) credit the first of these early trading expeditions to Baptiste La Lande who, in 1804, allegedly "followed the Platte and then the South Platte west into the Rockies, trapping along the way." In the year following that expedition, John Purcell also followed the South Platte to the Rockies (Mehls 1984:21). Unfortunately, the exact paths and nature of Native American interactions for these men and their parties remains unknown.

The only well documented evidence of interaction and trade between Euroamericans and Native Americans following La Lande and Purcell comes from the journals of Lieutenant Zebulan M. Pike who explored southwestern Colorado on behalf of the United States government from 1806-1807. While the majority of these interactions appear to have been with Pawnee bands in Kansas and did not result in any significant dissemination of Euroamerican trade items, they do provide some information of Native American trade customs and the varied scenarios in which this trade occurred.

Although the Pike expedition was able to explore a significant portion of the United States' newly acquired Louisiana Territory as well as disputed borderlands between the U.S. and Spain in southern Colorado, his party was ultimately captured by the Spanish and held as prisoners in Santa Fe, New Mexico, during the final year of his expedition. Fortunately, Pike was able to move freely about Santa Fe and continue making entries in his journal. It was during this period that Pike recorded a meeting with

John Purcell who confirmed his presence along the South Platte River and noted that he had been trading with the Native American tribes in that area for several years (Ubbelohde et al. 1972).

Direct Contact Phase (AD 1821-1832)

The period between 1821 and 1832 can be categorized as an explosion of Euroamerican activity in the South Platte River Basin when compared to previous periods. Although trappers had already familiarized themselves with the area, the trading companies which sustained the trappers began to acknowledge the area as an unexploited area with the potential to generate enormous profits. Additionally, the United States government saw a need for military exploration of the area following the Adams-Onis Treaty with Spain 1819 and Mexican independence from Spain in 1821 which resulted in the American acquisition of much of the northeastern portion of present day Colorado (Beck and Haase 1989; Noel et al. 1994).

One of the first and most prominent attempts to evaluate the need for establishing permanent trade in northeastern Colorado was made by trading entrepreneur William Ashley in 1824 and 1825. Ashley, one of the founders of the Rocky Mountain Fur Trade Company, led a party westward along the South Platte River before veering northwest along the Cache la Poudre River and into Wyoming (Noel et al. 1994). Although little is known about this exploration and the fact that Ashley did not attempt to establish a trade fort anywhere along his route, the path he took would later become the Colorado Branch of the Overland Trail.

By the time Ashley traveled through northeast Colorado, Andrew Sublette and Louis Vasquez had already found the area to be rich in beaver and buffalo and, in 1826, made the first attempt to float hides down the South Platte River to St. Louis (Mehls 1984:23). Despite their failed attempt to use the river as a waterway, both men sought alternate means to exploit local animal populations and establish trade partnerships with local Native American groups. In the 1830s, Vasquez and Sublette men would successfully secure funding from major trading companies in the surrounding regions in order to establish competing trade forts along the South Platte River (Peterson 1982).

Other traders arrived in northeastern Colorado via one of several prominent trails. The Taos Trail, also known as the Trapper's Trail, allowed the movement of trade items and furs along the Colorado Front Range between Fort Laramie in present day Wyoming, and Taos in present day New Mexico (Noel et al. 1994). A number of other traders likely deviated north from the Santa Fe Trail which ran from St. Louis, Missouri, to several locations in present day New Mexico including Santa Fe, Taos, and Las Vegas (Beck and Haase 1989). The majority of the trails that brought traders and trappers into northeastern Colorado were first used and introduced to Euroamericans by local Native American groups for hunting and/or trade. The Cherokee Trail, for example, was well known to the Pawnee and Cheyenne tribes before it was later used by Colorado trade fort owners and operators to supply their forts with trade goods from the eastern United States (Noel et al. 1994).

While unconfirmed by either archaeological evidence or historical records, some researchers have postulated the construction of at least two semi-permanent trading structures in northeastern Colorado during the *Direct Contact Phase*. The first of the alleged trading posts was constructed in the 1820s by the American Fur Company and was located near the future site of Fort Lupton (Mehls 1983:23). A second fort, Fort

Convenience, may have been constructed at the confluence of Clear Creek and the South Platte River in the early 1830s (Robertson 1999:101). It was not until 1835, however, that a permanent trading post would be constructed on the South Platte River.

Trading Post Phase (AD 1833-1850)

Euroamerican trade goods in eastern Colorado increased exponentially in 1833 with the construction of Bent, St. Vrain, and Company's adobe fort on the Arkansas River (Lavendar 1972). Strategically located in prime Native American hunting grounds, Bent's "Old" Fort effectively placed a monopoly on the regional bison robe trade. Seeing an opportunity for competition and large profits, Louis Vasquez and Andrew Sublette secured funding from one of Sublette's older brothers, Milton, and constructed their own fort on the South Platte River (Hafen 1964).

Fort Vasquez, constructed in 1835, stood alone in the South Platte River Basin until 1836 or 1837 when former military officer Lancaster P. Lupton constructed Fort Lupton, less than ten miles upriver (Robertson 1999:152). Together, it seems that Fort Vasquez and Fort Lupton had cornered enough of the local fur trade that the operators of Bent's "Old" Fort (owned by Bent, St. Vrain, and Company) saw a need to construct a rival post a short distance downriver in 1837. That same year, Peter Sarpy and Henry Fraeb also saw value in the South Platte River fur trade market and were able to secure funding from Pratte, Chouteau, and Company to construct Fort Jackson upriver from Fort Vasquez but downriver from Fort Lupton (Robertson 1999:136).

Despite increased competition, it seems that Fort Vasquez thrived in 1838 as James Beckworth noted,

We had a prosperous fall and winter trade and accumulated more peltry than our wagons (sp) could transport. . . We had cleared sufficient to pay Mr. Sublet's debts, and enough over to buy a handsome stock of goods for next season's trade (Bonner 1892:360, cited in Hafen 1964:206-207).

Apparently, despite early success, Vasquez and Sublette could not compete with Fort St. Vrain and sold their fort to Lock, Randolph, and Company in 1840. Lock and Randolph also conceded to Fort St. Vrain and Fort Vasquez was closed in 1842 (Peterson 1982; Robertson 1999).

Lancastor P. Lupton's decision to construct Fort Lupton was most likely the result of his observations at Bent's "Old" Fort when he visited eastern Colorado as the commander of Company A of Colonel Henry Dodge's detachment of Dragoons in 1835 (Peterson 1982:66; Robertson 1999:152). During his patrol, Lupton noted an abundance of Arapahoe and Cheyenne groups as well as an abundance of bison suitable for trade. Therefore, upon his return to the eastern United States, Lupton resigned from the military and made plans to construct a trading post on the South Platte River which was completed in either 1836 or 1837 (Robertson 1999:152).

Although Fort Lupton generated enough business to compete against Fort Vasquez and other, later forts, Lancaster P. Lupton had little knowledge of the fur trade and lacked the proper tools to generate significant profits (Peterson 1982:68). An example of Lupton's shortcoming is presented in an October 31st, 1839 journal entry by E. Willard Smith who accompanied a trading party bound for Fort Vasquez. Smith notes, "[Lupton] is trying to keep up with us, but probably, will not succeed, as our mules can travel much faster than his oxen" (Hafen 1950:168). Despite these issues, Fort Lupton remained in operation, apparently establishing itself as a small farm and later supplying livestock, farming implements, and other goods to the early white settlers in the area

(Peterson 1982:70). Operations at the fort were finally concluded in 1844 when Lupton left to visit his family in Michigan and failed to return to his fort.

Bent, St. Vrain, and Company constructed the third fort, Fort St. Vrain, on the South Platte River in 1837 (Hafen 1925; Robertson 1999: 218). Because the company had pre-existing trade relations with the Cheyenne and Arapahoe tribes, it took little time for Fort St. Vrain's operator, Marcellin St. Vrain, to establish a successful trade in the area. Success was likely amplified by the proximity of Fort St. Vrain to Bent's "Old" Fort, the company's flagship trading outpost, thus increasing the volume and diversity of trade goods which could be stocked at the South Platte branch throughout the year.

The ultimate goal of the construction of Fort St. Vrain was to drive out the other competitors on the South Platte River and regain exclusive control of the area. This was fully achieved by 1845 after Bent, St. Vrain, and Company purchased Fort Jackson and drove Fort Lupton and Fort Vasquez out of the regional fur trade. That same year, Fort St. Vrain was closed although some records suggest that the fort continued to operate seasonally for several more years before being permanently abandoned around 1850 (Lavender 1972:314).

The fourth and final fort on the South Platte River, Fort Jackson, was constructed by Peter A. Sarpy and Henry Fraeb in 1837 (Robertson 1999:136). Funding for the operation was provided by the American Fur Company who was interested in maintaining its trade interests south of their flagship fort, Fort Laramie, located on the North Platte River. Based upon a few surviving documents, it appears that Sarpy and Fraeb had a fairly successful first year of operation (Peterson 1982). Unfortunately for the pair, the American Fur Trade reconsidered its investment and sold Fort Jackson and its inventory of trade goods to Bent, St. Vrain, and Company. Shortly after the transaction, Fort Jackson was destroyed by American Fur Company employees (Robertson 1999:136).

Based upon known Native American occupation areas during the first half of the 19th Century (Baker et al. 2007; McMechan 1948), it is certain that the Arapahoe and Cheyenne tribes were trading buffalo robes along the South Platte River. Other tribes which may have also visited the forts include the Kiowa, Kiowa Apache, Comanche, Ute, Sioux, and Pawnee. The extent to which these tribes utilized the region and Euroamerican trade items acquired from the local trade forts is not, however, clearly known as Native American archaeological sites dating to the *Trade Fort Phase* are relatively sparse.

Archaeological investigation at the four trade forts on the South Platte River Basin have been relatively limited with the most extensive research conducted at Fort Vasquez where excavators mapped the original layout of the fort and collected thousands of artifacts (see Chapter 4). Limited fieldwork conducted at Fort St. Vrain in 1967 and a small assemblage of artifacts, including ceramics, glass trade beads, and metal, were recovered (Peterson 1982: 46-47). The remaining forts, Fort Lupton and Fort Jackson, have received virtually no archaeological attention and the actual locations of the forts have been argued. It appears, however, that portions of Fort Lupton remain intact on privately owned lands and currently function as part of a livestock corral. Fort Jackson was allegedly relocated by Leroy R. Hafen in the 1920s, although no efforts have been made to confirm his findings until recently when Cody Newton (a doctoral candidate at the University of Colorado at Boulder) used Hafen's notes to revisit the alleged site area where he was able to find surficial indicators of possible structural remains and a single white glass bead (Cody Newton, personal communication 2010).

A few historic records from the forts provide details as to the types of items traded at the South Platte River forts. In particular, two inventory records from Fort Jackson document the goods housed at the fort in 1837. The first record (Peterson 1982) lists blankets, clothing and cloth, dozens of pounds of glass trade beads, kitchen utensils, tools, and food, which were sent to the Arkansas River for trade to the Cheyenne on December 2, 1837. The other inventory documents the items given to Bent, St. Vrain, and Company as part of the transfer of the fort to that company by the American Fur Company. Items included in the sale include over 100 pounds of glass trade beads, coats, knives, combs, gunflints, clothing and cloth, blankets, and miscellaneous other items. Complete lists of the items included in both inventories are presented in Peterson (1982) and may be useful in future studies that could use the number of beads remaining at the locality as a proxy for estimating the overall volume of glass beads and other trade goods passing through the fort during the time it functioned as a trade center.

Expansion and Conflict Phase (AD 1851-1869)

Even before the closure of the trade forts along the South Platte River, American settlers, adventurers, and entrepreneurs had set their sights on the South Platte River Basin and other parts of the American West. Some of these Euroamericans were simply passing through on their way to Oregon and California, while others came to find gold and other precious minerals in the Rocky Mountains. Regardless of their reason for a westward migration, each individual who came westward had a direct or indirect effect on the Native American populations which had lived, more or less, peacefully with the explorers, trappers, and traders which had ventured to the area in the first half of the 18th century. Unfortunately, a general feeling of fear expressed by the white immigrants and the competition for land and resources with the Native American population perpetuated a general distrust between the two cultures which ultimately resulted in conflict and culminated in bloodshed.

To alleviate early concerns, John C. Fremont, who had visited the South Platte River Basin twice in 1842 and 1843, endorsed to the U.S. Congress the formation the Upper Platte and Arkansas Indian Agency (Brotemarkle 2001:91-92). At Fremont's recommendation, Thomas Fitzpatrick, former trapper and trail guide, was nominated for and eventually assigned to direct an agency which was planned for, but never based at the former site of Fort St. Vrain (the agency was actually located at Fort Laramie). In addition to raising and educating Northern Arapaho Chief Friday (Swanson 1975), Fitzpatrick was seemingly liked by all of the regional Native American groups and traders.

Part of Fitzpatrick's accomplishments included assisting the 1851 Treaty of Fort Laramie which helped to ease early tension between Native American groups and the European American settlers passing through the region along the Oregon Trail (Brotemarkle 2001:96). The Treaty of Fort Laramie provided annuities to the affected tribes in the form of money and trade goods that had been previously acquired from the regional trade forts. Two years after the signing of the Treaty of Fort Laramie, Fitzpatrick established another, similar treaty with the Kiowa, Comanche, and Apache to protect the increased use of the Santa Fe Trail by European Americans (Brotemarkle

2001:96). However, the U.S. Government took liberties in modifying the treaties effectively reducing annuities promised to the tribes.

Upon Fitzpatrick's death in 1854, John W. Whitfield was named agent of the Upper Platte and Arkansas agency. Shortly after his appointment, Whitfield was in New York where he purchased $10,000 worth of "blankets, beads, vermillion, thread, clothing, and many varieties and colors of cloth" (Brotemarkle 2001:97). The supply of these goods, however, angered the local traders who felt they were being robbed of profits. While this and other acts showed Whitfield to be acting within the interest of local tribes, he was responsible for a vast area. Tragically, while meeting with the Cheyenne and Arapahoe at Fort St. Vrain in late August of 1854, he was unable to prevent or stop a series of events at Fort Laramie that resulted in a breakdown of the 1851 Treaty of Fort Laramie.

The period known as the Great Plains Indian Wars began on August 19, 1854 when Lieutenant John L. Grattan led a small group of infantry into a Sioux camp near Fort Laramie and attempted to arrest a warrior for shooting an ox following a Mormon wagon train (Yenne 2006:64). When the warrior refused to come with Grattan, the infantry fired on the Sioux camp, killing a Brûlé chief, Brave Bear (Utley and Washburn 2002:186). Infuriated Sioux warriors retaliated, killing all but one soldier who fled to Fort Laramie, but later died of his wounds. In response to the "Grattan Massacre," General William S. Harney led a military force out of Fort Kearny, Nebraska, reaching the Sioux camp on September 3, 1855. Upon his arrival, Harney attacked the camp, killing 85 Sioux and capturing 70 women and children (Utley and Washburn 2002:186).

Harney followed his attack on the Sioux camp with a campaign through the Sioux territory.

The Cheyenne, ally to the Sioux, also became a focus of military action and, in 1857, 300 hundred warriors met and were defeated by Colonel Edwin V. Sumner in western Kansas (Utley and Washburn 2002:188). Further to the south, Major Earl Van Dorn led an attack on a Comanche village which had recently moved to Rush Creek in Oklahoma from the Arkansas River (Utely and Washburn 2002:191; Yenne 2006:49). Dorn easily won the battle and continued a campaign between the Red and Arkansas Rivers until Civil War broke out in the eastern United States in 1861.

Although the Civil War in the eastern United States resulted in the recall of many western troops, battle with the Native Americans continued with the enlistment of volunteer troops. Although the Colorado Native American tribes remained relatively peaceful during the years 1861-1865 they were frequently provoked into several small scale battles. Yenne (2006:104-105) reports that "during the first week of August [1864] alone, there were fifty-one people killed and seven abducted by mainly Cheyenne raiders [in Nebraska]." This led the territorial military commander, Colonel John M. Chivington, to declare the Cheyenne at war and he sent detachments of troops to attack they Cheyenne who had, by that time, allied with the Arapahoe, Sioux, Kiowa, and Comanche (Utley and Washburn 2002:206).

Cheyenne and Arapahoe leaders met with Chivington and Governor John Evans near Denver and gained an understanding that submission to military authority near one of the local forts would result in peace (Green and Scott 2004:14-15). Therefore, Chief Black Kettle moved 600 of his Cheyenne to a site on Sand Creek, near Fort Lyon on the

Arkansas River. Chivington, however, did not leave his meeting with the Cheyenne with the intention of peace and on November 29, 1864, Chivington's forces attacked Black Kettle's village, killing at least 150 Cheyenne and Arapahoe and desecrating their remains (Greene and Scott 2004:1-2, 17-20).

Primary and secondary accounts of the massacre vary although archaeological investigations at the site from 1998-1999 have clarified aspects of the battle (Greene and Scott 2004). In addition to locating and mapping the massacre site, a number of artifacts were discovered that allowed archaeologists to recreate the attack and an interpretation of the site structure. Artifacts recovered from the Sand Creek Massacre include: firearms munitions, cannon-related case-shot fragments, gun parts, metal projectile points, miscellaneous military equipment, miscellaneous personal ornaments, camp equipage and utensils, tin cans, tools, lithics, and various other items (Green and Scott 2004:123-161). In additional to archaeological remains, it is suspected that items of ethnographic importance were collected from the site and have subsequently been incorporated into local museum collections although no current records exist to confirm or refute this possibility. One item that is of particular interest to this study are a pair of beaded leggings housed at the Loveland Museum which are believed to have been collected from the massacre site.

The Sand Creek Massacre did not set the example for Colorado Native American groups that Chivington intended. A tribal meeting was held in which the "Cheyenne, Arapahoe, and Sioux chiefs smoked the war pipe" (Utley and Washburn 2002:207). The tribes then spent the early months of 1865 raiding white settlements along the South Platte River, "killing fifty whites, burning stage stations and ranches, destroying telegraph lines, twice sacking the hamlet of Julesburg, Colorado, and even attacking nearby Fort Rankin" (Utley and Washburn 2002:207-2009). However, because Black Kettle maintained a hope for peace, he did not permit his band of Cheyenne to participate in combat against white settlers. This policy did not prevail as Black Kettle was killed while his band of Cheyenne was forced to defend them self against an attack by General George Armstrong Custer at the Battle of Washita in Oklahoma in 1867.

Chief Friday of the Arapahos also had hopes for peaceful relations with the encroaching European Americans and attempted to create and maintain friendships with white settlers entering the South Platte River Basin. The group lived and hunted primarily around the Cache la Poudre River in the years following the Sand Creek Massacre, sometimes camping on or near local ranches, homesteads, or military forts (Swanson 1975). Often, European Americans were welcomed into Friday's camp. In 1866, for example, the proprietor of a Fort Collins boarding house, Elizabeth Stone, visited Friday's camp with several women from the fort. While there, Stone remembers collecting pieces of Native American art and meeting Friday's youngest wife who was holding a papoose wrapped in blue and white beaded antelope hide (Swanson 1975:63, 1993:82). During the time of Stone's account, the Euroamerican items that she would have observed in Friday's village were likely acquired through government annuities as well as intermittent trade with sutlers who operated dry goods stores at the local military forts.

Following the ending of the Civil War in 1865, trained military personal returned to the Great Plains to replace volunteers and continue military campaigns against the Native Americans. The period from 1865 until fall 1867 witnessed few major conflicts in northeastern Colorado although that period of relative peace ended on September 17, 1868. It was at this time that Major George A. Forsyth and his detachment of troops from Fort Learned, Kansas, encountered between 600 and 700 Cheyenne Dog Soldiers and southern Oglala Sioux along the Arikaree Fork of the Republican River, just west of the Kansas-Colorado border (Utley and Washburn 2002:222). The ensuing battle would come to be known as the Battle of Beecher Island.

According to Grinnell (1915:277-297), the Battle of Beecher Island lasted for seven days with the combatants facing off in a siege for the last several days of fighting. During the first days of the battle, the Native Americans inflicted a great deal of suffering on the soldiers, injuring Forsyth and killing his second in command, Lieutenant Frederick Beecher (for whom the battle is named) and approximately half of the company (Utley and Washburn 2002:222). Prior to his death, facing overwhelming odds and diminishing supplies, Forsyth sent two soldiers to Fort Wallace for reinforcements on September 18th who succeeded in gathering reinforcements. Additional troops finally arrived on September 25th and the Native Americans left the after reportedly losing about 50 warriors.

The success of the Cheyenne Dog Soldiers at Beecher's Island was short-lived. Less than a year after the battle, in 1869, a band of Dog Soldiers and Sioux under the leadership of Tall Bull left Kansas and moved north with plans to meet the Northern Cheyenne in the Powder River Basin of Wyoming. Upon reaching the south bank of the South Platte River, they rested at a place known as Summit Springs. Here, they were unexpectedly overtaken by the U.S. Fifth Cavalry under the direction of General Eugene

A. Carr. Accompanying the cavalry was William "Buffalo Bill" Cody and a battalion of Pawnee scouts (Yenne 2006:133-136).

The Cheyenne camp had been unaware that Carr had been following them; his troops attacked the camp shortly after noon on July 11th. Although the Dog Soldier attempted to repel the attack, the fight resulted in death of 52 Native Americans, and the capture of 15 Native American women and children (Grinnell 1915:318). Grinnell's (1915) account of the battle reveals that the Pawnee scouts were incredibly aggressive, killing and scalping an unspecified number of women, children, and elderly. Among the dead warriors was Tall Bull, who was shot in the head while attempting to defend a position on some nearby bluffs. Despite the efforts of the Dog Soldiers to defend their village, it is unclear if any of the soldiers or scouts were killed during the fighting.

Following the battle, Carr's troops burned all of the lodges found in the camp and were able to recover about $1200 worth of gold coins (Grinnell 1915:318). Although the Battle of Summit Springs has received little attention in the historic record, Dr. Charles A. Reher (personal communication, 2007) was able to locate the site and view a number of artifacts from the battle that are currently held in the private collection of a local metal detecting enthusiast. Among the artifacts are numerous metal artifacts discovered through the use of a metal detector as well as a small assemblage of glass trade beads.

Native American Relocation Phase (AD 1869-1880)

The Battle of Summit Springs had a lasting impact on the Native Americans that frequented Colorado. Even before the battle was fought, the U. S. government had begun establishing reservations for the Cheyenne, Arapahoe, and Sioux. Multiple defeats of the tribes prior to and including Summit Springs led leaders to recognize that further resistance would result in more warfare. Because the government had failed to preserve any of the tribal lands in Colorado, thousands of Native American submitted to the U.S. military and were relocated to reservations outside of the state. As laid out in various treaties concerning Native American Relocation, Euroamerican manufactured goods continued to be distributed to tribes through additional government annuities.

One available article chronicles the final days of tribal occupation within the state of Colorado. This account, given by Swanson (1975), provides some limited detail of Chief Friday's band of Arapaho. As discussed above, Friday was a peaceful leader who had hoped his good relations with white settlers would allow his people to remain in the South Platte River Basin and maintain hunting grounds around the Cache la Poudre and Boxelder drainages near present day Fort Collins (Swanson 1975:64). Despite his attempts, the government demanded that Friday and his followers move to the Arapahoe and Cheyenne Reservation in Indian Territory (i.e., present day Oklahoma). Finally, Friday conceded to the U.S. government in 1869, moving his people to the Wind Ridge Reservation established for the Shoshone in western Wyoming. Although Friday would periodically leave the reservation to return to Colorado between 1869 and 1873, he remained on the reservation until his death in 1881 (Swanson 1975:65-67).

Although no other accounts document the final days of the Native American occupation of northeastern Colorado, it is assumed that various groups who continued to fight Native American relocation periodically moved through the area. Many members of the Cheyenne and Sioux tribes continued to fight Native American relocation and preserve their tribal lands. The end of this presumed occupation came to an abrupt end in 1876 with the defeat of General George Armstrong Custer at the Battle of Little Bighorn and the renewed effort of the U.S. military to end Native American resistance. Multiple military campaigns in late 1876 and 1877 concluded the nomadic lifestyle of the Great Plains Native American tribes that had occupied the region for more than 10,000 years.

Summary

Trade items of Euroamerican manufacture were introduced and increasingly used by the Native American population of the South Platte River Basin between 1540 and 1880. The beginnings of the fur trade in the region saw the distribution of items such as glass beads, firearms, metal objects (e.g. knives, tinklers, kettles, arrow points, etc.), blankets, clothing, and alcohol. These items were acquired through direct and indirect contact with Euroamerican trappers, traders, explorers, governments, and settlers through a variety of activities such as gift giving, trade, and warfare and raiding. Starting in approximately 1850, the pattern of trade item distribution and item types shifted, largely due to the increased presence of European Americans arriving in the regions. Land treaties struck between Native American groups in the region and the United States government often included annuities in the form of goods that were once acquired through trade.

To better understand the shifting patterns in the acquisition of Euroamerican items by Native Americans, this chapter has outlined a chronological series of historic phases. The historic phases have not only described the economic and political climate of the South Platte River Basin through time, they also provide manageable units by which the historic record can be compared to the archaeological record. The potential assignment of dated and previously undated archaeological assemblages to the historic phases will permit an increased understanding of Native American and Euroamerican interactions in the region. These historic phases will be used to provide a relevant context for the beads discussed in the following chapters of this thesis and provide the audience with a context for understanding how glass beads were introduced in the region, the extent to which they were available, and, in some instances, the specific purpose those artifacts served.

CHAPTER 3: METHODS

Archaeologists have spent much time and resources in developing a universal method by which glass trade beads can be analyzed and interpreted by researchers (Beck 1928; Brain 1979; Kidd and Kidd 1970; Karklins 1982, 1985; Spector 1976; Stone 1974). The results of these efforts are multiple methodologies which can often confuse and, ultimately, complicate the results of glass bead analysis (Ahler and Drybred 1993). Additionally, researchers may often find themselves documenting bead characteristics which have little or no interpretive value. Therefore, the goal of this chapter is to outline a simple, straight-forward method for analyzing glass trade bead assemblages. This outline is achieved by breaking down existing methodologies and coding systems in order to obtain potentially informative data from bead characteristics for discrete variable analysis. Using this process, it will become possible to identify bead characteristics holding the greatest interpretive value. Once identified, these characteristics can be compared and contrasted with other bead characteristics to determine what, if any, relationship exists between characteristics of beads from within and between archaeological assemblages. Finally, I contend that the methods outlined below will be easily modeled for comparison with other bead assemblages within and outside of the study region.

Site Discovery

Several techniques were used to identify sites in the study area. These techniques included a file search of the Colorado Office of Archaeology and Historic Preservation's (OAHP) database, reviews of published and unpublished archaeological and historical literature, and inventories of archaeological collections housed at local and regional museums. Additional sites were located through communication with avocational archaeologists (e.g. the Colorado Archaeological Society, the Loveland Archaeological Society) and professional organizations and institutions (e.g. the Colorado Council of Professional Archaeologists).

The earliest stages of site discovery for this thesis proved to be extremely difficult, likely due to an overall lack of bead reporting and communication between researchers, avocational archaeologists, and archaeological societies. Fortunately, as the background research for this thesis progressed, numerous sites came to light as my inquiries stimulated communication within the archaeological community and prompted many individuals to suggest the names of archaeologists that should be contacted or reports which made reference to the discovery of bead sites. Additional contacts made at academic conferences and through introductions to avocational archaeologists, made possible by Dr. Jason M. LaBelle, proved to be invaluable sources of information.

Eventually, nearly 50 total bead sites were discovered in the South Platte River Basin. These sites varied greatly in the type and amount of reported information and because it was necessary to properly document the location and integrity of each archaeological glass bead assemblage, only sites with well documented discovery locations were further analyzed using the methods outlined below. A summary of the analyzed sites is presented in Chapter 4.

Site Location and Context

Only sites with accurate provenience information were subjected to intensive multi-variate analysis. Location was documented using Universal Transverse Mercator (UTM) coordinates recorded with respect to the 1983 North American Datum (NAD 83). This particular datum was selected because it is currently the most widely accepted datum used for the recordation of cultural sites in the United States. Because many of the sites included in the study could not be visited due to property access limitations and/or destruction of the site, locational data was acquired through historic records and reviews of United States Geological Survey (USGS) 7.5' quadrangle maps.

When UTM NAD 83 coordinates were established, primary landform/setting (e.g., drainage basin, open plain, ridgetop, etc.) was documented for each site. Although site location and spatial implications are briefly discussed in later chapters of this thesis, the patterns derived from topographic variables proved beyond the scope of this thesis project. As such, spatial data was collected for future studies of bead distribution.

Macroscopic Analysis

Color. Color has become one of the most difficult bead traits to systematically describe. While studies in the first half of the 20th century were limited to only the most basic descriptive color terms (e.g., Watt and Meroney 1937), the introduction of numerous color identification charts and manuals has greatly complicated color descriptions. These problems are best described by van der Sleen (1967:50) who acknowledged:

> There is such an enormous difference between a brilliantly shining, transparent bead and an opaque lustreless bead with the same chemical composition, that it is practically impossible to recognize them as being coloured by the same amount of the same agent…You need a painter's eye for this kind of work…
>
> van der Sleen (1967:50)

Despite these observations, archaeologists and bead enthusiasts have complicated the problems of color description by using a multitude of descriptive color guides. Most notable of these guides are the *Color Harmony Manual* used by Kidd and Kidd (1970), *Principles of Color and Color Mixing* used by Harris and Harris (1967) and Sudbury (1976), and the *Munsell Book of Color* recommended for use by Karklins (1982) and Spraque (1985).

Difficulties presented by bead color are further compounded when visiting museums to analyze collections. Consistent light sources and the opportunity to wet the surface of a bead, as recommended by Sprague (1985:99-100), are rarely available unless bead collections can be acquired on loan, which allows the use of a standard lighting technique, or with special permission to apply water to a specimen. Additionally, individual researchers who are able to acquire one of the more popular color guides may not have access to lighting which is consistent with other researchers, nor will the researchers view colors in the same manner.

Yet another issue hindering color is the effects of taphonomy. The author is not aware of any studies which recognize the potential effects of soil chemistry, ultraviolet light exposure, weathering, or other taphonomic processes which may affect bead color through time. However, recent experimental work by Colorado State University students has revealed that bead luster and possibly size and color may be affected by simulations of sediment abrasion. Recognizing the many analytical issues which can result in the incorrect identification of bead color, this analysis uses simple color descriptions acquired through the analysis of dry specimens under fluorescent lighting in windowless rooms. Color terms used in this analysis include white, light blue, bluish-green (more green than blue), greenish-blue (more blue than green), royal blue (brilliant bright blue), dark blue, black, pink, yellow, purple, and red. Additionally, these terms are also used to describe interior and exterior color for beads displaying layering and surface decoration (see below).

Shape. The most common method for describing a bead shape follows Kidd and Kidd (1970) and Karklins (1982, 1985). While useful in aggregate analysis, this method describes shape in conjunction with surface decoration, often making it difficult to isolate discrete morphological traits. Therefore, the Kidd and Kidd (1970) method is not used in this thesis.

This thesis defines bead shape as the final form of the bead immediately following manufacture. Descriptive terms such as torus, sphere, oval, facetted, etc., are used to describe shape with all forms of decoration described *post hoc*. This method, derived from Spector (1976:24-25), helps to resolve difficulties which arise from attempted to assign descriptive shape terms to "essentially three-dimensional forms."

Descriptive shape terms which are used in this study include torus, tube, oval, sphere, and facetted. While the majority of these terms do not warrant definition, the term "facetted" requires further discussion. Faceting is typically described as post-manufacture surface modification, often by grinding, resulting in a facetted surface.

Although the goal of this thesis is not to re-define existing bead typologies, it is the opinion of the author that faceting should be considered a stage manufacture which results in a bead's final form/shape, as opposed to *appliqué* surface decoration (see below).

Structure. Bead structure refers to the composition of a given specimen (Karklins 1985:105). Stone (1974:88-89) has outlined four types of structure: simple, compound, complex, and composite. Simple beads are defined as being composed of a single, undecorated layer of glass. Compound beads are composed of two or more undecorated layers of glass. Complex beads are simple specimens with adventitious surface decoration. Composite beads are compound specimens with adventitious surface decoration.

Like shape terminology, existing structure terms combine characteristics of bead morphology which may be isolated for discrete variable analysis. This is not to say, however, that structure is not useful for quickly dividing large samples of beads into more manageable subgroups. For example, Ahler and Drybred (1993) used structure to classify the arrangement, or layering, of colors within specimens for grouping prior to analysis of beads from various villages along the Knife River in North Dakota.

Because the focus of this study is the isolation of discrete variables for statistical analysis, the existing structural categories are not useful. Instead, the number of layers of glass in each specimen was counted with other aspects of structure described as decoration.

Decoration. Decoration is defined as any special ornamentation applied to the surface of the bead such as painting, glazing, inlay, overlay, or *appliqué* (Sprague

1985:100). According to Karklins (1985:106), the types of bead adornment on North American beads fall into three major categories. These categories include overlaid beads which display "appliqués of glass or another material that either rest on or protrude noticeably from the surface of the bead." The second type of adornment is inlay. Specimens with inlaid decoration display "embedded elements whose surfaces are either flush or only slightly above the surface of the bead" (Karlins 1985:106). The final type of adornment is internal. Specimens with internal decoration display "decorative elements, such as coloured cylinders, spiral bands and metal foil, located within the body of the bead" (Karlins 1985:106). Very few decorative elements were noted in a preliminary analysis of the bead assemblages analyzed in this study. Therefore, the decoration categories provided by Sprague (1985:100) and Karklins (1985:106) are omitted and only relevant terms for decorative elements are used.

A nearly infinite number of terms have been developed and used to classify the decorative elements that have been observed in archaeological bead assemblages. Complete use of the various descriptive terms for decorative elements were not necessary for this study as only two types of surface decoration were noted. These decorations include "stripes," a term used to describe straight lines applied to a monochrome bead, perpendicular to the perforation of the specimen. The second term used is "eyes," a term used to describe dots which have been applied to the surface of a monochrome bead. If additional decorative elements are noted on future discoveries of bead specimens in the study area, Beck (1928), van der Sleen (1967), and Francis (1979) should be consulted for complete lists, definitions, and illustrations.

Dimension/Size. Bead size was determined using a variety of methods. Following Kidd and Kidd (1970), beads are grouped into five size classes. *Very small* beads measure less than 2 mm in maximum diameter, *small* beads measure 2-4 mm in maximum diameter, *medium* beads measure 4-6 mm in maximum diameter, *large* beads measure 6-10 mm in maximum diameter, and *very large* beads measure greater than 10 mm in maximum diameter. The application of size class as outlined by Kidd and Kidd (1970) is easily achieved using graduated brass mesh sieves. The method has been found particularly useful by Ahler and Drybred (1993) who employed size classes to quickly divide several large bead assemblages into smaller sub-groups for aggregate analysis.

Other researchers have used slide or digital calipers to capture the outer diameter, length, and inner diameter. This method has proven particularly useful for generating quantitative results in both large and small bead assemblages. For example, Ross (1990) used scatter plots and histograms of bead length and outer diameter to estimate hypothetical screen sizes which may have been used to group beads prior to distribution from their place of manufacture. Another study, conducted by Reher and Scheiber (1993), used mean length and maximum bead diameter of beads from dated archaeological assemblages to generate a regression formula which could be used to estimate bead age.

For this analysis, digital calipers were used to obtain the length and outer diameter, to the nearest hundredth of a millimeter for each specimen. Length is defined as the maximum distance from either end of a specimen, parallel to the perforation. Outer diameter is defined as the maximum width of a specimen, perpendicular to the perforation. Because a small percentage of beads in several of the assemblages were broken, bead portion was also documented. Portion was document as being either "complete" or "incomplete." Incomplete specimens were measured for length or outer diameter only when it could be determined that a majority of the specimen remained intact. Interior diameter was not documented for any specimens in this study because preliminary analysis of several bead assemblages presented in this thesis have shown the measurement to be highly variable and impractical for documentation (von Wedell 2008).

In addition to metric dimensions, graduated brass mesh sieves were used to obtain size classes, following Kidd and Kidd (1970) for several of the assemblages in this study. Unfortunately, size class could not be obtained for all specimens for a variety of reasons, including the fragile nature of some specimens, museum regulations prohibiting potentially destructive analysis (including but not limited to the removal of beads from string or other mounting devices), and restricted time frames for viewing private collections.

Manufacture. There are four common types of bead manufacture: drawn, wound, mold-pressed, and blown. Because the types of manufacture are explained in exhausting detail elsewhere (i.e., Brain 1979; Davis 1973; Karklins 1982; Kidd and Kidd 1970; Smith and Good 1982; Sprague 1985; and others), only abbreviated descriptions are presented here.

Drawn beads are manufactured by drawing a tube of glass and breaking sections into desired lengths. Beads made using a drawn manufacture technique include the most common types such as torus/seed beads, tube beads, and facetted beads. Wound beads were made by winding strands of glass around a steel mandrel. Beads made using a wound manufacture technique include larger oval/egg-shaped beads and spherical beads.

Mold-pressed beads were made by pressing glass in a mold which often resulted in a characteristic seam. Beads made using the mold-pressed technique include unique or irregularly-shaped beads which cannot be easily made by processes such as grinding. Blown beads were made using standard glass blowing techniques, resulting in fragile, hollow beads. Beads made using the blown manufacture technique include specimens which Sprague (1985:97) likened to Christmas tree ornaments.

Manufacture is one of the few bead characteristics which can be consistently described by archaeologists. For this analysis, the terms drawn, wound, mold-pressed, and blown are used to describe manufacture although only drawn and wound beads were observed in the assemblages available for study.

Luster. Luster is used to describe the ability of a beads surface to reflect light or the "appearance of the bead in reflected light" (Karklins 1982:109). Sprague (1985:100) notes that taphonomic processes can greatly affect luster and may include "weathering in soil, sandblasting in a surface site, absorption of oil through wearing and handling both before and after excavation, and other factors of aging."

Descriptive terms for luster include, but are not limited to pearl, opal, metallic, greasy, and satiny (Karklins 1982:109; Sprague 1985:100). Karklins (1982:109) describes the most basic types of luster as "shiny (smooth and bright) and dull (not shiny)."

The use of multiple descriptive terms for luster beyond the widely understood categories of "shiny" and "dull" reintroduces problems similar to those encountered in documenting bead color (i.e., lighting issues and researcher perception). Therefore, the terms "shiny" and "dull" are used for this study with further descriptive terms omitted.

Diaphaneity. Diaphaneity, the capacity of beads to transmit light, is designated as falling within the categories: opaque, translucent, and transparent. Criteria for the three categories is provided by Smith and Good (1982:21):

> A bead is classified as transparent if its perforation is visible when it is held sideways to the light, and/or if there is little variation in the Munsell color classification when the color of the bead in reflected light is compared to its color in transmitted light. Likewise, it is considered translucent when light does penetrate the bead, and opaque when it does not.

Although the Smith and Good (1982) criteria for diaphaneity are sufficient for the majority of bead studies, their use of the Munsell color classification system is not consistent with the methodology of this study and may present some confusion. Therefore, this analysis uses a diaphaneity criteria outlined by Karklins (1985). Karklins (1985:112) defines opaque beads as specimens which are "impenetrable to light except on the thinnest edges. Translucent specimens transmit light, yet diffuse it so that objects viewed through them are indistinct…Objects viewed through transparent beads are clearly visible."

The eight macroscopic traits outlined above are used to describe each bead available for analysis in the South Platte River Basin. While it is not always possible to gather information for each characteristic on each specimen (e.g., dimension cannot always be measured on beads with incomplete portions) all attempts are made to gather as much data as possible. Within each category, the presence of a characteristic is coded as having a value of one (e.g., a bead which is blue in color is given a value of one in the column heading for blue); and, the absence of a characteristic is coded as having a value of zero (e.g., a bead which is not blue is given a value of zero in the column heading for blue). Using this technique, individual traits can be isolated for multi-variate statistical analysis and specimens can be grouped to address quantitative issues (see below).

Chemical Trace Element Analysis

Although the study of glass bead chemistry began in the first half of the 20th century (van der Hoop 1932, cited in van der Sleen 1967), few researchers have actively pursued trace element analyses using available modern techniques. Of the available published studies of glass bead chemistry, the majority have employed non-destructive Instrumental Neutron Activation Analysis (INAA) as the preferred mechanism for extracting trace element counts. More recently, researchers have employed the minimally destructive technique of Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) because of its ability to extract parts per million (*ppm*) counts for a greater number of trace elements.

Prior to selecting a procedure for extracting trace element counts for beads in the study sample, previously published studies were reviewed to determine the applicability of glass chemistry to archaeological glass bead studies, the context of previously analyzed glass bead assemblages, and the nature of results obtained through the analysis of glass beads from different regions, chronological periods, and of different colors. A brief discussion of the findings of the literature review is presented in Table 3.1, which demonstrates the evolution of techniques for gathering chemical trace elements counts of glass beads as well as the progression of questions asked about the acquired data.

Table 3. 1. Summary review of published studies pertaining to archaeological glass trade bead chemistry.

Reference	Bead Sample	Analysis Method	Results
Davison and Clark 1974	"Trade Wind" beads (various colors) from sub-Saharan Africa; Iron Age	NAA and XRF	Visual and chemical traits of beads and dating attempts were too general to provide diagnostic utility.
Hancock et al. 1994	Blue beads from the eastern Great Lakes, North America; 16th and 17th Centuries	INAA	Identified expected chemical content for beads colored with copper; hypothesized that observed chemistry change could be attributed to age and origin of a given assemblage
Kenyon et al. 1995	Blue beads from Ontario, Canada; dated 1660-1930	INAA	Identified chemical homogeneity and heterogeneity of elements; established provincial chronology based on chemistry
Hancock et al. 1996	Turquoise blue beads from Quebec, Canada; 17th to 19th Century	INAA	Identified changing chemical contents through time base on Na, K, and Cl
Sempowski et al. 2001	Red beads from Amsterdam and North America; 17th Century	INAA	Identified expected chemical contents for red glass beads; established provisional chronology for red glass beads; hypothesized that chemistry could be attributed to bead origin
Karklins et al. 2002	Glass beads and glass (various colors) from Amsterdam; early 17th Century	INAA	Identified expected chemical content for various colors of glass beads and glass from Amsterdam; attempted to link Amsterdam beads with North American assemblages
Robertshaw et al. 2003	Beads (various colors) from South Africa; 10th to 15th Century	LA-ICP-MS	Identified two groups of chemical additives; determined chemical groups were the product of bead sources.
Popelka et al. 2005	Beads (various colors) from sub-Saharan Africa and Southeast Asia; dated 700-1640	LA-ICP-MS	Glass color is related to chemical composition; lead and tin were correlated elements in some colors; beads could be divided into groups based on origins of magnesium and potassium
Billeck and Dussubieux 2005	Blue beads from the Central Great Plains, North America; 17th, 18th, and early 19th Centuries	LA-ICP-MS	Established a link between Central Great Plains bead assemblages and bead assemblages from the Great Lakes Region; identified a previously undocumented chemical pattern and hypothesized a non-French, non-Dutch origin
Robertshaw et al. 2006	Beads (various colors) from Madagascar; 7th to 14th Century	LA-ICP-MS	Glass sources were recognized within compositional groups; identified chemical changes through time; determined likely regions of bead origins

Based upon the findings of the literature review, it was determined that the INAA method was previously preferred for its ability to extract chemical signatures without harming the test sample. More recent studies, however, have benefited from the minimally destructive LA-ICP-MS method because of its ability to extract *ppm* counts for a greater number of chemical elements. Although LA-ICP-MS is minimally destructive, the extremely small portion of the sample which is required by the method does not result in any visible harm to the test specimen. Therefore, Dr. Hector Neff was contacted at the Institute for Integrated Research in Materials, Environment, and Society (IIRMES) located on the campus of California State University at Long Beach (CSULB).

Two hundred twenty-two glass beads from 11 archaeological sites and assemblages were shipped to Dr. Neff for LA-ICP-MS analysis (see Chapter 4). Beads were selected based upon assemblage size and color as well as museum policies on collections loans and destructive analysis.

The methodology by which beads were tested using the LA-ICP-MS process was provided by Dr. Hector Neff (personal communication 2008) and is as follows:

> The analyses were undertaken in the archaeometry lab at IIRMES, CSULB, on the GBC Optimass 8000 time-of-flight ICP-MS, with our New Wave UP-213 laser-ablation system used as the sample introduction system. Two-line rasters of approximately 0.3 x 0.2 mm were scanned with the laser set at 60% power and with a 100-micron spot size. Signal intensities were monitored for 46 analytes, including silicon-30, which was used as the internal standard.
>
> The LA-ICP-MS data were calibrated to parts per million using NIST glass standards (SRM614, SRM612, and SRM610) along with Brill standard glasses B, C, and D. The table below shows the concentrations of various analytes in the standards. For trace elements, including all the lanthanides and actinides, only SRM614 and 612 were used, since these low-concentration standards bracket most of the concentrations in the beads. The basic approach to calibration involves fitting standardized concentrations (ratios to silicon) in the standards to standardized counts (ratios of raw counts to raw silicon counts). The data were calibrated to concentrations by converting the standardized counts to standardized

oxide concentrations and summing to 100%. This is a variation of an approach suggested by Gratuze (1999) and described by Speakman and Neff (2005)."

Bead and Assemblage Age

Three archaeological glass bead assemblages from independently dated sites were available for inclusion in this thesis: Lykins Valley, Fort Vasquez, and Weinmeister. In addition to being the only glass bead sites in the South Platte River with confirmed dates, they also represent the largest and most varied glass bead assemblages in the region. Statistical means for individual bead characteristics present in these sites will be used as a chronological baseline for identifying positive and negative correlations of bead morphology and chemistry as well as a regression formula which can be used to estimate the ages of beads recovered from undated contexts.

The first site, Lykins Valley, is currently the oldest independently dated site in the South Platte River Basin (see Chapter 4). The Lykins Valley site contained a vast and variable artifact assemblage including several items of Euroamerican manufacture suitable for seriation dating. Based on similarities of style with known historical examples, Newton (2008:76-85, 86-92) used a gunflint, brass kettle lugs, CP Half Rib clay pipe fragments, and glass beads (von Wedell 2006), to estimate the age of the site to be between 1780 and 1900. This age determination was further refined with absolute data gathered from radiocarbon results. Newton (2008:101) pooled radiocarbon results from two charcoal and three bone collagen sample to acquire an absolute date of 1734-1806 which led him to conclude that the site was occupied between 1780 and 1830 (Newton 2008:159).

The second independently dated site, Fort Vasquez, was in operation from 1835 to 1842. Although the trading post was only open for a short period of time, it is well documented in surviving historical records (see Chapter 2; Hafen 1964; Peterson 192; Robertson 1999) and was subject to several excavations in the 1960s and 1970s (Peterson 1982:18). All historic and archaeological research conducted with regard to Fort Vasquez have confirmed its formal occupation from 1835 to 1842.

The third and final independently dated site, Weinmeister, contained only glass beads with no other items available for independently dating the site. Although this initially presented an issue, I was able to conservatively estimate the last possible age of occupation as 1880, the final year of the Native American Relocation Phase. To determine the earliest possible date of occupation, I consulted Davis's (1973) study of northern Great Plains archeological bead assemblages which shows that very small (less than 2mm in diameter) translucent dark blue, translucent dark green, and yellow beads are not reported in archaeological assemblages dating prior to 1858 (Davis 1973:22-29). Therefore, I conservatively estimate the earliest possible date for the occupation of the Weinmeister site as 1850.

Statistical Analysis

Once morphological and trace element information were acquired for the study sample, the data was entered into a Microsoft Excel file and coded for statistical analysis using *SPSS 16.0* computer software. Once the coded data was prepared, multiple tests were executed in order to identify sample variance. These test included Independent Samples t-Tests to identify significant variables within sites and the regional bead sample, Correlation tests to determine to what extent bead characteristics tended to change through time, and Linear Regression modeling to develop formulas that relied upon bead morphology and chemistry to estimate ages for undated sites/assemblages. Statistical tests such as these are relatively common in archaeological research (e.g., lithic and faunal analysis) although very few archaeologists have fully utilized them to answer questions of chronology in bead research.

Summary

The methodology outlined in this chapter was modeled to follow existing techniques as closely as possible. A secondary goal was to make the methodology easily understood so that it could be replicated in analyzing other bead assemblages. This includes dividing morphology into eight categories (i.e., color, shape, structure, decoration, dimension, manufacture, luster, and diaphaneity). Each of the categories contains multiple levels of analysis used to fully document discrete variables. These variables will be used in multivariate statistical analyses along with trace element counts obtained using LA-ICP-MS. The results of the analyses are presented in Chapter 5.

CHAPTER 4: SITES AND ASSEMBLAGES

This chapter contains descriptions of the various collections of archaeological glass bead sites and assemblages documented during the course of this study. The majority of the collections has been formally recorded as part of various cultural resource management activities or exists as part of museum collections, being donated by the individuals who discovered them. Others sites and assemblages have been reported by avocational archaeologists who currently maintain possession of collections.

The chapter contains two sections. First, I will describe sites and assemblages with confirmed locations of discovery. These are arranged alphabetically by county. Second, I present other known sites and assemblages from the study area that were excluded from quantitative analyses for various reasons (e.g. sites lacking provenience and/or were unavailable for analysis); however, these collections are briefly described in the latter pages of this chapter for the purposes of characterizing the known database of bead-bearing sites in the region. Figure 4.1 and Table 4.1 present the site locations and a summary description of the archaeological glass bead sites and assemblages discussed in the following pages.

Adams County

5AM632 (Comanche Creek Burial or Strausberg Burial). This site was originally discovered by Forest L. Powars in 1939 along the banks of Comanche Creek, north of Strasburg, Colorado. The assemblage includes the partial remains of two

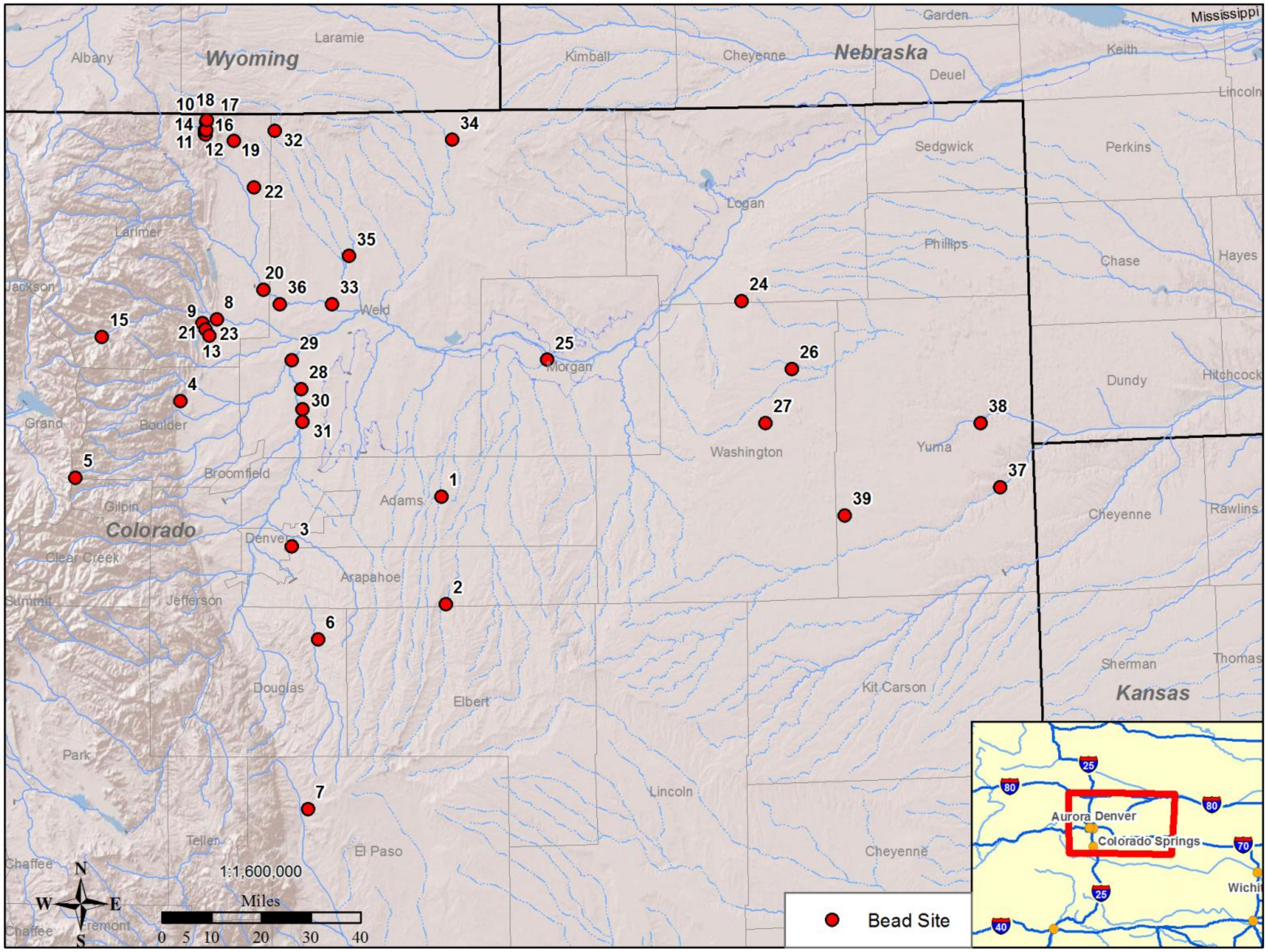

Figure 4. 1. Locations of archaeological glass trade beads sites and assemblages in the South Platte River discussed in this chapter.

Table 4. 1. List of archaeological glass bead sites and assemblages located in the South Platte River Basin available for inclusion in this thesis. The numbers in the Map Reference columns correspond with site locations presented in Figure 4.1.

Map Reference	County	Site Name (Number)	Count	Analysis Type		Reference
				Morphology	Chemistry	
1	Adams	Comanche Creek (5AM632)	13	X		DMNS 1996
2	Arapaho	5AH4	1			Neil Hauser, personal communication, 2008
3	Arapaho	Macon Street Burial	1,568	X		DMNS 1994
4	Boulder	Lykins Gulch Cave (5BL31)	1			Pipkins et al. 1989
5	Boulder	Rollins Pass (5BL148)	1			Olson 1971
6	Douglas	5DA268	12	X	X	Gilmore 1989
7	El Paso	5EP750	70	X		Muenig et al. 1985
8	Larimer	Marianna's Butte (5LR28)	41	X		Jason LaBelle, personal communication, 2008; Gates 1981
9	Larimer	5LR53	24	X	X	Wheat 1957
10	Larimer	Line Shack Draw (5LR110)	1			Jason LaBelle, personal communication, 2010
11	Larimer	5LR261	1	X	X	Morris et al. 1979
12	Larimer	Lykins Valley (5LR263)	430	X	X	Morris et al. 1979; Ohr et al. 1979; Newton 2007
13	Larimer	Coffin B (5LR357)	275	X		LaBelle and Bush 2009; Fort Collins Museum 1976a
14	Larimer	Coffin A (5LR359)	128	X		LaBelle and Bush 2009; Fort Collins Museum 1976a
15	Larimer	Tuxedo Park (5LR611)	1			Brunswig 2005

Table 4.1. Continued.

Map Reference	County	Site Name (Number)	Count	Analysis Type		Reference
				Morphology	Chemistry	
16	Larimer	5LR11724	3	X	X	LaBelle and Bush 2009
17	Larimer	5LR11726	4	X	X	LaBelle and Bush 2009
18	Larimer	5LR11819	3	X	X	LaBelle and Bush 2009
19	Larimer	5LR11838	2	X	X	Parks and LaBelle 2008
20	Larimer	Harvester (5LR12641)	3			Jessica Anderson, personal communication, 2009
21	Larimer	Arapaho Princess	26	X		Jason LaBelle, personal communication, 2008; Gates 1981
22	Larimer	Coffin C	Unknown			Fort Collins Museum 1976a
23	Larimer	Loveland Museum	17,179	X		Jason LaBelle, personal communication 2007
24	Logan	Battle of Summit Springs (5LO199)	Unknown			Grinnell 1915:310-318
25	Morgan	Westfall A	173	X		Tom Westfall, personal communication, 2008
26	Washington	Westfall B	5	X		Tom Westfall, personal communication, 2008
27	Washington	Westfall E	1	X		Tom Westfall, personal communication, 2008
28	Weld	Fort Vasquez (5WL568)	1,843	X	X	Hafen 1964; Peterson 1982
29	Weld	Fort St. Vrain (5WL814)	47+			Peterson 1982
30	Weld	Fort Jackson (5WL816)	1+			Hafen 1925; Newton, personal communication, July 2010

Table 4.1. Continued.

Map Reference	County	Site Name (Number)	Count	Analysis Type: Morphology	Analysis Type: Chemistry	Reference
31	Weld	Fort Lupton (5WL849)	Unknown			Carrillo 1991, 1994; McKibbin and Carrillo 2006
32	Weld	Biscuit Hill (5WL1298)	1	X	X	Day and Eighmy 1998
33	Weld	Charles Lohr	113	X		Greely Municipal Museum 1982
34	Weld	Marsh Collection	104			Fort Collins Museum 1976b
35	Weld	Owl Creek Burial	1,000+			Ball 1987
36	Weld	Weinmeister	966	X	X	Garry Weinmeister, personal communcation, 2007
37	Yuma	Battle of Beecher Island (5YM40)	Unknown			Grinnell 1915; Charles Reher, personal communication, 2007
38	Yuma	Westfall C	1	X		Tom Westfall, personal communication, 2008
39	Yuma	Westfall D	199	X		Tom Westfall, personal communication, 2008

individuals and their associated funerary objects unearthed during a construction project. Shortly after discovery, the assemblage from the site was donated to the Colorado Museum of Natural History (now the Denver Museum of Nature & Science [DMNS]).

The DMNS (1996) analyzed the human remains and estimated the age at time of as death 35-39 years (sex unknown) and 60+ years (male). Unfortunately, racial affiliation could not be discerned. The sex of the first individual could not be determined from the recovered skeletal elements. Because both of the individuals were disturbed during construction, there are no records of body position or mode of interment.

Funerary objects from the site are unusual both in frequency and in the peculiarity of types present. Included in the assemblage are a catlinite pipe bowl with a decorative, hand-carved wooden stem, 17 pieces of rusted metal from an animal trap, a rusted coffee grinder, two pieces of wound copper wire, a rusted belt buckle and pieces of belt leather, pieces of leather clothing displaying machined stitching, an awl sheath, two narrow leather straps, four pieces of cloth, 13 glass beads, and the bills of an Ivory-billed Woodpecker (*Campephilus principalis*) and a Pileated Woodpecker (*Ceophloeus pileatus*) (Bailey 1939:164).

The glass beads recovered from the Comanche Creek Burial were attached to a small piece of leather using thread. The beads are aligned in four rows with three beads in each of the upper three rows and a single bead in the fourth row. The assemblage from the site represents the only example of intact, protohistoric/historic-aged beadwork recorded by this study. While this beadwork specimen is currently the only know example from the South Platte River Basin, at least one other example is known in Colorado. A beaded legging recovered from the site of the Sand Creek Massacre in southeastern Colorado is housed in the collections of the Loveland Museum in Loveland, Colorado.

Arapahoe County

Macon Street Burial. This site was discovered in 1972 during the installation of a utilities pipeline for a condominium in Aurora, Colorado. At that time, construction workers noted the presence of human bones and artifacts in the walls of an excavated trench. Following investigation of the site by the Denver County Coroner's Office, the human remains were determined to be archaeological in origin and representatives from the DMNS were contacted. The specimens were subsequently excavated and collected from the trench and removed to the DMNS for analysis and curation (DMNS 1994). Currently, the Macon Street Burial has not been assigned a Smithsonian site number.

The human skeletal elements from the Macon Street Burial included six unspecified bone fragments and several teeth. To date, the age, sex, and racial identity of the individual have not been conclusively determined. In addition to the skeletal remains, some fragments of hair were collected and submitted to the University of Arizona for further analysis. The results of this analysis were not available for inclusion in this thesis.

Funerary objects from this site were sparse and included fragments of a flat, oval-shaped metal ring of unknown function, animal fur, three types of textiles (partial remains), and 1,568 beads. One the textiles is described as a possible rug of Southwestern origin based upon weaving technique and may, with further analysis, prove useful for dating the burial.

The bead assemblage from the Macon Street Burial could not be fully analyzed due to the fragile nature of the many beads in the assemblage. As such, a statistically significant sample was selected for analysis. During analysis of the assemblage a number of turquoise green-colored beads were noted. Although these beads were in a highly deteriorated state, it should be noted that this color of glass bead is particularly rare in the South Platte River Basin.

Douglas County

5DA268. This site was recorded during an archaeological survey of the proposed expansion/widening of Colorado State Highway 83 (Miller and Fiero 1977). As originally recorded, the site is a moderately-sized open camp measuring approximately 60 meters by 30 meters. It is located on a small ridge overlooking Kinney Creek to the north and Cherry Creek to the west. The recorded artifact assemblage consisted of lithic debris, six chipped stone tools, 42 utilized flakes, a mano, and 12 glass beads. As part of the initial recording, eight square meters were excavated. Based upon soil profiles obtained from the excavation, it was determined that cultural materials at the site were confined to the upper 10 to 15 centimeters below the surface. Despite the presence of subsurface cultural materials, the site was recommended not eligible for inclusion to the National Register of Historic Places (NRHP). Several impacts to the site were also noted including construction associated with SH 83 and a nearby golf course.

5DA268 was revisited following construction of SH 83 and was expanded to measure approximately 800 meters by 650 meters (Gilmore 1989). Updates to the site included the discovery of two deflated hearth features, a Late Archaic projectile point, and 12 glass beads. Gilmore (1989) concurred Miller and Fiero's (1977) assessment of the site and recommended the site remain ineligible for inclusion on the NRHP.

The glass bead assemblage from 5DA268 is currently curated at the Museum of Natural History at the University of Colorado-Boulder and includes 12 seed beads, including five white and seven blue specimens. Two of the glass beads were made available for trace element analysis using LA-ICP-MS testing at the IIRMES lab at CSULB.

El Paso County

5EP750. This site was originally recorded for the proposed expansion of SH 83 (Academy Boulevard North to Shoup Road). As originally recorded, the site is a moderately-sized open camp measuring 90 meters by 80 meters. It is located east of the Pine Valley airport and north of Kettle Creek (Colorado Department of Highways 1985). The recorded artifact assemblage consisted of subsurface hearth features exposed in a roadcut, lithic debris, two Late Archaic-aged projectile points, two flaked stone tools, two pieces of groundstone, fire-cracked rock, unburned bone, and 70 glass beads strung on a small brass wire. Based upon the depth at which the features were recorded and the additional discovery of artifacts in each of four test units excavated at the site, researchers determined that the area held good potential for intact, subsurface cultural deposits. A radiocarbon date of 1070±70 RCYBP (Beta-12799) was obtained from one of the hearth features.

The glass beads from 5EP750 are the only sample in this study strung on brass wire and is one of only two sites in which intact beadwork was recorded. Preliminary historical research of the area by Colorado Department of Highways archaeologists (1985) revealed that a Boy Scouts of America Jamboree had taken place in the site vicinity in 1959. This information, along with the discovery of additional modern materials at the site, a lack of corrosion on the brass wire which held the beads, and the presence of red seed beads without white interiors (a type not recorded in any other assemblage in this study), seems to support a date for the bead assemblage of 1959. Although this dates the assemblage to the historic/modern period and it is likely not protohistoric in age, the assemblage is included in this study as a control sample with a precise date and location of origin.

Larimer County

5LR53. This site was originally discovered by Edison Lohr in the middle 20th century and recorded by Joe Ben Wheat of the University of Colorado in the 1950s (Wheat 1954). The site is located along Dry Creek, a tributary of the Big Thompson River, in one of the hogback glades west of Loveland. Because the site has not been recently visited and the only known site sketch map lacks a scale, the size of the site could not be determined for this study. Numerous artifacts were recorded at the site and including lithic debris, several manos, a metate, fragments of a steatite vessel, and 24 glass beads.

The glass bead assemblage from 5LR53 is currently curated at the University of Colorado Henderson Museum. Two of the glass beads were made available for trace element analysis using LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR261. This site was originally recorded by field crews from Colorado State University during an archaeological survey of the proposed construction of several earthen check dams along Boxelder Creek in northern Larimer County, Colorado. As originally recorded, the site is described as a small lithic scatter located on a small ridge overlooking Boxelder Creek. Artifacts at the site consisted of lithic debris, one Middle Archaic projectile point (possibly Duncan), one spokeshave, one biface fragment, utilized flakes, and one blue glass bead.

The bead specimen from 5LR261 was discovered in an ant hill and Morris et al. (1979:62) hypothesize that it "may have been lost by an inhabitant of 5LR263 who was on the site temporarily." The specimen was submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR263 (Lykins Valley). The Lykins Valley site is a protohistoric-aged open camp located in northern Larimer County, along the Boxelder Creek drainage. The site was originally recorded in the 1970s by field crews from Colorado State University who were surveying drainages in the area as part of the Boxelder Creek Watershed Program (Morris et al. 1979). During the initial recording, field crews performed a surface inventory of the site. The discovery of subsurface features prompted further work at the site, including intensive surface survey and test excavations (Ohr et al. 1979). During the latter investigations of the site, field crews documented lithic materials, faunal remains, and numerous Euroamerican-manufactured items including fragments of a clay pipe, a brass kettle lug, a gun flint, a metal tinkler, and 430 glass beads (Figure 4.2). Charcoal obtained from the thermal features was submitted for radiocarbon dating (Ohr et al.

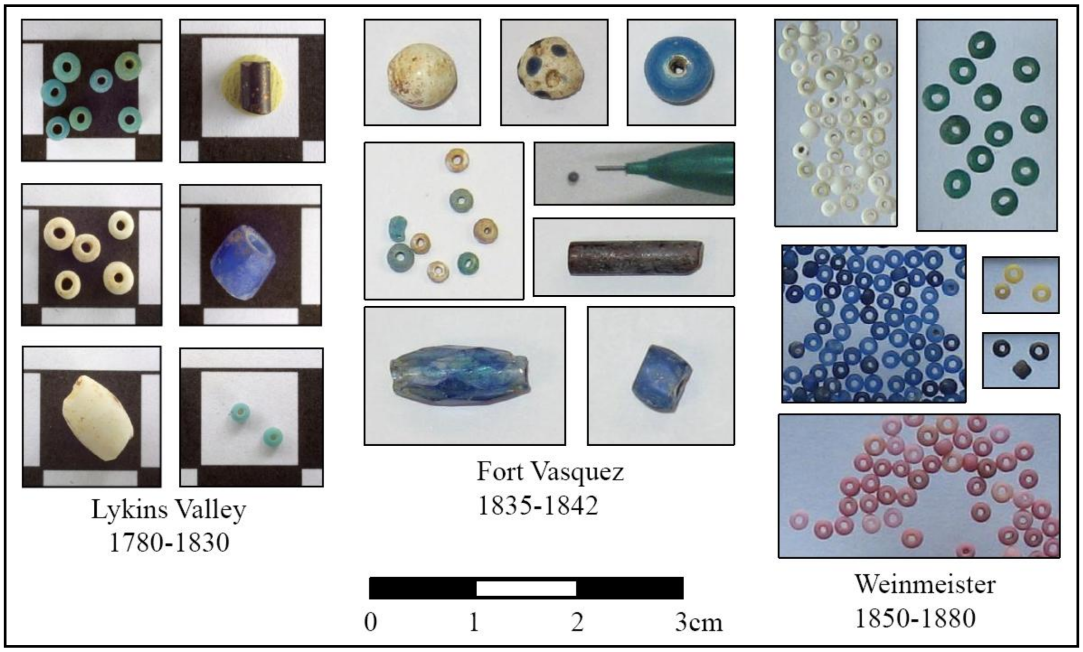

Figure 4. 2. Examples of beads from dated archaeological sites located within the South Platte River Basin, Colorado. Photographed by C. Evans and C. von Wedell.

1979). Dates of 250±85 RCYBP (UGa-816) and 210±95 RCYBP (UGa-813) were obtained.

The Lykins Valley site was revisited by field crews from Colorado State University in 2006 as part of the *Class II Archaeological Survey of the Red Mountain Ranch Open Space, Larimer County, Colorado* project (LaBelle et al. 2007). Fieldwork at that time included the placement of a datum, surface mapping of the site, surface inventory, metal detector survey, relocation of the 1974 block excavation, and photographic documentation of changes to the site (LaBelle et al. 2007:104-105). Lithic debitage, faunal remains, a brass kettle lug, and modern trash were documented as part of this recording.

Newton (2007) reanalyzed the Lykins Valley site and who concluded that the previously established dates for the site were too early. A critical reevaluation of dates of production for the Euroamerican trade goods and newly acquired radiometric dates obtained from faunal remains allowed Newton (2007:100-103,159-160) to place the date of occupation for the site sometime around the turn of the 19th Century, likely between 1780 and 1830. This date is consistent with age estimates of the Lykins Valley glass bead assemblage proposed by von Wedell (2006, 2007).

The age estimate provided by Newton (2007) makes the Lykins Valley site one of only three independently dated glass trade bead assemblages available for this analysis. It is comprised primarily of blue and white seed beads although it also contains several additional types which are relatively rare in the South Platte River Basin. Uncommon types include a tubular bead, several oval-shaped beads, and a polychrome facetted bead. All of the specimens were collected during the 1970s field investigations conducted at the Lykins Valley site with no additional specimens collected during the 2007 reinvestigation. Many of the specimens were collected from shallow deposits and recovered from screening of sediments at the site. Currently, the artifact assemblage from the Lykins Valley site is curated at the Laboratory of Public Archaeology (LOPA). One hundred of the glass beads were made available for trace element analysis using LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR11724. This site was discovered in 2007 by archaeological field crews from Colorado State University during survey of the Red Mountain Open Space in northern Larimer County, Colorado (LaBelle and Bush 2009). It is located northwest of Table Mountain, along the banks of the active channel of Boxelder Creek and is defined as a multi-component lithic scatter. Artifacts at the site include a bison skull cap and rib fragment, three flakes, one bullet casing, and three glass beads. The bison bones were recorded as eroding from a nearby cutbank of a former Boxelder Creek channel and suggest that the site retains good potential for intact subsurface cultural deposits.

Site 5LR11724 is located near 5LR11726 (see below) and it is possible that the two sites represent a large single site/occupational episode which was originally recorded as site 5LR359 by Major Roy G. Coffin, Judge Claude C. Coffin, and E.B. Renaud in the 1930s. During their recording of the site, the Coffins reportedly collected numerous glass beads which were later donated to the Fort Collins Museum. It is hypothesized, but not concluded, that a strand of beads from the Fort Collins Museum which include white, blue, and several Cornaline D'Alleppo beads (i.e, seed beads with red exteriors and white interiors) was likely collected from 5LR359 which is most recently recorded as 5LR11724 and/or 5LR11726 (see Coffin Collection A below).

The three bead specimens from 5LR11724 were recovered from a harvester ant mound which was screened using 1/8" wire mesh. Currently, the specimen is curated at the Laboratory of Public Archaeology (LOPA) and will later be curated at the Fort Collins Museum. A bead from 5LR11724 was submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR11726. This site was discovered in 2007 by archaeological field crews from Colorado State University during survey of the Red Mountain Open Space in northern Larimer County, Colorado (LaBelle and Bush 2009). Like 5LR11724, it is located northwest of Table Mountain, along the banks of the active channel of Boxelder Creek and is defined as a multi-component lithic scatter. Artifacts at the site include four scrapers, one retouched flake, one biface, a bullet casing, metal fragments and wire, clear glass, a hoe blade displaying bullet holes, and four glass beads.

Site 5LR11726 is located near 5LR11724 (see above) and it is possible that they represent a single site/occupational episode which was originally recorded as 5LR359 (see above). It is hypothesized, but not concluded, that a strand of beads from the Fort Collins Museum was likely collected from this site (see Coffin Collection A below).

The bead specimens from 5LR11726 were recovered from a harvester ant mound which was screened using 1/8" wire mesh. Currently, the specimens are curated at LOPA and will later be curated at the Fort Collins Museum. Three beads from 5LR11726 were submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR11819. This site was discovered in 2007 by archaeological field crews from Colorado State University during survey of the Red Mountain Open Space in northern Larimer County, Colorado (LaBelle and Bush 2009). It is located along the east terrace of Sand Creek several hundred meters south of the mouth of Haygood Canyon. It is defined as a protohistoric lithic scatter with artifacts including lithic debitage, and three glass beads.

Site 5LR11819 is located near a small lithic scatter, site 5LR11557 (LaBelle et al. 2007), and it is possible that they represent a single site/occupational episode which was originally recorded as site 5LR357 by Major Roy G. and Judge Claude C. Coffin in the 1920s or 1930s. During their recording of the site, the Coffins reportedly collected numerous glass beads which were later donated to the Fort Collins Museum. It is hypothesized, but not concluded, that a strand of beads from the Fort Collins Museum which includes white and various shades of blue beads was likely collected from 5LR357 which is most recently recorded as 5LR11819 and/or 5LR11557 (see Coffin Collection B below).

The bead specimens from 5LR11819 were recovered from a harvester ant mound which was screened using 1/8" wire mesh. Currently, the specimens are curated at LOPA and will later be curated at the Fort Collins Museum. All three beads from 5LR11819 were submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

5LR11838. This multi-component site was discovered in 2007 by archaeological field crews from Colorado State University during survey of the access road leading to Soapstone Prairie Natural Area in northern Larimer County, Colorado (Parks and LaBelle 2008). It is located on a small terrace in Rawhide Flats with Round Butte visible to the east. Two features are present at the site including the foundation of a historic homestead and a depression, possibly representing a root cellar. Artifacts at the site consist of historic trash, including diagnostic ceramics, which date the homestead to the 1900s, two pieces of lithic debitage, and one glass bead.

The bead recovered from 5LR11838 is the largest example of a seed bead recovered from the South Platte River Basin and could be classified as a "pony bead" (Conn 1972). The unusually large size of the specimen and its discovery on a historic period homestead site suggest that the bead was likely unassociated with Native American activity.

The bead specimen from 5LR11838 was recovered from the surface of a harvester ant mound. Currently, the specimen is curated at LOPA and will later be curated at the

Fort Collins Museum. The bead from 5LR11838 was submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

Coffin Collection A. This assemblage, donated to the Fort Collins Museum by the Major Roy G. Coffin in the 1920s or 1930s, is identified as site 5LR359. Colorado State University field crews working in the area in 2007 were able to locate additional glass beads from two areas which are currently defined as sites 5LR11724 and 5LR11726. This determination is based upon spatial proximity of the sites as well as consistency in bead morphology (including size and color) between the three sites in question.

The Coffin A assemblage contains 129 glass seed beads (Figure 4.3) including Cornaline D'Allepo (red beads with a white interior) specimens as well as white, blue, greenish-blue, dark blue, and black glass beads (Fort Collins Museum 1976a).

Coffin Collection B. This assemblage, donated to the Fort Collins Museum by the Major Roy G. Coffin in the 1920s or 1930s (Fort Collins Museum 1976a), is identified as site 5LR357. Colorado State University field crews working in the area in 2007 were able to locate additional glass beads from an area which is currently defined as site 5LR11819 and which may be contiguous with site 5LR11557. This determination is based upon spatial proximity of the sites as well as consistency in bead morphology (including size and color) between the three sites in question.

The Coffin B assemblage contains 276 seed beads made of white and various shades of blue glass.

Figure 4. 3. Examples of beads from undated archaeological sites located within the South Platte River Basin, Colorado. Photographed by C. von Wedell.

Morgan County

Westfall A. This site was discovered by the Tom Westfall family of Wray, Colorado. The site is located west of Fort Morgan along the banks of the South Platte River in Morgan County (Tom Westfall, personal communication, 2008). The Westfall A Collection contains 173 glass beads including one unique form, a translucent red seed bead with square-rounded appearance resulting from the application of pressure during manufacture. The remaining beads in the assemblage include seed beads made of white, pink, red, yellow, black, and various shades of blue glass.

Washington County

Westfall B. This site was discovered by the Westfall family of Wray, Colorado. It is located northwest of the town of Yuma, among several unnamed tributaries of Surveyor Creek in Washington County (Tom Westfall, personal communication, 2008). The South Platte River is located approximately 30 miles to the northwest. The Westfall B Collection contains five glass beads including two white beads, two blue beads, and one Cornaline D'Aleppo (beads with red exteriors and white interiors) bead. All of the beads were found in ant mounds near plowed fields, thus providing little context for the discovery.

Westfall E. This site was discovered by the Westfall family of Wray, Colorado. It is located southeast of the town of Akron in Washington County (Tom Westfall, personal communication, 2008). The Westfall B collection was discovered approximately 15 miles to the north and the South Platte River is located about 40 miles to the northwest. The Westfall E collection contains a single glass trade bead which is unique to this study. The specimen is a translucent red color and displays numerous ground facets. The singular bead was discovery in a plowed field, thus providing little context for the discovery.

Weld County

5WL568 (Fort Vasquez). Fort Vasquez is a fur trade fort located along a former bend of the South Platte River near the present day city of Platteville, Colorado. Archaeological investigations of the fort were originally undertaken in the form of a brief site visit and recording by Leroy F. Hafen (1964:211) in August 1924. Subsequent interest in the site resulted in the erection of a monument at the site in 1932 and reconstruction of the trading post as a Works Progress Administration (WPA) project between 1935 and 1936.

The reconstruction of Fort Vasquez was based on an architectural design of the structure assembled from accounts of area residents who had visited the site prior to its nearly complete deterioration. Although the reconstruction provided an interpretive center for Fort Vasquez, a portion of the site was irreparably damaged with several walls being moved (Peterson 1982:18). Later damage to the area surrounding the fort also occurred as a result of the construction of U.S. Highway 85 in 1958. The highway, which has a north to south orientation, now brackets the original site of Fort Vasquez as well as the interpretive center.

At the time that U.S. Highway 85 was constructed, the Colorado Historical Society (CHS) gained control of the Fort Vasquez property. Under the management of CHS, Fort Vasquez received its first formal archaeological excavations. These excavations were led by Galen Baker of Trinidad State Junior College in 1963, 1966, and 1967, and by James Judge of Colorado State University between 1968 and 1970 (Peterson 1982:20). Unfortunately, records of the work performed under Baker as well as the majority of recovered artifacts could not be located for inclusion in this thesis.

Excavations by Jim Judge determined the exact location, dimensions, and layout of the original fort and unearthed nearly 14,500 artifacts. Nails, wood, adobe, clay pipes, lithics, ceramics, metal, hawk bells, a musketball, gun flints, and 1762.5 glass beads were included amongst the artifacts (Peterson 1982:20). Currently, these artifacts are housed at the Colorado History Museum along with a very small collection of less than ten beads and other artifacts collected during survey of the fort's interior in 2000. The beads discovered during this most recent survey were also analyzed for this thesis.

The current bead assemblage available for analysis from Fort Vasquez includes 1843 glass beads. Although this number does not correlate with the number of beads reported by Peterson (1982:20), it is suspected that his total number of beads did not count broken specimens individually. Additionally, the recent tally does not include specimens which were found in 2000 or gathered during undocumented during various surface collections in the last three decades. Of the 1843 beads from Fort Vasquez, the majority are blue and white seed beads. The assemblage also contains several Cornaline D'Allepo beads and singular examples of unique forms, some of which do not appear in any of the other assemblages described in this Chapter.

5WL1298 (Biscuit Hill Site). The Biscuit Hill site was originally recorded by the Fort Collins Chapter of the Colorado Archaeological Society. As recorded, the site is a large stone circle site containing more than one hundred stone circles in a protected valley, south of Biscuit Hill in northwestern Weld County, Colorado (Day and Eighmy 1998). Artifacts at the site were sparse and included 14 flakes, one heavily reworked projectile point, one end scraper, and one glass bead.

The single bead from 5WL1298 was recorded from Circle Feature 100, a large but incomplete stone circle. The specimen is currently curated at LOPA. The glass bead from the Biscuit Hill Site was submitted for LA-ICP-MS testing at the IIRMES lab at CSULB.

Charles Lohr Collection. This assemblage was collected by Charles Lohr ca. 1900 from an island created by the South Platte River, near the city of Greeley in Weld County, Colorado. It was subsequently donated to the Greeley Municipal Museum by his son, Edison Lohr, in 1982 (Greely Municipal Museum 1982). Artifacts in the assemblage included two steel “spearheads” and 113 glass beads. Both of the points were heavily corroded although one bore a stamped label reading “Real Steel” and some illegible text, possibly the name of a trade company or manufacturer.

According to museum records, the beads in the Charles Lohr Collection were recovered from ant hills on the site. Local folklore suggests that the locality of collection once served as a popular location for Arapahoe and Cheyenne camps. Although no ethnographic records have been located which support this claim, the prominence of the site as a landmark on the South Platte River and the known occupation of the area by multiple tribes may provide validity to the story.

Weinmeister. The Weinmeister site is named for its discoverer and is located approximately three miles south of the town of Windsor. The site is situated on a finger ridge of a bluff on the south side of the Cache la Poudre River and overlooks a modern housing development to the north. According to Garry Weinmeister (personal communication, 2007), the site was formerly a popular area for children and teenagers to fire rifles in the 1960s and 1970s and the presence of artifacts at the site was not known to him until he revisited the area after obtaining an interest in avocational archaeology as a young adult. During his early visits to the area, Weinmeister noted the presence of glass seed beads in harvester ant mounds that were scattered across the surface of the site.

The author accompanied Garry Weinmeister to the site in fall 2007 to document topography and perform a brief surface inventory of the area. At that time, beads were again observed in ant mounds and a shallow depression was noted in the center of the site. The area was photographed and mapped using a handheld GPS unit. No additional artifact types were found and a high density of rifles casings were noted which would prevent the use of metal detection to locate additional Euroamerican manufactured items.

The Weinmeister site represents one of the largest assemblages analyzed for this study and currently contains 966 glass seed beads. Unlike the majority of glass beads recorded for this thesis, the majority of specimens are very small. A low frequency of larger seed beads may be the product of recycling as Native Americans began to favor and thus acquire smaller beads in the mid- to late 19th century (Conn 1972; Sprague 1985). Therefore, it is hypothesized that the Weinmeister assemblage was assembled over a period of time (likely between 1850 and 1880; see Chapter 3), from multiple locations, that the area was subject to multiple occupations, or the site was occupied later in time. Bead colors include white, dark blue, dark green, black, pink, and yellow. Of these colors, the dark blue, dark green, pink and yellow are rare in the South Platte River Basin. Additionally, several of these colors do not seem to occur archaeologically prior to 1858 (Davis 1973:22-29; see Chapter 3).

When the site was visited in fall 2007, the area was proposed for development and impact and/or destruction of the site was presumed imminent (Garry Weinmeister, personal communication, 2007). Because the land was privately owned, the site was not tested for subsurface cultural deposits. Recent changes in the proposed development will preserve the site. To date, no NRHP eligibility recommendation or Smithsonian site number has been assigned to the site although the surface sediments appear undisturbed and there may be a potential to discover intact subsurface cultural deposits making the site eligible for inclusion to the NRHP.

Six white glass beads from the Weinmeister site were made available for trace element analysis using LA-ICP-MS testing at the IIRMES lab at CSULB.

Yuma County

Westfall C. This site was discovered by the Westfall family of Wray, Colorado. It is located a short distance southwest of the town of Wray, just south of the North Fork of the Republican River in Yuma County (Tom Westfall, personal communication, 2008). The Westfall C Collection contains one large translucent red spherical shaped bead. The specimen is unique in this study and may represent the only example of this bead type in the South Platte River Basin. This specimen was discovered in a plowed field and lacks association with other protohistoric artifacts and features.

Westfall D. This site was discovered by the Westfall family of Wray, Colorado. It is located approximately 15 miles south of the town of Yuma in an area of rolling sand hills (Tom Westfall, personal communication, 2008). The North Fork of the Republican River and the Arikaree River are located approximately 15 miles to the north and south respectively. The Westfall D collection contains 199 glass beads including blue, white, black, Cornaline D'Aleppo specimens. Several of the Cornaline D'Aleppo specimens are extremely small compared to the remainder of the assemblage, possibly suggesting an age or origin that differs from other specimens from the site. These specimens were discovered in a plowed field and lack association with other protohistoric artifacts and features.

Other Sites

A number of additional archaeological glass bead assemblages were not included in this thesis because they were not available for detailed analysis despite having a known provenience. Although each unanalyzed assemblage has the potential to yield information relevant to this study, most lacked adequate provenience data, could not be located in a curation facility or private collection, or have only been documented in the ethnohistoric record. As such, these collections were not included in the current study although there potential research value and relevance to future studies on bead related questions necessitates their inclusion in this thesis.

Unknown Provenience

The first group of assemblages which were not available for analysis included assemblages which lack confirmed provenance. These include the Owl Creek Burial, two assemblages curated at the Fort Collins Museum (i.e., the Marsh Collection and a unnamed strand of black glass beads designated Coffin C), an unnamed collection from the Loveland Museum and the Arapaho Princess Burial.

The Owl Creek Burial was discovered in 1932 by Bob and Eddie Hughes when they chased a coyote into a badger hole in northern Weld County. In the hole, they discovered a human burial containing an abundance of associated funerary objects. The discovery was reported in the *Greeley Daily Tribune* and the *Denver Post*, sparking a public interest in the site that eventually resulted in looting of the burial. Fortunately, prior to destruction of the burial, items from the site were described and photographed by the Hughes' (Ball 1987).

The Owl Creek Burial contained the remains of one individual, likely a male, buried in a seated position with the head approximately one foot beneath the ground surface. The remains were wrapped in a bison robe and the skull of the individual retained some gray hair in braids. Funerary objects were abundant and included a U.S. Cavalry hat, neckerchief, and jacket (with shoulder epaulets) as well as ten silver conchas strung on sinew and hung about the individual's neck. Other goods included parts of a wooden piece pipe with a hexagonal-shaped stone bowl, silver watch chain with an attached heart-shaped medal, a small perfume bottle with a cork, a steel hunting knife, the tongue of a belt buckle, numerous buttons, six corroded flat steel mill files, three corroded triangular steel files, one flint whetstone, several pieces of unspecified corroded steel (possible metal projectile points), pieces of a wooden bow, a pieced of tanned leather (3 x 15 in) with a leather thong (possibly an arrow quiver), pieces of an arrow shaft, some red paint, pieces of a copper bracelet, a diamond-shaped silver clip attached to the hair of the individual, a flat piece of glass (possibly a mirror), many pieces of broken wood poles, and a large stone maul. Beaded items from the site included a knife sheath and a single moccasin. Thousands of scattered blue, white, red, green and black glass seed beads were also noted in and around the burial (Ball 1987).

The Marsh Collection, curated at the Fort Collins Museum, includes 104 blue, dark blue, white, pink, dark green, black, and yellow beads and was discovered in the early 20th Century by Alex M. Marsh (Fort Collins Museum 1976b). The collection was donated to the museum by the Roy G. Coffin in 1976 and is reported to have been collected from an area near Grover, Colorado. To date, however, the exact location of the site is unknown.

Another collection of beads at the Fort Collins museum (designated Coffin C in this study) is reported to have been collected from an area north of the town of Wellington (Fort Collins Museum 1976a). The age of this assemblage is believed to be relatively recent due to the generally excellent condition of the assemblage as well as several odd characteristics such as the presence of only black seed bead and one small black facetted bead which is less than three millimeters in outer diameter. Although these peculiarities do not justify excluding this site from the current study, the general lack of provenience does.

An unnamed assemblage curated at the Loveland Museum consists of a large bag of beads from an unconfirmed location (Jason LaBelle, personal communication 2007). Based upon a literature hunt and "hearsay," it seems likely that the assemblage was discovered in a rock crevice southwest of Loveland, Colorado, by a young man in the late 1930s or early 1940s. The beads were supposedly recovered from the crevice using the aid of a spoon tied to the end of a wooden rod. The assemblage, quantified by student researchers at Colorado State University, contains 17,179 beads (Table 4.2) as well as very small bone fragments.

Table 4. 2. Bead counts from an unnamed assemblage curated at the Loveland Museum.

Color	**Size Grade**	**No. Specimens**	**Mass (Grams)**
Black (Complete)	1	241	0.7
	2	135	9.9
	3	2204	90.4
Black (Incomplete)	1	2	**
	2	2	**
Blue (Complete)	2	2355	67
	3	2	0.1
Blue (Incomplete)	1	141	0.6
	2	9	0.1
Clear/Translucent (Complete)	1	1	**
Red (Complete)	2	20	0.3
Orange (Complete)	2	3	0.2
Red with White Interior (Complete)	2	122	5.8
Red with White Interior (Incomplete)	1	27	0.1
	2	5	**
White (Complete)	1	212	0.7
	2	11547	380
	3	13	1.2
White (Incomplete)	1	99	0.9
	2	39	0.8
Totals		**17179**	**558.8**

**Did not register on scale, too light.

Two additional sites are known from the Loveland, Colorado area. Beads from the Arapaho Princess Burial and Marianna's Butte were brought forth by avocational historian Bill Meirath. The Arapaho Princess burial beads come from the collection of

Harold Dunning, the founder of the Loveland Museum. The small collection, housed on a safety pin, was passed from Dunning to Zethyl Gates (another well-known local historian), who subsequently passed them on to Bill Meirath. The beads are reported to have come from the famous Arapaho Princess Burial. The exact location of the site is unknown at the present time, but believed to be in the hogbacks west of Loveland, Colorado, perhaps in the vicinity of Larimer County Road 29.

Meirath also shared beads recovered from a rockshelter on the side of Mariana's Butte, a prominent landmark in western Loveland. The Butte is a well known historical site and has been recorded as a prehistoric site, although it has been heavily looted over the past 75 years (Jason LaBelle, personal communication 2010). It is not known whether the Marianna Butte beads are modern or not, however Gates (1981:59-60) does note that glass beads have been commonly found in the area surrounding Marianna's Butte and along the Big Thompson River.

Unavailable Assemblages

The second group of assemblages which were not available for analysis included assemblages which could not be located in a curation facility or were unavailable for analysis due to time constraints. These include the assemblages from Lykins Gulch Cave (5BL31), Rollins Pass (5BL148), the Line Shack Draw site (5LR110), 5LR611, the historic battle of Summit Springs (5LO199), Fort St. Vrain (5WL814), several beads from the Harvester site (5LR12641) located on the Larimer County River Bluff Open Space (Jessica Anderson, personal communication 2010), and a single bead discovered during a field trip of the Colorado Archaeological Society along the West Bijou Creek drainage in Arapahoe County, Colorado (5AH4).

A single glass bead of unknown color was recorded in collection from the the Lykins Gulch Cave (5BL31) in 1985 during a re-inventory of that and other sites in Boulder County, Colorado (Pipkens et al. 1989: 21). Despite the name of the site, the occupation area is actually described as a rock overhang sheltered on all but the southern side. Originally excavated by the University of Colorado (Shrader and Campbell 1954 cited in Pipkin et al. 1989), artifacts from the site included square-head iron nails, grey cord-marked pottery fragments, faunal remains, groundstone, chipped stone projectile points, scrapers, utilized flakes, and debitage in addition to a variety of more modern or recent historic materials (i.e. modern nails and rifle shell casings). At the time of this study, the facility where the materials recovered from Lykins Gulch Cave are curated could not be determined; therefore, the glass bead from this site could not be analyzed.

One glass bead was recovered by Byron Olson in his 1960s excavation of game blinds at 5BL148, one of a series of game drives along Rollins Pass (Olson 1971). The site is located adjacent to the Continental Divide, near the intersection of Boulder, Gilpin, and Grand Counties, in alpine tundra. As such, it represents the highest known occurrence of a glass bead in Colorado. The Rollins Pass sites are currently being examined by Colorado State University and the bead is curated at the Laboratory of Public Archaeology (Jason LaBelle, personal communication 2010).

The Line Shack Draw site (5LR110) was originally recorded by the CSU Boxelder Survey in the 1970s. At that time, a series of stone circles were noted, along with a light lithic scatter (Morris et al. 1979). The site was rerecorded by CSU in 2006 and subject to investigation by the CSU field school in 2009. No beads were noted in 2006 or the summer of 2009. However, Charlie Gindler recovered a glass bead from an ant mound during a routine visit to the site in the fall of 2009 (Jason M. LaBelle, personal communication 2010). The ant mound is located adjacent to a very large stone circle on the southern portion of the site. No attempt was made to screen the mound for other beads, but the discovery of a bead in close proximity to a large stone circle was an exciting discovery, much like the bead that was seen at the Biscuit Hill site (5WL1298) in western Weld County.

Site 5LR611 is a multi-component (historic and prehistoric) archaeological site located in Tuxedo Park within the boundaries of Rocky Mountain National Park, west of the town of Estes Park. The site has produced a single blue glass bead, as well as forty pieces of lithic debitage, an edge retouched tool, and a biface basal fragment suspected to be the base of a Clovis point. The historic component of the site included several cabin and shed structures, rock-lined paths, fire rings, an outhouse, and a trash scatter (Brunswig 2005:470).

The Battle of Summit Springs (5LO199) is a historic battle which occurred on July 11, 1869 when a camp of Cheyenne Dog Soldiers and Sioux were attacked by the Fifth Calvary and a Pawnee Battalion. The battle was fought with a disadvantage to the Cheyenne and Sioux as they were not alerted to the presence of enemy forces until it was nearly too late (see Chapter 2). The ensuing melee resulted in the death and/or capture of many Cheyenne and Sioux warriors, women, and children, and following the battle all items remaining in the camp were piled together and burned (Grinnell 1915:310-318).

Dr. Charles Reher (personal communication, 2007) has noted that the actual location of the Summit Springs Battle is on private property and that the land owner has collected a number of artifacts from the site including metal items and blue and white glass trade beads. It is believed that this collection remains with the current or a former land owner, but was not available for this analysis.

A small assemblage of 47 glass beads was reported from excavations at Fort St. Vrain in 1967 by the State Historical Society, the Public Service Company, and Otero Junior College of La Junta, under the direction of Galen Baker (Peterson 1982:45). The excavations took place near a marker of Fort St. Vrain placed by the Daughters of the American Revolution in 1911. The archaeological testing revealed a trash pit containing the beads as well as clay pipe fragments, burned adobe brick, and buffalo bone. Unfortunately, as with the early assemblages excavated from Fort Vasquez, these artifacts were subsequently lost and never fully analyzed. To date, no further extensive testing of the Fort St. Vrain site location has been undertaken and, despite multiple inquires, no collections from the site could be located in private collections or curation facilities.

The River Bluffs Open Space (The Harvester site, 5LR12641) has produced three glass trade beads along with various lithic tools and a significant collection of incised bone beads. The site was discovered by Garry Weinmeister, and the collection is being analyzed by Jessica Anderson (personal communication, 2009) for her Master's project at Colorado State University. The glass bead specimens in this assemblage as well as the original area of discovery are currently under investigation to determine possible age and cultural affiliation of the occupation. With the exception of the prehistoric bone beads recovered from the site, the Harvester site bead assemblage is not significantly unusual, containing only blue and white seed bead specimens.

Site 5AH4 has also produced a single blue glass seed bead. The specimen was discovered by members of the Colorado Archaeological Survey in 2007 as part of a cultural resource survey under the direction of Jon Kent (Neil Hauser, personal communication, 2008). As originally recorded, 5AH4 yielded only prehistoric cultural remains. The discovery of the single bead specimen suggests multiple occupations dating from at least the Middle Archaic through the Protohistoric Period. This site is typical of many of the South Platte River Basin sites as it is located along a significant tributary of the South Platte River and consists of a very small bead sample.

Historic Forts Lacking Provenience and Associated Artifacts

Another pair of assemblages which could not be included in this analysis and which do not fall under the category of unknown provenance and lacking artifacts available for analysis are the historic fur trade era forts, Fort Lupton (5WL849) and Fort Jackson (5WL816). These forts, located along the South Platte River and discussed in Chapter 2 have the potential to produce glass trade beads although none have been conclusively documented with the exception of a single bead specimen which was recovered in the presumed immediate vicinity of Fort Jackson (Cody Newton, personal communication, June 2009). This current lack of information is due largely in part to the limited nature of archaeological work conducted at the sites.

Information regarding archaeological investigations of Fort Lupton is provided by the Colorado State Historic Preservation Office site form. According to these records, portions of one or more of the original adobe walls which comprised the fort remain intact as a result of preservation by Ewing Ranch and the South Platte Valley Historical Society. These remnants represent the only known remnants of the four fur trade forts constructed along the South Platte River in the 1830s.

Steele (1982) reported that these wall remnants of Fort Lupton were moved during the construction of an oil well as part of the Colorado Front Range oil boom of the 1960s and 1970s. The remnants are hypothesized by Steele (1982) to be the actual location of the fort. Richard F. Carrillo et al. (1991, 1994) tested the locality as part of the Fort Lupton Historic Site Testing Project. This particular investigation of the site included the excavation of 15 test units and 18 exploratory backhoe trenches. Although several of the test units and trenches produced cultural materials, researchers concluded that none of the tested areas could be placed temporally with the occupation of Fort Lupton.

Despite the lack of discovery by Carrillo et al. (1991, 1994), further work at the site including analysis of historic photographs and aerial photos determined a probable location for Fort Lupton to the north of the previously tested areas (McKibbin and Carrillo (2006). To date, there is no record of testing in the area identified by MiKibbin and Carrillo (2006), however, it seems likely that ground penetrating radar, test excavation, or further trenching may produce evidence of Fort Lupton in the form of structures and/or artifacts including glass trade beads.

Archaeological investigations at Fort Jackson have been less fruitful than those at Fort Lupton for two reasons. First, Fort Jackson was only in operation for approximately a year before failing and is reported to have been in poor condition as early as 1842 by

Rufus B. Sage (1957 cited in Hafen 1925). Second, as a result of Fort Jackson's quick deterioration and lack of interest in the fort by area residents, the actual location of the fort remains in question.

Hafen (1925:340) claimed to have located Fort Jackson in the form of a buried adobe foundation atop a slight rise exhibiting a variation in soil texture. Hafen's (1925) description of the site differs from ethnohistoric accounts which claim that this fort was constructed of wood, thus explaining its deteriorated state in 1842 (Sage 1957). Although Hafen's (1925) discovery may be legitimate, the location of Fort Jackson remains in question although current investigations of the presumed fort location, based on Hafen's notes, have revealed a single glass bead and an 'area of interest' that may be the actual fort location (Cody Newton, personal communication, June 2009). Although Fort Jackson was only in operation for a short time and may be considered one of the less prominent forts along the South Platter River, future work at the site has the potential to produce new information as well as confirm the presence of Euroamerican trade goods, particularly glass trade beads.

Summary

The abundance and diversity of the bead sites/assemblages occurring in the South Platte River Basin as described above is neither rare nor unique to Colorado and its surrounding region. It is clear that glass beads can occur in a number of contexts and likely have a number of origins. The time and energy necessary to compile such a list has proven rather surprising. Currently the majority of glass bead sites reported to the Colorado Office of Archaeology and Historic Preservation (OAHP) remains low. It is not completely clear if these issues are the result of accidental omissions or dismissal of beads as insignificant sources of temporal insight. Whatever the reason, beads are a dominant artifact type of the protohistoric period and often represent the only artifact type recovered from such sites.

The following chapter presents a statistical analysis of the beads discussed in this chapter which were available for morphological and/or chemical analysis. I contend that the results of the statistical analysis will show that bead characteristics are useful tools for estimating the age of beads in an undated context and this analysis will help stimulate more detailed recordation of such specimens when encountered during archaeological investigations in field and laboratory settings.

CHAPTER 5: STATISTICAL ANALYSIS OF BEAD CHARACTERISTICS

In this chapter I will quantify and statistically analyze the assemblages of glass beads currently available for study in the South Platte River Basin. The goal of this analysis is to identify patterns within and between assemblages which will assist in developing a regression model for determining the age of undated bead assemblages. Independently dated archaeological examples (i.e., Lykins Valley, Fort Vasquez, and Weinmeister) will be used to establish a baseline chronology for changes in morphology and chemistry of glass beads through time (see Chapters 3 and 4). Using this baseline, it is anticipated that the characteristics of undated bead assemblages will fall within a continuum of changing bead characteristics through time.

A total of 4415 glass trade beads from 24 archaeological sites in the South Platte River Basin were macroscopically analyzed during the course of this thesis. Documented characteristics (as outlined in Chapter 3) were coded and entered into a spreadsheet for analysis using SPSS. Of these specimens, 222 glass beads from 11 sites were analyzed for LA-ICP-MS trace chemical analysis. Statistical tests were performed on the dataset to determine if specific morphological attributes or chemical trace elements were significant within and between sites and/or assemblages. Additionally, attempts were made to identify any traits which may hold chronological significance and allow the development of a model for determining the age of one or more archaeological glass beads in an undated context. Statistical analyses performed included descriptive statistics, Independent Samples t-Tests, Tests of Correlation, and, for the development of dating models, Linear Regression. The findings of these tests are provided in the following pages with morphological discussions being followed by a discussion of trace elements. Figure 5.1 provides a flow chart explaining the process of statistical analysis described in the following pages.

Descriptive Analysis of Morphology

Descriptive analyses were used to identify which morphological characteristics occurred in the highest frequencies and which could act as grouping variables in later statistical tests. As shown in Table 5.1, beads with a torus shape and manufactured using the drawn technique (i.e., seed beads) are the dominate bead type in the South Platte River Basin. Beads with complete portions are also common in the total sample; however, bead portion may be attributable to post-depositional taphonomic effects unrelated to cultural activities.

Because drawn, torus beads are the predominate bead type in the study sample and appear to be the most common type of bead recovered from archaeological sites, descriptive analysis of their dimensions was conducted independent of all non-drawn, non-torus beads. Site and/or assemblage names were used to group the drawn, torus beads for descriptive analysis of dimension, the results of which are reported in Table 5.2 and Figure 5.2.

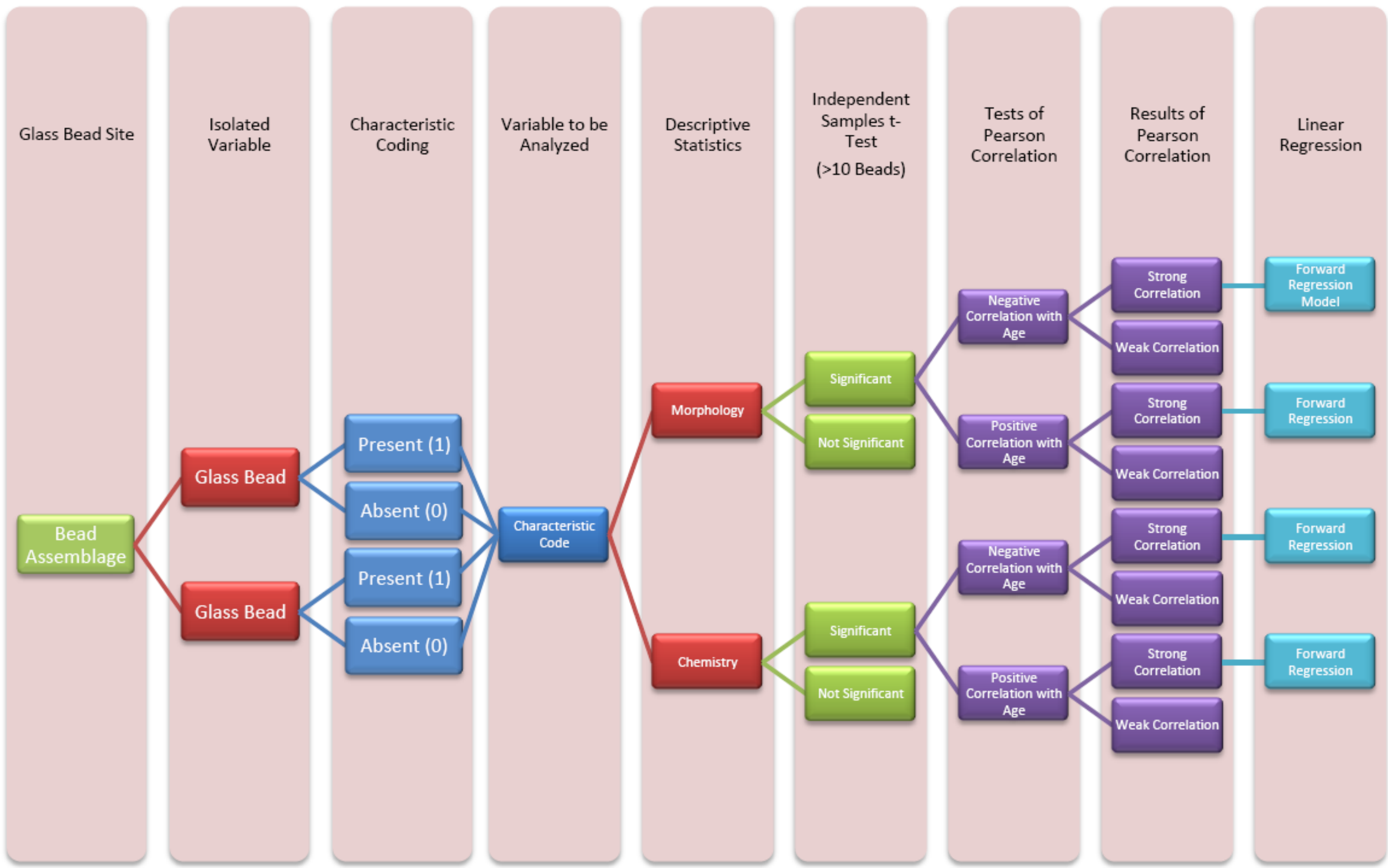

Figure 5. 1. Flow chart describing the process of statistical analysis used in this Chapter. Note that each bead assemblage (Column 1) will be considered as an initial grouping variable with individuals beads (Column 2) analyzed independently for coding purposes (Column 3).

Table 5. 1. Frequency counts and percentage totals for all beads analyzed for morphological characteristics in the South Platte River Basin.

Characteristic	Description	N	%
Portion	Complete	4392	99.5
	Incomplete	23	0.5
Manufacture	Drawn	4321	97.9
	Wound	93	2.1
Shape	Torus	4306	97.5
	Tube	8	0.2
	Oval	8	0.2
	Facetted	3	0.1
	Cube	1	0.0
	Sphere	89	2.0
Luster	Dull	3639	82.5
	Shiny	771	17.5
Diaphaneity	Translucent	744	16.9
	Opaque	3671	83.1
		5	0.1
Exterior Color	Yellow	5	0.1
	White	2579	58.4
	Violet	1	0.0
	Royal Blue	1	0.0
	Red	92	2.1
	Pink	38	0.9
	Orange	2	0.0
	Greyish Blue	4	0.1
	Greenish Blue	56	1.3
	Green	21	0.5
	Dark Violet	1	0.0
	Dark Green	10	0.2
	Dark Blue	378	8.6
	Bluish Green	47	1.1
	Blue	1084	24.6
	Black	95	2.2

The descriptive data for bead dimension in dated archaeological contexts suggests that bead size decreases through time with older beads being larger than more recent specimens. These results are misleading; however, as 15 of the 21sites containing seed beads have a mean diameter greater than the oldest

Table 5. 2. Descriptive analysis for drawn, torus beads in the South Platte River Basin with site name used as the grouping variable.

Site Name	Variable	N	Mean	Std. Deviation	Std. Error Mean
5DA268	Outer Diameter	11	3.12	0.25	0.08
	Length	11	2.32	0.19	0.06
5EP750	Outer Diameter	50	2.19	0.22	0.03
	Length*	50			
5LR11724	Outer Diameter	2	3.03	0.27	0.14
	Length	2	2.23	0.92	0.65
5LR11726	Outer Diameter	4	3.17	0.27	0.14
	Length	4	2.16	0.18	0.09
5LR11819	Outer Diameter	2	3.31	0.50	0.36
	Length	2	2.57	0.33	0.24
5LR11838	Outer Diameter	1	5.39		
	Length	1	4.31		
5LR261	Outer Diameter	1	2.48		
	Length	1	1.48		
5LR53	Outer Diameter	22	2.88	0.42	0.09
	Length	22	2.16	0.39	0.08
Arapahoe Princess	Outer Diameter	26	3.52	0.36	0.07
	Length	26	2.55	0.42	0.08
Biscuit Hill	Outer Diameter	1	2.34		
	Length	1	1.59		
CAS Denver	Outer Diameter	1	3.00		
	Length	1	2.20		
Charles Lohr	Outer Diameter	113	2.98	0.62	0.06
	Length	113	2.27	0.87	0.08
Coffin A	Outer Diameter	128	2.89	0.46	0.04
	Length	128	2.00	0.41	0.04
Coffin B	Outer Diameter	275	3.09	0.33	0.02
	Length	275	2.18	0.35	0.02
Comanche Creek	Outer Diameter	13	3.37	0.22	0.06
	Length	2	2.15	0.44	0.31
Fort Vasquez	Outer Diameter	1727	2.41	0.38	0.01
	Length	1727	1.81	0.43	0.01
Lykins Valley	Outer Diameter	427	2.68	0.42	0.02
	Length	427	1.94	0.41	0.02
Macon Street	Outer Diameter	121	2.94	0.29	0.03
	Length	121	2.08	0.34	0.03
Weinmeister	Outer Diameter	966	1.72	0.15	0.00
	Length	935	1.16	0.18	0.01
Westfall A	Outer Diameter	172	1.95	0.39	0.03
	Length	1	2.2		
Westfall B	Outer Diameter	5	4.04	0.57	0.26
	Length	5	2.86	0.44	0.20
Westfall C	Outer Diameter	1	11.5		
	Length	1	10.5		
Westfall D	Outer Diameter	199	3.11	0.40	0.03
	Length*	199			
Westfall E	Outer Diameter	1	5.11		
	Length	1	4.06		

*Data could not be collected due to curation issues.

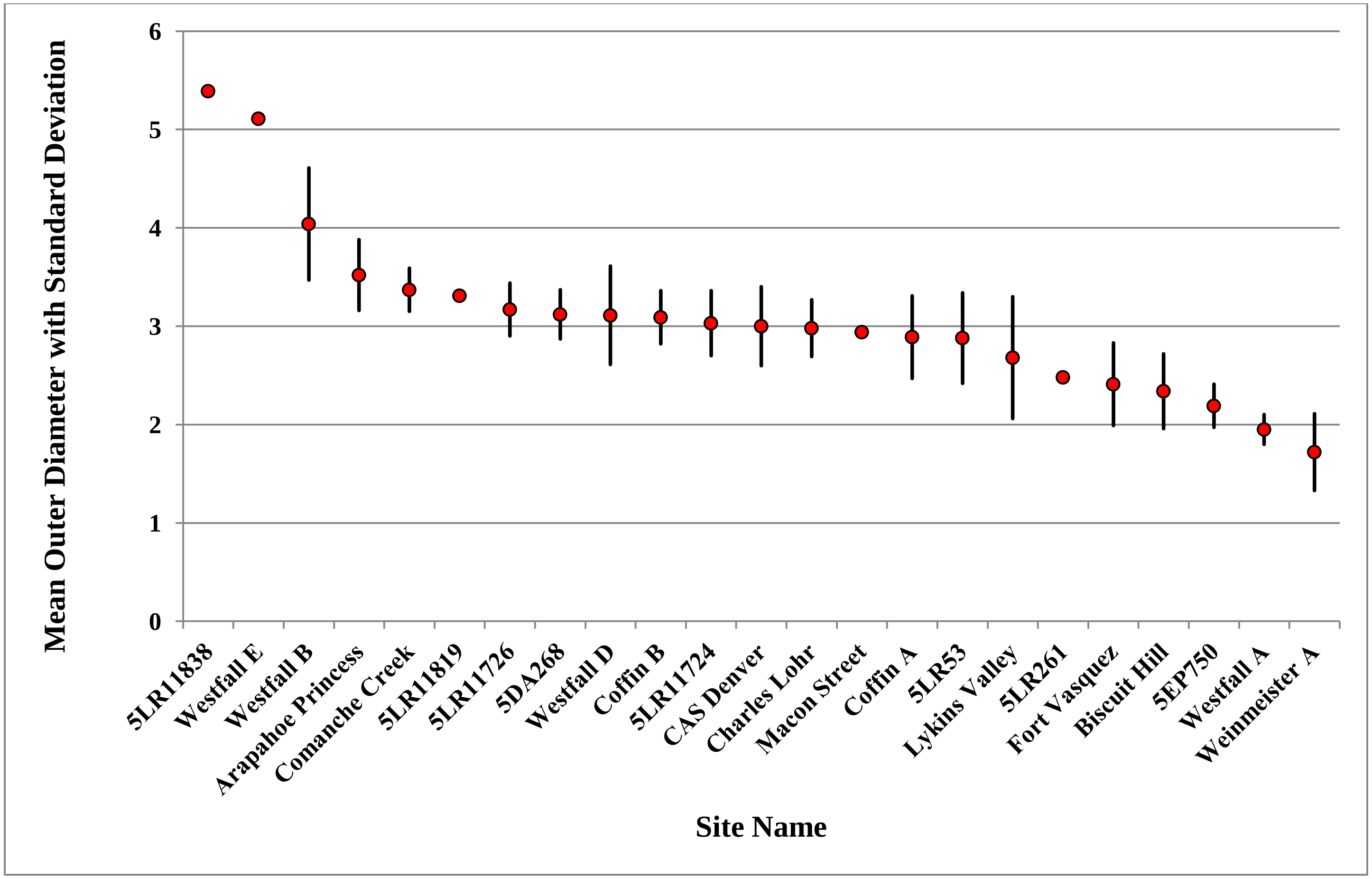

Figure 5. 2. Plot of mean outer diameter and for drawn, torus beads in the South Platte River Basin. This single bead from Westfall C is omitted because of its irregularly large size and overall inconsistency with other drawn, torus beads in this study.

independently dated site in the region, Lykins Valley, whose mean diameter for seed beads is 2.68±0.42. This difference would suggest that 69.5% of all sites in the South Platte River Basin date prior to the start of the Trading Post Phase. This conclusion is problematic as several of these undated sites/assemblages contain an abundance of Euroamerican trade items that are most likely representative of direct contact with Euroamerican groups operating at or out of trade forts. Furthermore, it is important to recognize that Native American groups using glass beads during the Indirect, Transitional, and Direct Contact Phases may have intentionally sorted beads prior to use after they were acquired from Euroamerican traders. If this is the case, it is possible that size may be a cultural factor which has yet to be accounted for in archaeological glass bead studies.

Glass bead color, particularly red beads with white interiors (i.e. Cornaline D'Allepo beads) or blue facetted beads with blue interiors (i.e. Hudson Bay Facetted beads), may be more indicative of manufacture date. It is unfortunate that these types of beads are relatively uncommon in the South Platte River Basin and can only be given approximate ages using seriation studies from other regions such as the northern Great Plains (Davis 1973), the Carribean (Karklins and Barka 1989), and the Southeastern United States (Brain 1979). Because these studies are from other regions and often predate the estimated arrival of beads and other trade goods in the South Platte River Basin, they should be used as a guideline for estimating assemblage age within an appropriate historical context.

Independent Samples t-Tests of Morphology

Independent Samples t-Tests were used to compare sites/assemblages with more than 10 beads with all other beads sampled on morphological characteristics. These tests were intended to identify any variables which were significantly unique to each assemblage or which could be used to determine if beads from different sites/assemblages could have originated from a single population.

As suspected, t-Test results showed that sites with larger assemblages generally had significant results ($p<0.05$ or $p<0.01$, Equal variance not assumed) for a greater number of morphological traits than smaller assemblages, indicating that variability within assemblages increased with sample size (Appendix A). Smaller assemblages normally produced significant values ($p<0.05$ or $p<0.01$, Equal variance not assumed) for color and diaphaneity only. This suggests that the assemblages in this study are unique to one another and are most likely unrelated (i.e., beads are not from the same population and did not originate from the source) based on morphological characteristics.

Tests of Correlation for Morphology

Tests of Correlation were used to determine if morphological characteristics of beads were related to age and to identify which morphological features might be useful in developing a regression formula which could be used to estimate age for assemblages currently lacking adequate dates. This is achieved using the Pearson Correlation which measures the strength and direction of the linear relationship between two variables. For the current sample, it is predicted that morphological characteristics such as bead size will have a negative correlation with bead age as younger assemblages tend to have smaller average diameters and lengths. Positive correlations are difficult to anticipate although the variation in the colors observed between assemblages suggest that unique bead colors such as dark green, dark blue, pink, and black may fall within this category.

Table 5.3 displays the results of the Pearson Correlation of morphological variables and mean bead age. The left column reports correlations which display modestly strong and statistically significant negative association between bead features and mean bead age. The right column reports correlations which display modestly strong and statistically significant positive association between bead features and mean bead age. As predicted, bead size is negatively correlated with age with unique bead colors displaying a positive correlation. This confirms the findings of Scheiber and Reher (1994) and Reher and Scheiber (1995) who concluded that bead size decreases through time and is, therefore, a suitable proxy for estimating bead age. It is suspected the increased appearance of new although still relatively rare glass bead colors explains the weaker but still relatively significant negative Pearson correlation produced for the most

Table 5.3. Results of the Pearson Correlation of morphological characteristics and mean bead age.

Negative Correlation		**Positive Correlation**	
Characteristic	**r-value**	**Characteristic**	**r-value**
Outer Diameter	-0.408**	Drawn	0.043*
Length	-0.254**	Torus	0.052**
Wound	-0.043*	Shiny	0.092**
Spherical	-0.039*	Transparent	0.303**
Dull	-0.092**	Red	0.520**
Opaque	-0.303**	Pink	0.076**
White	-0.177**	Dark Green	0.045**
Greyish Blue	-0.048**	Dark Blue	0.273**
Greenish Blue	-0.096**	Black	0.132**
Blue	-0.154**		

*p=<0.05, **p=<0.01

common bead colors, white and blue. These results are used to assist in the development of a regression model based solely upon morphological traits.

Linear Regression of Morphology

It is logical that morphological bead traits which correlate most strongly with age provide the best point from which to begin the development of a regression model for age. Therefore, the variables of outer diameter, length, translucent and opaque diaphaneity, and the colors red, white, and dark blue were suspected to produce the most accurate regression models. Problematically, interval-ratio data is provided only by bead size with all other variables represented as ordinal data. In order to account for this issue, bead size was included in each attempt at regression with other variables being added or removed in attempts to increase R- and R squared-values. The use of forward regression proved to be the most effective method for increasing the previously mentioned values. The following paragraphs provide the four-, three-, two-, and one variable solutions for determining bead age using morphological characteristics of *all* beads with the greatest R- and R-squared values as reported by the SPSS output.

Four-Variable Model

Estimated Age = 1897.957 + Outer Diameter (-18.125) + Spherical (95.670) + Opaque (-16.642) + Blue (-8.546)

R = .715, R Squared = .511

Three-Variable Model

Estimate Age = 1898.018 + Outer Diameter (-19.781) + Spherical (104.858) + Opaque (-14.127)

R = .695, R Squared = .482

Two-Variable Model

Estimated Age = 1894.308 + Outer Diameter (-23.297) + Spherical (121.151)

R = .641, R Squared = .410

One Variable Model

Estimated Age = 1873.534 + Outer Diameter (-13.863)

R = .499, R Squared = .249

When the above regression models are applied to mean assemblage characteristics of known and unknown ages, acceptable estimated dates are acquired (see Chapter 6) although it is acknowledged that some results may not be accurate as the data was greatly skewed due to the increased frequency of torus-shaped beads (the dominate bead shape in the sample) and significantly low frequency of non-torus-shaped beads. Based upon this observation, additional forward regression tests were used to determine if the removal of non-torus-shaped beads from the tests could enhance the R- and R Squared-Values and the accuracy of the final regression formula. The results for four- through one-variable models for torus-shaped beads are as follows.

Four-Variable Model

Estimated Age = 1886.959 + Outer Diameter (-20.539) + Translucent (15.201) + Blue (-8.042) + Greenish-Blue (-13.102)

R = .737, R Squared = .543

Three-Variable Model

Estimate Age = 1887.233 + Outer Diameter (-20.774) + Translucent (15.184) + Blue (-7.742)

R = .732, R Squared = .536

Two-Variable Model

Estimated Age = 1890.231 + Outer Diameter (-22.569) + Translucent (12.755)

R = .716, R Squared = .513

One Variable Model

Estimated Age = 1900.828 + Outer Diameter (-26.290)

R = .675, R Squared = .456

By applying forward regression to only torus-shaped beads, the accuracy of the results increases. This indicates that isolation of torus-shaped beads from all other bead types increase the accuracy of estimated age. Additional tests were applied to non-torus-shaped beads with unsuccessful results as all calculations produced negative correlations with the constant value in each model and regularly resulted in estimated ages within the Indirect Contact Phase, a time in which significant frequencies of glass bead sites and assemblages were not likely in the South Platte River Basin based upon known historical literature and archaeological timelines for trade patterns which would have brought trade items into the area.

Descriptive Analysis of Chemistry

Only torus-shaped beads were submitted for LA-ICP-MS testing. Descriptive analyses were used to identify which chemical trace elements occurred in the highest frequencies and which could act as grouping variables in later statistical tests. As shown in Appendix B and summarized in Table 5.4, only white, blue, grayish-blue, and greenish-blue beads were included in this analysis. Blue beads (N=141) of various

Table 5. 4. Summary of glass beads from the study area tested using LA-ICP-MS analysis.

Site Number/Name	Bead Color	Count	Total
5DA268	Blue White	1 1	2
5LR53	Blue White	1 1	2
5LR261	Blue	1	1
5LR263 – Lykins Valley	Blue White Greenish-blue Grayish-blue	47 30 20 3	100
5LR11724	Blue White	2 1	3
5LR11726	Blue Grayish-blue	2 1	3
5LR11819	Blue White	2 1	3
5LR11838	Blue	1	1
5WL568 – Fort Vasquez	Blue White Bluish-green	48 40 12	100
5WL1298 – Biscuit Hill	Blue	1	1
Weinmeister Collection	White	6	6
Total		222	222

shades were selected in an attempt to replicate the results of previous studies (see Hancock et al. 1994; Kenyon et al. 1995; Hancock et al. 1996; Billeck and Dussubieux 2005) and to determine if slight differences in color are chemical in origin or simply the product of taphonomic processes. White beads (N=81) were selected for their universally recognized color and because they represent the most common bead type in the study sample, representing 58.4% of all beads included in this thesis.

The descriptive data for bead chemistry in dated archaeological contexts suggests that chemical contents vary widely in older sites and become more homogeneous as age decreases. It is possible that this is a reflection of refinements in bead manufacturing techniques throughout the 19th century although this is only hypothetical. It is likely that any improvement to or refinements in 19th century bead manufacture would have emphasized a reduction in glass impurities and increased control of chemical additives. Based upon these results it seems likely that sites with larger assemblages available for LA-ICP-MS analysis will have the greatest potential to add to the development of a temporal model based on trace element contents. It is also possible that the division of data by color could enhance the accuracy of a temporal model since the presence/absence of color additives in the manufacturing process may skew any data that is cumulatively analyzed.

Independent Samples t-Test of Chemistry

Independent Samples t-Tests were used to compare sites/assemblages with more than five beads to all other beads sampled on chemical trace element counts. These tests were intended to identify any variables which were significantly unique to each assemblage or which could be used to determine if beads from different sites/assemblages could have originated from a single population. The results of Independent Samples t-Tests are presented in Appendix C and are discussed below. It should be noted that the only sites meeting the criteria for Independent Samples t-Tests were sites with pre-established dates. Problems presented by this scenario are discussed in the Chapter 6.

As suspected, t-Test results showed that two of three sites tested using LA-ICP-MS methods generally produced significant results ($p<0.05$ or $p<0.01$, Equal variance not assumed). Most noticeably, Fort Vasquez, the site with the greatest overall number of archaeological glass beads as well as beads submitted for trace element analysis, revealed 34 trace elements which produced significant values as a result of t-Tests. It is suspected that an even greater number of variables from the Weinmeister site have potential for producing significant results although this site lacked blue beads (i.e., blue beads from the Weinmeister site were dark blue as opposed to blue) and funding prevented the testing of a sample size of white bead specimens equivalent to Lykins Valley and Fort Vasquez. Furthermore, the data from the Weinmeister site may be additionally skewed as the result of a bead size. As previously mentioned, it is suspected that the Weinmeister site contains a population of larger beads which may have been recycled from an earlier period. Because 50% of the submitted specimens from the site are small seed beads and the remainder are larger seed beads, it is possible that the data should be split to reflect the any differences and determine if the Weinmeister assemblage is actually a reflection of recycling or if the visual difference in size is coincidental. Unfortunately investigation of this topic is beyond the scope of this thesis.

Tests of Correlation of Chemistry

Tests of Correlation were used to determine if trace element counts of beads were related to age and to identify which elements might be useful in developing a regression formula which could be used to estimate age for assemblages currently lacking adequate dates. This analysis is achieved using the Pearson Correlation which is described earlier in this chapter. For the current sample, it is unclear if chemicals will correlate positively or negatively with age although it is it assumed that chemical impurities which would be reduced through time with improvement in glass making will have a strong and identifiable negative correlation as was the case with the morphological characteristic of outer diameter.

Table 5.5 displays the results of the Pearson Correlation of chemical trace elements counts and mean bead age. Unlike the correlation results for morphology, nearly all trace elements reflect a negative correlation with age. The predictions for calcium, aluminum, and titanium proved incorrect and only arsenic produced the predicted positive correlation. High R-value elements with negative correlation with age included magnesium, silicon, titanium, zirconium, and hafnium while high R-value elements with positive correlation with age included arsenic and lead. As such, it is suspected that the results in Table 5.3 reflect changes and, perhaps, refinements to glass manufacture in the 19th Century. The discovery of methods to remove impurities and the discovery of chemical additives to enhance glass durability, color, and homogeneity are likely explanations for the observed results. Further investigation of glass making technology during the last centuries may confirm these hypotheses are beyond the scope of this thesis.

Table 5. 5. Results of the Pearson Correlation of chemical trace element counts (ppm) and mean bead age.

Characteristic	r-value	Characteristic	r-value
Sodium	-0.257**	Niobium	-0.220**
Magnesium	-0.371**	Barium	-0.176*
Aluminum	-0.262**	Cerium	-0.148*
Silicon	-0.294**	Praseodymium	-0.148*
Potassium	-0.218**	Samarium	-0.149*
Calcium	-0.253**	Europium	-0.141*
Scandium	-0.186**	Terbium	-0.146*
Titanium	-0.303**	Dysprosium	-0.168*
Chromium	0.188**	Ytterbium	-0.167*
Manganese	-0.154**	Actinium	-0.271*
Nickel	-0.240**	Hafnium	-0.350**
Cobalt	-0.297**	Tantalum	-0.257**
Arsenic	0.344**	Lead	0.335**
Zirconium	-0.322**		

*p=<0.05, **p=<0.01

Linear Regression of Chemistry

Like morphological traits, chemical trace elements which correlate most strongly with age are assumed to provide the best point from which to begin the development of a regression model for age. Therefore, magnesium, arsenic, zirconium, hafnium, and lead are suspected to produce the most accurate regression models. Unlike morphology, all chemical data analyzed was interval-ratio. Despite this difference, forward regression continued to generate formulas for estimated age. The following paragraphs provide the four-, three-, two-, and one variable solutions for determining bead age using chemical trace element counts of all LA-ICP-MS tested beads with the greatest R- and R-squared values as reported by the SPSS output.

Four-Variable Model

Estimated Age = 1828.262 + Magnesium (-.005) + Manganese (-.014) + Strontium (.066) + Actinium (-59.547)

R = .527, R Squared = .278

Three-Variable Model

Estimate Age = 1831.265 + Magnesium (-.004) + Manganese (-.011) + Strontium (.039)

R = .497, R Squared = .247

Two-Variable Model

Estimated Age = 1834.424 + Magnesium (-.003) + Manganese (-.015)

R = .460, R Squared = .212

One-Variable Model

Estimated Age = 1829.303 + Magnesium (-.003)

R = .371, R Squared = .138

When the above regression models are applied to mean assemblage characteristics of known and unknown ages, calculated estimated ages appear to be somewhat inconsistent from those ages produced using morphology (see Table 6.1) although it is acknowledged that some results may not be accurate as the data was greatly skewed due to the use of many variables which correlate negatively with age. In order for the proper formation of a viable regression formula, positive and negative correlations must exist in order to allow the estimated age to move closer and further from the constant and permit increased computational accuracy. In an attempt to increase the accuracy of the model and provide the necessary opposing correlations, additional forward regression models were calculated with the dataset being split by bead color. The resulting regression formulas showed favorable opposing values as well as increased R- and R Squared Values, thereby increasing the accuracy of the final regression formula. These results present problems as they exclude certain sites from inclusion in the final regression formula. When only blue beads are considered the latest of the dated sites in this study, Weinmeister, is excluded. In the case of white beads, three undated sites are excluded.

Although neither the exclusion of white or blue beads presents results which can be applied to all sites in this study the four variable results for each category produce significantly higher R- and R-Squared Values. The resulting four-variable models for blue and white colored beads are as follows.

Four-Variable Model (Blue Beads)

Estimated Age = 1804.526 + Actinium (-178.557) + Antimony (0.001) + Uranium (11.089) + Cobalt (-0.329)

R = .692, R Squared = .478

Four-Variable Model (White Beads)

Estimated Age = 1843.966 + Tin (0.174) + Uranium (8.774) +
Copper (0.009) + Ytterbium (-10.896)

R = .708, R Squared = .501

Although the split data results for blue beads show a marked increase in accuracy they one of the independently dated sites, Weinmeister, is excluded from the analysis. When the tests were attempted using only white-colored beads which occur at all of the independently dated sites, accuracy increases, thus indicating the omission of Weinmeister from the regression has a negative impact to the overall results. It is important to note that more independently dated sites will need to be included in the overall dataset before a completely acceptable dating method can be developed using chemical trace elements.

Summary

The preceding pages have introduced descriptive statistics, correlation tests, and linear regression models for estimating the age of archaeological glass trade beads in the South Platte River Basin. The data shows that strong correlations exist between both morphology and chemical content and estimated bead age, indicating a distinct possibility that glass beads in dated contexts can be used to estimate the age of beads in undated contexts. Linear regression models and their associate R- and R-Squared Values suggest that bead morphology, particularly within populations of torus-shaped beads is a more valid predictor of age than that of chemistry, regardless of attempts to split the chemical dataset or limit the parameters of the associated regression.

The following chapter provides a more detailed discussion of the results of the statistical findings and also addresses the possibility of integrating morphological and chemical datasets to increase the accuracy of age estimates using linear regression.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

The results of the current study indicate that it is possible to estimate the age of undated archaeological glass bead sites/assemblages using morphological or chemical analytical methods. The former of the two methods appears to be more accurate although the analytical costs involved with this approach – time and effort involved in obtaining the necessary quantitative data – are prohibitive. The latter method appears to produce less reliable statistical results although chemical analysis using LA-ICP-MS is less costly and quickly acquired. Because each method has its advantages, this chapter will present a more detailed discussion of the results. Further, this chapter provide answers to the questions presented in the introductory chapter of this thesis, and conveys the overall finding and conclusions of this research project.

Discussion of Morphological Analysis

I began this thesis with a series of questions. First, is it possible to use morphological patterns in dated archaeological glass trade bead sites/assemblages in order to establish a technique for dating beads (i.e. a statistical regression model) from undated contexts? Based upon the high R- and R-Squared Values produced by the regression formula developed for morphological characteristics of all beads and beads with torus shapes, I conclude that bead morphology *is* a viable tool for estimating bead age. Although some of the estimated dates appearing in Table 6.1 are earlier than anticipated (i.e., seed beads with actual dates believed to post-date 1840 based on the presence of Cornaline D'Allepo specimens), these dates are not typically more than 15-20 years earlier than anticipated and may simply be the result of bead recycling in which a small sample of newer bead styles are were being incorporated OR are incorporated into existing, but older, assemblages over time.

Table 6.1 demonstrates, as expected, accurate dates have been projected for each of the three dated archaeological sites in this thesis (i.e., Lykins Valley, Fort Vasquez, and Weinmeister). The estimated ages derived from morphology for undated bead assemblages appear to peak in frequency just before the Trading Post Phase (AD 1833-1850) with 10-11 sites; the frequency steadily declines throughout the Trading Post Phase and later. While this peak in frequency was expected to occur during or just after the Trading Post Phase, it is not unreasonable that regional Native American interest in beads waned with the introduction of trading posts offering a wider and more appealing variety of merchandise. Perhaps more likely, the data collected for glass beads in the South Platte River Basin is a reflection of earlier sites and that unavailable data from later sites has generated results which are skewed to produce similarly earlier dates. Sites 5LR261, 5LR11724, 5LR11726, and 5LR11819, for example, received estimated dates of 1828/1828, 1821/1819, 1820/1818, and 1816/1814, respectively. These dates are acceptable as they are all located within the same valley as the Lykins Valley site(estimated age of 1829/1828) and may reflect the seasonal use of the area by Native American groups, perhaps as a winter campsite.

Assemblages Coffin A and Coffin B are estimated at 1827/1825 and 1818/1817 respectively and are assumed to be contemporaneous with one or all of the sites located

Table 6. 1. Estimated ages for all analyzed glass bead sites. Age estimates are calculated from four-variable regression models presented in Chapter 5.

Site/Assemblage Name	Actual (Calendar) Date	Estimated Age Derived from Proposed Regression Formulas: Morphology (All)	Morphology (Torus)	Chemistry (All)	Chemistry (Blue)	Chemistry (White)	Morphology/ Chemistry (Torus and White)
Comanche Creek (5AM32)		1812	1809				
Macon Street Burial		1832	1830				
5DA268		1820	1818	1823	1822	1868	1859
5EP750	1959	1841	1841				
5LR53		1822	1821	1828	1828	1847	1845
5LR261		1828	1828	1793	1759		
Lykins Valley (5LR263)	1780-1830	1829	1828	1824	1820	1845	1847
5LR11724		1821	1819	1823	1803	1843	1847
5LR11726	Post 1840	1820	1818	1817	1839		
5LR11819		1816	1814	1819	1835	1907*	1893
5LR11838		1775	1768	1808	1737		
Coffin A	Post 1840	1827	1825				
Coffin B		1818	1817				
Westfall A		1852	1852				
Westfall B	Post 1840	1811	1807				
Westfall C		1769					
Westfall D	Post 1840	1824	1822				
Westfall E		1789					
Fort Vasquez (5WL568)	1835-1842	1840	1835	1832	1840	1858	1854
Biscuit Hill (5WL1298)		1830	1831	1807	1798		
Charles Lohr	Post 1840	1830	1829				
Weinmeister	1850-1880	1857	1858	1824		1868	1874
Rollins Pass (5BL148)		1847	1850				
5AH4		1818	1833				
Arapahoe Princess	Post 1840	1820	1817				

*Estimated age falls within a recent historic period and is unlikely related to protohistoric Native American material culture.

Historic Phases:

- Indirect Contact Phase (AD 1540-1802)
- Transitional Contact Phase (AD 1803-1820)
- Direct Contact Phase (AD 1821-1832)
- Trading Post Phase (AD 1833-1850)
- Expansion and Conflict Phase (1851-1869)
- Native American Relocation Phase (AD 1869-1880)

near Lykins Valley. The estimated ages for beads from the Macon Street Burial, 5DA268, Biscuit Hill, and Charles Lohr site date to the 1830s and possibly represent some of the earliest beads to have been acquired from trade forts located in or near the South Platte River Basin. Although this age estimate cannot be determined with any great certainty, the metal arrow point from the Charles Lohr site is stamped with what may be the name of a trade post or trading company, thus indicating the bead assemblage may have been acquired from a fixed topographical location (i.e, a trading post) and not the result of indirect acquisition.

Two significant issues are apparent when reviewing the estimated ages for morphology presented in Table 6.1. The first issue is the relatively young ages calculated for 5EP750 (a site thought to date to 1959), 5LR11838 (a historic homestead), Westfall C, and Westfall E. It is suspected that results for each of these assemblages are erroneous because the beads from them are unique; each contain one or multiple atypical beads types which were not present at any other site reported in the South Platte River Basin. The second issue arising in this study concerns sites containing Cornaline D'Allepo beads. Davis (1973) has suggested that these types of beads do not occur in the Great Plains prior to the 1840s (Baker et al. 2007). The estimated ages presented in Table 6.1 for sites containing Cornaline D'Allepo beads date prior to 1830. This result suggests that Cornaline D'Allepo may have reached the South Platte River Basin earlier than other regions of the Great Plains or that the proposed morphological regression models are not yet as accurate as bead seriation dating techniques that rely upon bead types as opposed to the bead characteristics discussed in this thesis. The former possibility presents the most likely scenario as this type of bead does not appear in extremely well dated contexts (i.e., trading posts) occupied prior to 1840.

Discussion of Chemical Analysis

The second question at the beginning of this thesis asked the following: Is it possible to use mean trace element similarities between dated archaeological glass trade bead sites/assemblages to establish a technique for dating undated beads (i.e. a statistical regression model)? Similar to the morphological regression results, the chemical data acquired using LA-ICP-MS techniques produced relatively high R- and R-Squared Values for the regression models developed from the chemical data. Therefore, I contend that the chemical signature of glass beads *can* be used to estimate the age of undated archaeological sites although the dataset analyzed in this thesis indicates that the method is not currently as accurate as the morphological method.

Three, four-variable regression formulas were developed using trace element chemistry. The first formula utilized all the chemical data available while the other two formulas split the data by color groups (Chapter 5). Estimated dates calculated using the three chemical regression formulas are also shown in Table 6.1 alongside the estimated ages acquired using the morphological data. Interestingly, the estimated ages calculated from the chemical data appear to be younger than the estimated ages calculated using the morphological data.

Consistently the chemical regression formulas give the dated sites of Fort Vasquez and Weinmeister estimated ages that are 10-20 years older than the actual age of the sites in all but one case. Age estimates for Lykins Valley, the oldest independently dated site in the study area, are plausible in two out of three cases for chemistry. The other sites/assemblages located near Lykins Valley (i.e. 5LR261, 5LR11724, 5LR11726, and 5LR11819) and the assemblages believed to be from the same valley (i.e., Coffin A and Coffin B) all produced dates similar to Lykins Valley again suggesting that the valley may have functioned as a seasonal camp for local Native American groups in the early 19^{th} Century.

The most intriguing site tested for chemistry is 5LR53. This site is located adjacent to a small drainage across which a protohistoric rock art panel "The Many Guns Site" was discovered in a rock shelter. Preliminary analysis of the Many Guns site by Knapp and LaBelle (2009) describe this site as a rock overhang in which 13 rifles are depicted in charcoal drawings, perhaps representing an instance of "counting coup." The chemical dataset as well as the morphological dataset estimate the age of this site to be between 1821 and 1847 with 1828 being the most common age estimate produced by both methods (see Table 6.1). The depiction of rifles, another popular Euroamerican trade item of the protohistoric period, in close proximity to the bead site, may represent a contemporaneous occupation of the two sites.

Discussion of Morphology and Chemistry as an Integrated Dataset

The third and final question in this thesis asked the following: assuming that morphological and/or trace element mean counts produce statistically significant evidence that dated archaeological glass trade bead sites/assemblages can be used to estimate the ages of undated archaeological glass bead sites/assemblages, which method produces the most reliable and accurate results? In order to answer this question it was necessary to generate additional regression models to determine if R- and R-squared values could be acquired which were higher than those produced by the singular analysis of morphological or chemical characteristics. The final results showed that splitting the dataset to analyze only white, torus-shaped beads (as was done for the singular analyses) tested for chemistry did, in fact, increase the R- and R-Squared values significantly for a four variable solution as shown below.

Four-Variable Model (White, Torus-Shaped Beads Tested for Chemistry)

Estimated Age = 1863.815 + Length (-10.825) + Uranium (6.374) +
Tin (.137) + Copper (.008)

R = .755, R Squared = .570

Using the four-variable solution, age estimates were calculated for all sites containing white, torus-shaped beads which were also tested through chemistry (see Table 6.1). Only seven sites met the criteria for the integrated regression model developed for morphology and chemistry. Three of these sites are represented by the independently dated sites available for inclusion in this study. While the age estimate generated for the Weinmeister site falls within the actual date range for the site, dates estimated for Lykins Valley and Fort Vasquez are more recent than the site's actual ages. The undated sites (5DA268, 5LR53, 5LR11724, and 5LR11819) also produced age estimates which were more recent than age estimates produced by singular models for morphology and chemistry.

Based upon the calculated age estimates obtained from the integrated morphological and chemical datasets, I conclude that despite the increase R- and R-Squared values, the integrated regression model produces age estimates which are less accurate than the age estimates generated using only morphological or chemical data. It is likely that the statistical significance of the model is the result of data skewed by a lack of white, torus-shaped beads tested for chemistry from dated archaeological contexts. Additionally, the increased testing of such beads from undated archaeological contexts should help determine mean trace chemical element counts which are more reliable than those acquired from single specimens.

Conclusion

This thesis has shown that morphological and trace chemical analyses are useful tools for estimating the age of archaeological glass trade beads in undated contexts whenever dated glass bead assemblages are available for analysis. According to the statistical data and estimated ages of the assemblages calculated from them, it appears that morphological analysis is currently the most accurate method for dating archaeological glass beads despite the method's several drawbacks. The chemical analysis, while less accurate, appears to show great potential for contributing to future studies. As more archaeological glass beads become available for LA-ICP-MS testing, this method will ultimately prove more accurate, expedient, and cost-effective than any currently existing analytical method.

I opened this thesis with a quote by Gene Galloway (1978:7) positing that bead analysis was in need of a direct dating method. I contend that this thesis is a major step toward answering that need. While I do not propose that the models or the results in this thesis are completely infallibly accurate, the models do indicate that increasing our sample of bead forms, incorporating additional dated and undated archaeological bead sites to the sample population, and broadening a dataset for bead chemical trace element counts, may eventually allow archaeologists the opportunity to estimate the age of protohistoric glass bead sites on an extremely refined chronological scale. At this time, however, the methodology presented herein remains a pilot project and many of the undated sites included in this study warrant further investigation to refine the accuracy of the age estimates I have developed and to what extent the existing datasets may be leading to skewed results (i.e., why a number of the resultant age estimates are slightly earlier than those age estimates previously established by bead seriation studies). It will also be important to test the proposed model in regions beyond the South Platte River Basin to determine if the analytical approach can be replicated elsewhere and/or expanded outward from the current study area. It is also vital that additional archaeological glass bead sites and assemblages with confirmed dates be incorporated with the current sample. Additional dated beads will fill chronological gaps in the study and substantiate or refute the viability of my statistical results.

Cumulatively, the field of archaeological glass bead research holds a great potential to offer a proxy measure for dating undated archaeological sites and assemblages when other dating methods are not an option. It will continue to be important for researchers must strive to develop new and innovative methods for dating these often overlooked trade items as glass beads likely represent the single most common artifact used by Native Americans in the 19th century; millions and possibly billions of glass trade beads occur in every region of the North American continent. , I, building upon research by Reher and Schieber (1993) and Scheiber (1994), have posited the idea that isolated bead characteristics such as size, color, or chemistry *do* hold the potential to inform a researcher about bead age. Further investigation of bead chemistry will ultimately provide a means by which researchers can determine the age of protohistoric archaeological sites and assemblages that would otherwise be relegated to a museum shelf without the opportunity to contribute to our understanding of the past.

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Appendix A:

Results of Descriptive Statistics and Independent Samples t-Tests for morphological characteristics in sites/assemblages containing more than 10 glass beads.

Table A.1. Descriptive Statistics and Independent Samples t-Tests, comparing site 5DA268 and all other beads sampled on morphological characteristics.

Characteristic	Site Name 5DA268	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	11	3.1245	.25477	.07682	.69065	3.196*
	No	4296	2.4339	.71645	.01093		
-Length	Yes	11	2.3200	.19058	.05746	.42515	1.220
	No	3898	1.8949	1.15548	.01851		
Portion							
-Complete†	Yes	12	.9167	.28868	.08333	-.07834	-.940**
	No	4403	.9950	.07052	.00106		
-Incomplete†	Yes	12	.0833	.28868	.08333	.07834	.940**
	No	4403	.0050	.07052	.00106		
Manufacture							
-Drawn	Yes	12	1.0000	.00000	.00000	.02135	.512
	No	4403	.9787	.14456	.00218		
-Wound	Yes	12	.0000	.00000	.00000	-.02112	-.509
	No	4403	.0211	.14381	.00217		
Shape							
-Torus	Yes	12	1.0000	.00000	.00000	.02476	.552
	No	4403	.9752	.15540	.00234		
-Tube	Yes	12	.0000	.00000	.00000	-.00182	-.148
	No	4403	.0018	.04259	.00064		
-Oval	Yes	12	.0000	.00000	.00000	-.00182	-.148
	No	4403	.0018	.04259	.00064		
-Faceted	Yes	12	.0000	.00000	.00000	-.00068	-.090
	No	4403	.0007	.02610	.00039		
-Cube	Yes	12	.0000	.00000	.00000	-.00023	-.052
	No	4403	.0002	.01507	.00023		
-Spherical	Yes	12	.0000	.00000	.00000	-.02021	-.497
	No	4403	.0202	.14075	.00212		
Luster							
-Dull†	Yes	12	.5833	.51493	.14865	-.24156	-1.624**
	No	4403	.8249	.38010	.00573		
-Shiny†	Yes	12	.4167	.51493	.14865	.24269	1.631**
	No	4403	.1740	.37913	.00571		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.1. Continued.

Characteristic	Site Name 5DA268	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	12	.0000	.00000	.00000	-.16898	-29.918
	No	4403	.1690	.37477	.00565		
-Opaque†	Yes	12	1.0000	.00000	.00000	.16898	29.928
	No	4403	.8310	.37477	.00565		
Exterior Color							
-Yellow	Yes	12	.0000	.00000	.00000	-.00014	-.117
	No	4403	.0011	.03368	.00051		
-White	Yes	12	.4167	.51493	.14865	-.16793	-1.179
	No	4403	.5846	.49285	.00743		
-Violet	Yes	12	.0000	.00000	.00000	-.00023	-.052
	No	4403	.0002	.01507	.00023		
-Royal Blue	Yes	12	.0000	.00000	.00000	-.00023	-.052
	No	4403	.0002	.01507	.00023		
-Red	Yes	12	.0000	.00000	.00000	-.02089	-.506
	No	4403	.0209	.14305	.00216		
-Pink	Yes	12	.0000	.00000	.00000	-.00863	-.323
	No	4403	.0086	.09251	.00139		
-Orange	Yes	12	.0000	.00000	.00000	-.00045	-.074
	No	4403	.0005	.02131	.00032		
-Greyish-blue	Yes	12	.0000	.00000	.00000	-.00091	-.104
	No	4403	.0009	.03013	.00045		
-Greenish-blue	Yes	12	.0000	.00000	.00000	-.01272	-.393
	No	4403	.0127	.11207	.00169		
-Green	Yes	12	.0000	.00000	.00000	-.00477	-.240
	No	4403	.0048	.06890	.00104		
-Dark Violet	Yes	12	.0000	.00000	.00000	-00023	-.052
	No	4403	.0002	.01507	.00023		
-Dark Green	Yes	12	.0000	.00000	.00000	-.00227	-.165
	No	4403	.0023	.04761	.00072		
-Dark Blue†	Yes	12	.0000	.00000	.00000	-.08585	-20.332*
	No	4403	.0859	.28018	.00422		
-Bluish-Green	Yes	12	.0000	.00000	.00000	.02967	-.360
	No	4403	.0107	.10278	.00155		
-Blue	Yes	12	.5833	.51493	.14865	.33873	2.724
	No	4403	.2446	.42990	.00648		
-Black	Yes	12	.0000	.00000	.00000	-.02158	-.514
	No	4403	.0216	.14531	.00219		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.2. Descriptive Statistics and Independent Samples t-Tests, comparing site 5EP750 and all other beads sampled on morphological characteristics.

Characteristic	Site Name 5EP750	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	50	2.1926	.21620	.03058	-.24591	-7.565**
	No	4257	2.4385	.71982	.01103		
-Length	Yes	0[a]	.	.	.		
	No	3909	1.8960	1.15411	.01846		
Portion							
-Complete	Yes	70	1.0000	.00000	.00000	.00529	.610
	No	4345	.9947	.07257	.00110		
-Incomplete	Yes	70	.0000	.00000	.00000	-.00529	-.610
	No	4345	.0053	.07257	.00110		
Manufacture							
-Drawn†	Yes	70	1.0000	.00000	.00000	.02163	9.801*
	No	4345	.9784	.14550	.00221		
-Wound†	Yes	70	.0000	.00000	.00000	-.02140	-9.747*
	No	4345	.0214	.14474	.00220		
Shape							
-Torus†	Yes	70	1.0000	.00000	.00000	.02509	10.573**
	No	4345	.9749	.15641	.00237		
-Tube	Yes	70	.0000	.00000	.00000	-.00184	-.359
	No	4345	.0018	.04287	.00065		
-Oval	Yes	70	.0000	.00000	.00000	-.00184	-.359
	No	4345	.0018	.04287	.00065		
-Faceted	Yes	70	.0000	.00000	.00000	-.00069	-.220
	No	4345	.0007	.02627	.00040		
-Cube	Yes	70	.0000	.00000	.00000	-.00023	-.127
	No	4345	.0002	.01517	.00023		
-Spherical†	Yes	70	.0000	.00000	.00000	-.02048	-9.531*
	No	4345	.0205	.14166	.00215		
Luster							
-Dull†	Yes	70	.3857	.49028	.05860	-.44559	-7.568**
	No	4345	.8313	.37453	.00568		
-Shiny†	Yes	70	.6143	.49028	.05860	.44674	7.588**
	No	4345	.1675	.37351	.00567		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed, [a] Missing values, t not computed.

Table A.2. Continued.

Characteristic	Site Name 5EP750	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	70	.0000	.00000	.00000	-.17123	-29.958**
	No	4345	.1712	.37675	.00572		
-Opaque†	Yes	70	1.0000	.00000	.00000	.17123	29.958**
	No	4345	.8288	.37675	.00572		
Exterior Color							
-Yellow	Yes	70	.0000	.00000	.00000	-.00115	-.284
	No	4345	.0012	.03391	.00051		
-White†	Yes	70	.1714	.37960	.04537	-.41937	-9.120**
	No	4345	.5908	.49174	.00746		
-Violet	Yes	70	.0000	.00000	.00000	-.00023	-.127
	No	4345	.0002	.01517	.00023		
-Royal Blue	Yes	70	.0000	.00000	.00000	-.00023	-.127
	No	4345	.0002	.01517	.00023		
-Red†	Yes	70	.6429	.48262	.05768	.63204	10.953**
	No	4345	.0108	.10345	.00157		
-Pink	Yes	70	.0000	.00000	.00000	-.00875	-.786
	No	4345	.0087	.09312	.00141		
-Orange	Yes	70	.0000	.00000	.00000	-.00046	-.180
	No	4345	.0005	.02145	.00033		
-Greyish-blue	Yes	70	.0000	.00000	.00000	-.00092	-.254
	No	4345	.0009	.03033	.00046		
-Greenish-blue	Yes	70	.0000	.00000	.00000	-.01289	-.956
	No	4345	.0129	.11281	.00171		
-Green	Yes	70	.0000	.00000	.00000	-.00483	-.583
	No	4345	.0048	.06936	.00105		
-Dark Violet	Yes	70	.0000	.00000	.00000	-.00023	-.127
	No	4345	.0002	.01517	.00023		
-Dark Green	Yes	70	.0000	.00000	.00000	-.00230	-.402
	No	4345	.0023	.04792	.00073		
-Dark Blue†	Yes	70	.0143	.11952	.01429	-.07248	-4.861**
	No	4345	.0868	.28152	.00427		
-Bluish-Green	Yes	70	.0000	.00000	.00000	-.01082	-.875
	No	4345	.0108	.10345	.00157		
-Blue†	Yes	70	.0714	.25940	.03100	-.17690	-5.582**
	No	4345	.2483	.43209	.00656		
-Black†	Yes	70	.1000	.30217	.03612	.07975	2.204**
	No	4345	.0203	.14088	.00214		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed, [a] Missing values, t not computed.

Table A.3. Descriptive Statistics and Independent Samples t-Tests, comparing site 5LR53 and all other beads sampled on morphological characteristics.

Characteristic	Site Name 5LR53	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter	Yes	22	2.8805	.42461	.09053	.44708	2.922
	No	4285	2.4334	.71700	.01095		
-Length	Yes	22	2.1605	.38921	.08298	.26590	1.078
	No	3887	1.8946	1.15685	.01856		
Portion							
-Complete†	Yes	24	1.0000	.00000	.00000	-.07855	-1.363**
	No	4391	.9786	.14475	.00218		
-Incomplete†	Yes	24	.0000	.00000	.00000	.07855	1.363**
	No	4391	.0212	.14400	.00217		
Manufacture							
-Drawn	Yes	24	1.0000	.00000	.00000	.02141	.724
	No	4391	.9786	.14475	.00218		
-Wound	Yes	24	.0000	.00000	.00000	-.02118	-.720
	No	4391	.0212	.14400	.00217		
Shape							
-Torus	Yes	24	1.0000	.00000	.00000	.02482	.781
	No	4391	.9752	.15560	.00235		
-Tube	Yes	24	.0000	.00000	.00000	-.00182	-.209
	No	4391	.0018	.04265	.00064		
-Oval	Yes	24	.0000	.00000	.00000	-.00182	-.209
	No	4391	.0018	.04265	.00064		
-Faceted	Yes	24	.0000	.00000	.00000	-.00068	-.128
	No	4391	.0007	.02613	.00039		
-Cube	Yes	24	.0000	.00000	.00000	-.00023	-.074
	No	4391	.0002	.01509	.00023		
-Spherical	Yes	24	.0000	.00000	.00000	-.02027	-.704
	No	4391	.0203	.14093	.00213		
Luster							
-Dull†	Yes	24	.6667	.48154	.09829	-.15843	-1.609**
	No	4391	.8251	.37993	.00573		
-Shiny†	Yes	24	.3333	.48154	.09829	.15957	1.621**
	No	4391	.1738	.37895	.00572		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.3. Continued.

Characteristic	Site Name 5LR53	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	24	.0000	.00000	.00000	-.16944	-29.926**
	No	4391	.1694	.37518	.00566		
-Opaque†	Yes	24	1.0000	.00000	.00000	.16944	29.926**
	No	4391	.8306	.37518	.00566		
Exterior Color							
-Yellow	Yes	24	.0000	.00000	.00000	-.00114	-.165
	No	4391	.0011	.03373	.00051		
-White†	Yes	24	.1667	.38069	.07771	-.41976	-5.377**
	No	4391	.5864	.49253	.00743		
-Violet	Yes	24	.0000	.00000	.00000	-.00023	-.074
	No	4391	.0002	.01509	.00023		
-Royal Blue	Yes	24	.0000	.00000	.00000	-.00023	-.074
	No	4391	.0002	.01509	.00023		
-Red	Yes	24	.0000	.00000	.00000	-.02095	-.717
	No	4391	.0210	.14324	.00216		
-Pink	Yes	24	.0000	.00000	.00000	-.00865	-.458
	No	4391	.0087	.09263	.00140		
-Orange	Yes	24	.0000	.00000	.00000	-.00046	-.105
	No	4391	.0005	.02134	.00032		
-Greyish-blue	Yes	24	.0000	.00000	.00000	-.00091	-.148
	No	4391	.0009	.03017	.00046		
-Greenish-blue	Yes	24	.0000	.00000	.00000	-.01275	-.557
	No	4391	.0128	.11222	.00169		
-Green	Yes	24	.0000	.00000	.00000	-.00478	-.340
	No	4391	.0048	.06900	.00104		
-Dark Violet	Yes	24	.0000	.00000	.00000	-.00023	-.074
	No	4391	.0002	.01509	.00023		
-Dark Green	Yes	24	.0000	.00000	.00000	-.00228	-.234
	No	4391	.0023	.04767	.00072		
-Dark Blue†	Yes	24	.0000	.00000	.00000	-.08609	-20.335**
	No	4391	.0861	.28052	.00423		
-Bluish-Green	Yes	24	.0000	.00000	.00000	-.01070	-.509
	No	4391	.0107	.10292	.00155		
-Blue†	Yes	24	.8333	.38069	.07771	.59102	7.579*
	No	4391	.2423	.42853	.00647		
-Black	Yes	24	.0000	.00000	.00000	-.02164	-.728
	No	4391	.0216	.14551	.00220		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.4. Descriptive Statistics and Independent Samples t-Tests, comparing site Arapahoe Princess and all other beads sampled on morphological characteristics.

Characteristic	Site Name Arapahoe Princess	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter	Yes	26	3.5212	.36116	.07083	1.09209	15.239*
	No	4281	2.4291	.71310	.01090		
-Length	Yes	26	2.5538	.42070	.08251	.66220	2.919
	No	3883	1.8916	1.15621	.01855		
Portion							
-Complete	Yes	26	1.0000	.00000	.00000	.00524	.370
	No	4389	.9948	.07221	.00109		
-Incomplete	Yes	26	.0000	.00000	.00000	-.00524	-.370
	No	4389	.0052	.07221	.00109		
Manufacture							
-Drawn	Yes	26	1.0000	.00000	.00000	.02142	.754
	No	4389	.9786	.14479	.00219		
-Wound	Yes	26	.0000	.00000	.00000	-.02119	-.750
	No	4389	.0212	.14403	.00217		
Shape							
-Torus	Yes	26	1.0000	.00000	.00000	.02483	.814
	No	4389	.9752	.15564	.00235		
-Tube	Yes	26	.0000	.00000	.00000	-.00182	-.218
	No	4389	.0018	.04266	.00064		
-Oval	Yes	26	.0000	.00000	.00000	-.00182	-.218
	No	4389	.0018	.04266	.00064		
-Faceted	Yes	26	.0000	.00000	.00000	-.00068	-.133
	No	4389	.0007	.02614	.00039		
-Cube	Yes	26	.0000	.00000	.00000	-.00023	-.077
	No	4389	.0002	.01509	.00023		
-Spherical	Yes	26	.0000	.00000	.00000	-.02028	-.733
	No	4389	.0203	.14097	.00213		
Luster							
-Dull	Yes	26	.8077	.40192	.07882	-.01664	-.222
	No	4389	.8243	.38058	.00574		
-Shiny	Yes	26	.0000	.00000	.00000	-.17567	-30.579**
	No	4389	.1757	.38058	.00574		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.4. Continued.

Characteristic	Site Name Arapahoe Princess	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent	Yes	26	.1923	.40192	26	.02393	.325
	No	4389	.1684	.37424	4389		
-Opaque	Yes	26	.8077	.40192	26	-.02393	-.325
	No	4389	.8316	.37424	4389		
Exterior Color							
-Yellow	Yes	26	.0000	.00000	26	-.00114	-.172
	No	4389	.0011	.03374	4389		
-White†	Yes	26	.3077	.47068	26	-.27809	-3.003**
	No	4389	.5858	.49264	4389		
-Violet	Yes	26	.0000	.00000	26	-.00023	-.077
	No	4389	.0002	.01509	4389		
-Royal Blue	Yes	26	.0000	.00000	26	-.00023	-.077
	No	4389	.0002	.01509	4389		
-Red†	Yes	26	.1923	.40192	26	.17249	2.187**
	No	4389	.0198	.13941	4389		
-Pink	Yes	26	.0000	.00000	26	-.00866	-.476
	No	4389	.0087	.09266	4389		
-Orange†	Yes	26	.0769	.27175	26	.07692	1.443**
	No	4389	.0000	.00000	4389		
-Greyish-blue	Yes	26	.0000	.00000	26	-.00091	-.154
	No	4389	.0009	.03018	4389		
-Greenish-blue	Yes	26	.0000	.00000	26	-.01276	-.580
	No	4389	.0128	.11225	4389		
-Green	Yes	26	.0000	.00000	26	-.00478	-.353
	No	4389	.0048	.06901	4389		
-Dark Violet	Yes	26	.0000	.00000	26	-.00023	-.077
	No	4389	.0002	.01509	4389		
-Dark Green	Yes	26	.0000	.00000	26	-.00228	-.244
	No	4389	.0023	.04768	4389		
-Dark Blue†	Yes	26	.0000	.00000	26	-.08612	-20.335**
	No	4389	.0861	.28058	4389		
-Bluish-Green	Yes	26	.0000	.00000	26	-.01071	-.530
	No	4389	.0107	.10294	4389		
-Blue†	Yes	26	.1154	.32581	26	-.13091	-2.038**
	No	4389	.2463	.43090	4389		
-Black†	Yes	26	.3077	.47068	26	.28787	3.118**
	No	4389	.0198	.13941	4389		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.5. Descriptive Statistics and Independent Samples t-Tests, comparing site Charles Lohr and all other beads sampled on morphological characteristics.

Characteristic	Site Name Charles Lohr	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter	Yes	113	2.9779	.62025	.05835	.55683	8.215
	No	4194	2.4210	.71329	.01101		
-Length	Yes	113	2.2682	.87239	.08207	.38326	3.484
	No	3796	1.8850	1.15971	.01882		
Portion							
-Complete	Yes	113	1.0000	.00000	113	.00535	.779
	No	4302	.9947	.07293	4302		
-Incomplete	Yes	113	.0000	.00000	113	-.00535	-.779
	No	4302	.0053	.07293	4302		
Manufacture							
-Drawn †	Yes	113	1.0000	.00000	113	.02185	9.802**
	No	4302	.9781	.14621	4302		
-Wound†	Yes	113	.0000	.00000	113	-.02162	-9.748**
	No	4302	.0216	.14545	4302		
Shape							
-Torus†	Yes	113	1.0000	.00000	.00000	.02534	10.574**
	No	4302	.9747	.15716	.00240		
-Tube	Yes	113	.0000	.00000	.00000	-.00186	-.459
	No	4302	.0019	.04309	.00066		
-Oval	Yes	113	.0000	.00000	.00000	-.00186	-.459
	No	4302	.0019	.04309	.00066		
-Faceted	Yes	113	.0000	.00000	.00000	-.00070	-.281
	No	4302	.0007	.02640	.00040		
-Cube	Yes	113	.0000	.00000	.00000	-.00023	-.162
	No	4302	.0002	.01525	.00023		
-Spherical†	Yes	113	.0000	.00000	.00000	-.02069	-9.532**
	No	4302	.0207	.14235	.00217		
Luster							
-Dull	Yes	113	.8407	.36758	113	.01691	.466
	No	4302	.8238	.38103	4302		
-Shiny	Yes	113	.1593	.36758	113	-.01574	-.435
	No	4302	.1750	.38004	4302		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.5. Continued.

Characteristic	Site Name Charles Lohr	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	113	.2389	.42833	113	.07227	1.776**
	No	4302	.1667	.37272	4302		
-Opaque†	Yes	113	.7611	.42833	113	-.07227	-1.776**
	No	4302	.8333	.37272	4302		
Exterior Color							
-Yellow	Yes	113	.0000	.00000	113	-.00116	-.363
	No	4302	.0012	.03408	4302		
-White†	Yes	113	.6726	.47137	113	.09074	2.018**
	No	4302	.5818	.49332	4302		
-Violet	Yes	113	.0000	.00000	113	-.00023	-.162
	No	4302	.0002	.01525	4302		
-Royal Blue	Yes	113	.0000	.00000	113	-.00023	-.162
	No	4302	.0002	.01525	4302		
-Red†	Yes	113	.1327	.34081	113	.11484	3.575**
	No	4302	.0179	.13260	4302		
-Pink†	Yes	113	.0000	.00000	113	-.00883	-6.191*
	No	4302	.0088	.09358	4302		
-Orange	Yes	113	.0000	.00000	113	-.00046	-.229
	No	4302	.0005	.02156	4302		
-Greyish-blue	Yes	113	.0000	.00000	113	-.00093	-.324
	No	4302	.0009	.03048	4302		
-Greenish-blue†	Yes	113	.0000	.00000	113	-.01302	-7.532*
	No	4302	.0130	.11336	4302		
-Green	Yes	113	.0000	.00000	113	-.00488	-.744
	No	4302	.0049	.06970	4302		
-Dark Violet†	Yes	113	.0088	.09407	113	.00885	1.000**
	No	4302	.0000	.00000	4302		
-Dark Green	Yes	113	.0000	.00000	113	-.00232	-.513
	No	4302	.0023	.04816	4302		
-Dark Blue†	Yes	113	.0000	.00000	113	-.08787	-20.355**
	No	4302	.0879	.28313	4302		
-Bluish-Green†	Yes	113	.0442	.20656	113	.03448	1.769**
	No	4302	.0098	.09834	4302		
-Blue†	Yes	113	.1062	.30946	113	-.14299	-4.790**
	No	4302	.2492	.43259	4302		
-Black†	Yes	113	.0354	.18561	113	.01425	.809*
	No	4302	.0212	.14391	4302		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.6. Descriptive Statistics and Independent Samples t-Tests, comparing site Coffin A and all other beads sampled on morphological characteristics.

Characteristic	Site Name Coffin A	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	128	2.8905	.45988	.04065	.46882	11.125**
	No	4179	2.4217	.71842	.01111		
-Length†	Yes	128	2.0028	.40971	.03621	.11038	2.698**
	No	3781	1.8924	1.17091	.01904		
Portion							
-Complete	Yes	128	1.0000	.00000	.00000	.00537	.831
	No	4287	.9946	.07306	.00112		
-Incomplete	Yes	128	.0000	.00000	.00000	-.00537	-.831
	No	4287	.0054	.07306	.00112		
Manufacture							
-Drawn†	Yes	128	1.0000	.00000	.00000	.02193	9.802**
	No	4287	.9781	.14646	.00224		
-Wound†	Yes	128	.0000	.00000	.00000	-.02169	-9.749**
	No	4287	.0217	.14570	.00223		
Shape							
-Torus†	Yes	128	1.0000	.00000	.00000	.02543	10.574**
	No	4287	.9746	.15743	.00240		
-Tube	Yes	128	.0000	.00000	.00000	-.00187	-.489
	No	4287	.0019	.04316	.00066		
-Oval	Yes	128	.0000	.00000	.00000	-.00187	-.489
	No	4287	.0019	.04316	.00066		
-Faceted	Yes	128	.0000	.00000	.00000	-.00070	-.299
	No	4287	.0007	.02645	.00040		
-Cube	Yes	128	.0000	.00000	.00000	-.00023	-.173
	No	4287	.0002	.01527	.00023		
-Spherical†	Yes	128	.0000	.00000	.00000	-.02076	-9.532**
	No	4287	.0208	.14260	.00218		
Luster							
-Dull†	Yes	128	.9531	.21220	.01876	.13274	6.755**
	No	4287	.8204	.38391	.00586		
-Shiny†	Yes	128	.0469	.21220	.01876	-.13157	-6.697**
	No	4287	.1784	.38293	.00585		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.6. Continued.

Characteristic	Site Name Coffin A	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	128	.0391	.19450	.01719	-.13332	-7.352**
	No	4287	.1724	.37776	.00577		
-Opaque†	Yes	128	.9609	.19450	.01719	.13332	7.352**
	No	4287	.8276	.37776	.00577		
Exterior Color							
-Yellow	Yes	128	.0000	.00000	.00000	-.00117	-.387
	No	4287	.0012	.03414	.00052		
-White	Yes	128	.5469	.49975	.04417	-.03838	-.868
	No	4287	.5853	.49273	.00753		
-Violet	Yes	128	.0000	.00000	.00000	-.00023	-.173
	No	4287	.0002	.01527	.00023		
-Royal Blue	Yes	128	.0000	.00000	.00000	-.00023	-.173
	No	4287	.0002	.01527	.00023		
-Red†	Yes	128	.0391	.19450	.01719	.01877	1.083**
	No	4287	.0203	.14102	.00215		
-Pink†	Yes	128	.0000	.00000	.00000	-.00886	-6.191*
	No	4287	.0089	.09374	.00143		
-Orange	Yes	128	.0000	.00000	.00000	-.00047	-.244
	No	4287	.0005	.02160	.00033		
-Greyish-blue	Yes	128	.0000	.00000	.00000	-.00093	-.346
	No	4287	.0009	.03054	.00047		
-Greenish-blue	Yes	128	.0156	.12451	.01100	.00303	.302
	No	4287	.0126	.11154	.00170		
-Green	Yes	128	.0000	.00000	.00000	-.00490	-.794
	No	4287	.0049	.06983	.00107		
-Dark Violet	Yes	128	.0000	.00000	.00000	-.00023	-.173
	No	4287	.0002	.01527	.00023		
-Dark Green	Yes	128	.0000	.00000	.00000	-.00233	-.547
	No	4287	.0023	.04825	.00074		
-Dark Blue†	Yes	128	.0078	.08839	.00781	-.08013	-8.973**
	No	4287	.0879	.28324	.00433		
-Bluish-Green†	Yes	128	.0000	.00000	.00000	-.01096	-6.893*
	No	4287	.0110	.10414	.00159		
-Blue†	Yes	128	.3359	.47417	.04191	.09311	2.195**
	No	4287	.2428	.42884	.00655		
-Black†	Yes	128	.0547	.22826	.02018	.03416	1.683**
	No	4287	.0205	.14181	.00217		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.7. Descriptive Statistics and Independent Samples t-Tests, comparing site Coffin B and all other beads sampled on morphological characteristics.

Characteristic	Site Name Coffin B	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	275	3.0924	.33329	.02010	.70150	30.463**
	No	4032	2.3909	.71372	.01124		
-Length†	Yes	275	2.1774	.35082	.02116	.30262	10.457**
	No	3634	1.8748	1.19040	.01975		
Portion							
-Complete†	Yes	275	1.0000	.00000	.00000	.00556	4.809*
	No	4140	.9944	.07434	.00116		
-Incomplete†	Yes	275	.0000	.00000	.00000	-.00556	-4.809*
	No	4140	.0056	.07434	.00116		
Manufacture							
-Drawn†	Yes	275	1.0000	.00000	.00000	.02271	9.806**
	No	4140	.9773	.14898	.00232		
-Wound†	Yes	275	.0000	.00000	.00000	-.02246	-9.753**
	No	4140	.0225	.14820	.00230		
Shape							
-Torus†	Yes	275	1.0000	.00000	.00000	.02633	10.579**
	No	4140	.9737	.16013	.00249		
-Tube	Yes	275	.0000	.00000	.00000	-.00193	-.730
	No	4140	.0019	.04392	.00068		
-Oval	Yes	275	.0000	.00000	.00000	-.00193	-.730
	No	4140	.0019	.04392	.00068		
-Faceted	Yes	275	.0000	.00000	.00000	-.00072	-.446
	No	4140	.0007	.02691	.00042		
-Cube	Yes	275	.0000	.00000	.00000	-.00024	-.258
	No	4140	.0002	.01554	.00024		
-Spherical†	Yes	275	.0000	.00000	.00000	-.02150	-9.536**
	No	4140	.0215	.14505	.00225		
Luster							
-Dull†	Yes	275	.9636	.18753	.01131	.14866	11.597**
	No	4140	.8150	.38836	.00604		
-Shiny†	Yes	275	.0364	.18753	.01131	-.14745	-11.509**
	No	4140	.1838	.38738	.00602		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.7. Continued.

Characteristic	Site Name Coffin B	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	275	.0000	.00000	.00000	-.17971	-30.113**
	No	4140	.1797	.38399	.00597		
-Opaque†	Yes	275	1.0000	.00000	.00000	.17971	30.113**
	No	4140	.8203	.38399	.00597		
Exterior Color							
-Yellow	Yes	275	.0000	.00000	.00000	-.00121	-.577
	No	4140	.0012	.03474	.00054		
-White†	Yes	275	.1418	.34950	.02108	-.47171	-21.065**
	No	4140	.6135	.48700	.00757		
-Violet	Yes	275	.0000	.00000	.00000	-.00024	-.258
	No	4140	.0002	.01554	.00024		
-Royal Blue	Yes	275	.0000	.00000	.00000	-.00024	-.258
	No	4140	.0002	.01554	.00024		
-Red†	Yes	275	.0000	.00000	.00000	-.02222	-9.699**
	No	4140	.0222	.14742	.00229		
-Pink†	Yes	275	.0000	.00000	.00000	-.00918	-6.192**
	No	4140	.0092	.09538	.00148		
-Orange	Yes	275	.0000	.00000	.00000	-.00048	-.364
	No	4140	.0005	.02198	.00034		
-Greyish-blue	Yes	275	.0000	.00000	.00000	-.00097	-.516
	No	4140	.0010	.03107	.00048		
-Greenish-blue†	Yes	275	.0000	.00000	.00000	-.01353	-7.534**
	No	4140	.0135	.11553	.00180		
-Green†	Yes	275	.0000	.00000	.00000	-.00507	-4.594*
	No	4140	.0051	.07105	.00110		
-Dark Violet	Yes	275	.0000	.00000	.00000	-.00024	-.258
	No	4140	.0002	.01554	.00024		
-Dark Green	Yes	275	.0000	.00000	.00000	-.00242	-.816
	No	4140	.0024	.04909	.00076		
-Dark Blue†	Yes	275	.0000	.00000	.00000	-.09130	-20.393**
	No	4140	.0913	.28808	.00448		
-Bluish-Green†	Yes	275	.0000	.00000	.00000	-.01135	-6.894**
	No	4140	.0114	.10596	.00165		
-Blue†	Yes	275	.8582	.34950	.02108	.65335	29.712**
	No	4140	.2048	.40363	.00627		
-Black†	Yes	275	.0000	.00000	.00000	-.02295	-9.859**
	No	4140	.0229	.14975	.00233		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.8. Descriptive Statistics and Independent Samples t-Tests, comparing site Comanche Creek and all other beads sampled on morphological characteristics.

Characteristic	Site Name Comanche Creek	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	13	3.3708	.22062	.06119	.93794	15.090*
	No	4294	2.4328	.71562	.01092		
-Length	Yes	13	3.3708	.22062	.06119	.25408	.311
	No	4294	2.4328	.71562	.01092		
Portion							
-Complete	Yes	13	1.0000	.00000	13	.00522	.261
	No	4402	.9948	.07210	4402		
-Incomplete	Yes	13	.0000	.00000	13	-.00522	-.261
	No	4402	.0052	.07210	4402		
Manufacture							
-Drawn	Yes	13	1.0000	.00000	.00000	.02135	.532
	No	4402	.9786	.14458	.00218		
-Wound	Yes	13	.0000	.00000	.00000	-.02113	-.530
	No	4402	.0211	.14382	.00217		
Shape							
-Torus	Yes	13	1.0000	.00000	.00000	.02476	.574
	No	4402	.9752	.15542	.00234		
-Tube	Yes	13	.0000	.00000	.00000	-.00182	-.154
	No	4402	.0018	.04260	.00064		
-Oval	Yes	13	.0000	.00000	.00000	-.00182	-.154
	No	4402	.0018	.04260	.00064		
-Faceted	Yes	13	.0000	.00000	.00000	-.00068	-.094
	No	4402	.0007	.02610	.00039		
-Cube	Yes	13	.0000	.00000	.00000	-.00023	-.054
	No	4402	.0002	.01507	.00023		
-Spherical	Yes	13	.0000	.00000	.00000	-.02022	-.518
	No	4402	.0202	.14076	.00212		
Luster							
-Dull†	Yes	13	1.0000	.00000	.00000	.17628	30.690**
	No	4402	.8237	.38110	.00574		
-Shiny†	Yes	13	.0000	.00000	.00000	-.17515	-30.570**
	No	4402	.1751	.38014	.00573		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.8. Continued.

Characteristic	Site Name Comanche Creek	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	13	.0000	.00000	.00000	-.16901	-29.919**
	No	4402	.1690	.37481	.00565		
-Opaque†	Yes	13	1.0000	.00000	.00000	.16901	29.919**
	No	4402	.8310	.37481	.00565		
Exterior Color							
-Yellow	Yes	13	.0000	.00000	.00000	-.00114	-.122
	No	4402	.0011	.03369	.00051		
-White†	Yes	13	.0000	.00000	.00000	-.58587	-78.906**
	No	4402	.5859	.49263	.00742		
-Violet	Yes	13	.0000	.00000	.00000	-.00023	-.054
	No	4402	.0002	.01507	.00023		
-Royal Blue	Yes	13	.0000	.00000	.00000	-.00023	-.054
	No	4402	.0002	.01507	.00023		
-Red	Yes	13	.0000	.00000	.00000	-.02090	-.527
	No	4402	.0209	.14306	.00216		
-Pink	Yes	13	.0000	.00000	.00000	-.00863	-.336
	No	4402	.0086	.09252	.00139		
-Orange	Yes	13	.0000	.00000	.00000	-.00045	-.077
	No	4402	.0005	.02131	.00032		
-Greyish-blue	Yes	13	.0000	.00000	.00000	-.00091	-.109
	No	4402	.0009	.03013	.00045		
-Greenish-blue†	Yes	13	.0769	.27735	.07692	.06443	.837**
	No	4402	.0125	.11109	.00167		
-Green	Yes	13	.0000	.00000	.00000	-.00477	-.250
	No	4402	.0048	.06891	.00104		
-Dark Violet	Yes	13	.0000	.00000	.00000	-.00023	-.054
	No	4402	.0002	.01507	.00023		
-Dark Green	Yes	13	.0000	.00000	.00000	-.00227	-.172
	No	4402	.0023	.04761	.00072		
-Dark Blue†	Yes	13	.0000	.00000	.00000	-.08587	-20.333*
	No	4402	.0859	.28020	.00422		
-Bluish-Green	Yes	13	.0000	.00000	.00000	-.01068	-.374
	No	4402	.0107	.10279	.00155		
-Blue†	Yes	13	.9231	.27735	.07692	.67955	8.803**
	No	4402	.2435	.42926	.00647		
-Black	Yes	13	.0000	.00000	.00000	-.02158	-9.853
	No	4402	.0216	.14533	.00219		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.9. Descriptive Statistics and Independent Samples t-Tests, comparing site Fort Vasquez and all other beads sampled on morphological characteristics.

Characteristic	Site Name Fort Vasquez	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	1761	2.4888	.71182	.01696	.08984	4.059**
	No	2546	2.3989	.71754	.01422		
-Length†	Yes	1826	2.1455	1.50619	.03525	.46814	12.342**
	No	2083	1.6774	.63965	.01402		
Portion							
-Complete†	Yes	1843	.9902	.09837	.00229	-.00782	-3.192**
	No	2572	.9981	.04406	.00087		
-Incomplete†	Yes	1843	.0098	.09837	.00229	.00782	3.192**
	No	2572	.0019	.04406	.00087		
Manufacture							
-Drawn†	Yes	1843	.9495	.21895	.00510	-.05007	-9.789**
	No	2572	.9996	.01972	.00039		
-Wound†	Yes	1843	.0505	.21895	.00510	.05046	9.894**
	No	2572	.0000	.00000	.00000		
Shape							
-Torus†	Yes	1843	.9441	.22977	.00535	-.05355	-9.852**
	No	2572	.9977	.04825	.00095		
-Tube†	Yes	1843	.0033	.05698	.00133	.00248	1.725**
	No	2572	.0008	.02788	.00055		
-Oval†	Yes	1843	.0043	.06576	.00153	.00434	2.834**
	No	2572	.0000	.00000	.00000		
-Faceted	Yes	1843	.0005	.02329	.00054	-.00024	-.295
	No	2572	.0008	.02788	.00055		
-Cube	Yes	1843	.0000	.00000	.00000	-.00039	-.846
	No	2572	.0004	.01972	.00039		
-Spherical†	Yes	1843	.0477	.21329	.00497	.04736	9.503**
	No	2572	.0004	.01972	.00039		
Luster							
-Dull†	Yes	1843	.8144	.38886	.00906	-.01683	-1.440**
	No	2572	.8313	.37460	.00739		
-Shiny†	Yes	1843	.1856	.38886	.00906	.01877	1.609**
	No	2572	.1668	.37287	.00735		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.9. Continued.

Characteristic	Site Name Fort Vasquez	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	1843	.0445	.20624	.00480	-.21289	-21.569**
	No	2572	.2574	.43728	.00862		
-Opaque†	Yes	1843	.9555	.20624	.00480	.21289	21.569**
	No	2572	.7426	.43728	.00862		
Exterior Color							
-Yellow†	Yes	1843	.0000	.00000	.00000	-.00194	-2.238**
	No	2572	.0019	.04406	.00087		
-White†	Yes	1843	.7911	.40663	.00947	.35525	26.094**
	No	2572	.4358	.49596	.00978		
-Violet†	Yes	1843	.0005	.02329	.00054	.00054	1.000*
	No	2572	.0000	.00000	.00000		
-Royal Blue	Yes	1843	.0000	.00000	.00000	-.00039	-.846
	No	2572	.0004	.01972	.00039		
-Red†	Yes	1843	.0016	.04032	.00094	-.03298	-8.853**
	No	2572	.0346	.18281	.00360		
-Pink†	Yes	1843	.0000	.00000	.00000	-.01477	-6.209**
	No	2572	.0148	.12067	.00238		
-Orange†	Yes	1843	.0000	.00000	.00000	-.00078	-1.414*
	No	2572	.0008	.02788	.00055		
-Greyish-blue†	Yes	1843	.0000	.00000	.00000	-.00156	-2.001**
	No	2572	.0016	.03941	.00078		
-Greenish-blue†	Yes	1843	.0157	.12448	.00290	.00524	1.484**
	No	2572	.0105	.10194	.00201		
-Green†	Yes	1843	.0087	.09279	.00216	.00674	2.892**
	No	2572	.0019	.04406	.00087		
-Dark Violet	Yes	1843	.0000	.00000	.00000	-.00039	-.846
	No	2572	.0004	.01972	.00039		
-Dark Green†	Yes	1843	.0000	.00000	.00000	-.00389	-3.168**
	No	2572	.0039	.06224	.00123		
-Dark Blue†	Yes	1843	.0005	.02329	.00054	-.14604	-20.873**
	No	2572	.1466	.35375	.00698		
-Bluish-Green†	Yes	1843	.0228	.14927	.00348	.02084	5.816**
	No	2572	.0019	.04406	.00087		
-Blue†	Yes	1843	.1584	.36525	.00851	-.14949	-11.997**
	No	2572	.3079	.46173	.00910		
-Black†	Yes	1843	.0000	.00000	.00000	-.03694	-9.930**
	No	2572	.0369	.18864	.00372		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.10. Descriptive Statistics and Independent Samples t-Tests, comparing site Lykins Valley and all other beads sampled on morphological characteristics.

Characteristic	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	430	2.6884	.44196	.02131	.28074	11.522**
	No	3877	2.4076	.73540	.01181		
-Length†	Yes	430	1.9597	.48596	.02343	.07157	2.297**
	No	3479	1.8882	1.21118	.02053		
Portion							
-Complete†	Yes	430	1.0000	.00000	.00000	.00577	4.809**
	No	3985	.9942	.07576	.00120		
-Incomplete†	Yes	430	.0000	.00000	.00000	-.00577	-4.809**
	No	3985	.0058	.07576	.00120		
Manufacture							
-Drawn†	Yes	430	1.0000	.00000	.00000	.02359	9.811**
	No	3985	.9764	.15178	.00240		
-Wound†	Yes	430	.0000	.00000	.00000	-.02334	-9.757**
	No	3985	.0233	.15099	.00239		
Shape							
-Torus†	Yes	430	.9930	.08333	.00402	.01962	4.123**
	No	3985	.9734	.16093	.00255		
-Tube†	Yes	430	.0047	.06812	.00329	.00315	.941**
	No	3985	.0015	.03878	.00061		
-Oval	Yes	430	.0000	.00000	.00000	-.00201	-.930
	No	3985	.0020	.04477	.00071		
-Faceted†	Yes	430	.0023	.04822	.00233	.00182	.775**
	No	3985	.0005	.02240	.00035		
-Cube	Yes	430	.0000	.00000	.00000	-.00025	-.328
	No	3985	.0003	.01584	.00025		
-Spherical†	Yes	430	.0000	.00000	.00000	-.02233	-9.540**
	No	3985	.0223	.14779	.00234		
Luster							
-Dull†	Yes	430	.9744	.15807	.00762	.16639	16.891**
	No	3985	.8080	.39390	.00624		
-Shiny†	Yes	430	.0256	.15807	.00762	-.16513	-16.780**
	No	3985	.1907	.39291	.00622		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.10. Continued.

Characteristic	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	430	.0023	.04822	.00233	-.18412	-27.922**
	No	3985	.1864	.38952	.00617		
-Opaque†	Yes	430	.9977	.04822	.00233	.18412	27.922**
	No	3985	.8136	.38952	.00617		
Exterior Color							
-Yellow	Yes	430	.0000	.00000	.00000	-.00125	-.735
	No	3985	.0013	.03540	.00056		
-White†	Yes	430	.5349	.49936	.02408	-.05458	-2.156**
	No	3985	.5895	.49199	.00779		
-Violet	Yes	430	.0000	.00000	.00000	-.00025	-.328
	No	3985	.0003	.01584	.00025		
-Royal Blue†	Yes	430	.0023	.04822	.00233	.00233	1.000**
	No	3985	.0000	.00000	.00000		
-Red†	Yes	430	.0000	.00000	.00000	-.02309	-9.703**
	No	3985	.0231	.15020	.00238		
-Pink†	Yes	430	.0000	.00000	.00000	-.00954	-6.193**
	No	3985	.0095	.09720	.00154		
-Orange	Yes	430	.0000	.00000	.00000	-.00050	-.465
	No	3985	.0005	.02240	.00035		
-Greyish-blue†	Yes	430	.0070	.08333	.00402	.00673	1.670**
	No	3985	.0003	.01584	.00025		
-Greenish-blue†	Yes	430	.0465	.21084	.01017	.03748	3.647**
	No	3985	.0090	.09463	.00150		
-Green†	Yes	430	.0000	.00000	.00000	-.00527	-4.594**
	No	3985	.0053	.07241	.00115		
-Dark Violet	Yes	430	.0000	.00000	.00000	-.00025	-.328
	No	3985	.0003	.01584	.00025		
-Dark Green†	Yes	430	.0000	.00000	.00000	-.00251	-3.166*
	No	3985	.0025	.05004	.00079		
-Dark Blue†	Yes	430	.0000	.00000	.00000	-.09486	-20.433**
	No	3985	.0949	.29305	.00464		
-Bluish-Green†	Yes	430	.0000	.00000	.00000	-.01179	-6.896**
	No	3985	.0118	.10797	.00171		
-Blue†	Yes	430	.4000	.49047	.02365	.17114	6.965**
	No	3985	.2289	.42015	.00666		
-Black†	Yes	430	.0093	.09611	.00463	-.01353	-2.600**
	No	3985	.0228	.14940	.00237		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.11. Descriptive Statistics and Independent Samples t-Tests, comparing site Macon Street and all other beads sampled on morphological characteristics.

Characteristic	Site Name Macon Street	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	121	2.9365	.28753	.02614	.51535	18.140**
	No	4186	2.4212	.71998	.01113		
-Length†	Yes	121	2.0837	.33646	.03059	.19367	5.377**
	No	3788	1.8901	1.17037	.01902		
Portion							
-Complete	Yes	122	1.0000	.00000	.00000	.00536	.810
	No	4293	.9946	.07301	.00111		
-Incomplete	Yes	122	.0000	.00000	.00000	-.00536	-.810
	No	4293	.0054	.07301	.00111		
Manufacture							
-Drawn†	Yes	122	1.0000	.00000	.00000	.02190	9.802**
	No	4293	.9781	.14636	.00223		
-Wound†	Yes	122	.0000	.00000	.00000	-.02166	-9.749**
	No	4293	.0217	.14560	.00222		
Shape							
-Torus†	Yes	122	1.0000	.00000	.00000	.02539	10.574**
	No	4293	.9746	.15733	.00240		
-Tube	Yes	122	.0000	.00000	.00000	-.00186	-.477
	No	4293	.0019	.04313	.00066		
-Oval	Yes	122	.0000	.00000	.00000	-.00186	-.477
	No	4293	.0019	.04313	.00066		
-Faceted	Yes	122	.0000	.00000	.00000	-.00070	-.292
	No	4293	.0007	.02643	.00040		
-Cube	Yes	122	.0000	.00000	.00000	-.00023	-.169
	No	4293	.0002	.01526	.00023		
-Spherical†	Yes	122	.0000	.00000	.00000	-.02073	-9.532**
	No	4293	.0207	.14250	.00217		
Luster							
-Dull†	Yes	122	.0082	.09054	.00820	-.83923	-85.075**
	No	4293	.8474	.35962	.00549		
-Shiny†	Yes	122	.9918	.09054	.00820	.84039	85.275**
	No	4293	.1514	.35849	.00547		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.11. Continued.

Characteristic	Site Name Macon Street	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	122	.5000	.50206	.04545	.34090	7.444**
	No	4293	.1591	.36581	.00558		
-Opaque†	Yes	122	.5000	.50206	.04545	-.34090	-7.444**
	No	4293	.8409	.36581	.00558		
Exterior Color							
-Yellow	Yes	122	.0000	.00000	.00000	-.00116	-.377
	No	4293	.0012	.03411	.00052		
-White	Yes	122	.4918	.50199	.04545	-.09497	-2.099
	No	4293	.5868	.49247	.00752		
-Violet	Yes	122	.0000	.00000	.00000	-.00023	-.169
	No	4293	.0002	.01526	.00023		
-Royal Blue	Yes	122	.0000	.00000	.00000	-.00023	-.169
	No	4293	.0002	.01526	.00023		
-Red†	Yes	122	.0000	.00000	.00000	-.02143	-9.695**
	No	4293	.0214	.14483	.00221		
-Pink†	Yes	122	.0000	.00000	.00000	-.00885	-6.191*
	No	4293	.0089	.09368	.00143		
-Orange	Yes	122	.0000	.00000	.00000	-.00047	-.238
	No	4293	.0005	.02158	.00033		
-Greyish-blue	Yes	122	.0000	.00000	.00000	-.00093	-.337
	No	4293	.0009	.03051	.00047		
-Greenish-blue	Yes	122	.0082	.09054	.00820	-.00461	-.449
	No	4293	.0128	.11247	.00172		
-Green	Yes	122	.0000	.00000	.00000	-.00489	-.774
	No	4293	.0049	.06978	.00106		
-Dark Violet	Yes	122	.0000	.00000	.00000	-.00023	-.169
	No	4293	.0002	.01526	.00023		
-Dark Green	Yes	122	.0000	.00000	.00000	-.00233	-.534
	No	4293	.0023	.04821	.00074		
-Dark Blue†	Yes	122	.0000	.00000	.00000	-.08805	-20.357**
	No	4293	.0881	.28340	.00433		
-Bluish-Green†	Yes	122	.0000	.00000	.00000	-.01095	-6.893*
	No	4293	.0109	.10407	.00159		
-Blue†	Yes	122	.5000	.50206	.04545	.26171	5.699**
	No	4293	.2383	.42609	.00650		
-Black†	Yes	122	.0000	.00000	.00000	-.02213	-9.855**
	No	4293	.0221	.14712	.00225		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.12. Descriptive Statistics and Independent Samples t-Tests, comparing site Weinmeister and all other beads sampled on morphological characteristics.

Characteristic	Site Name Weinmeister	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	966	1.7231	.14559	.00468	-.91852	-72.267**
	No	3341	2.6417	.68295	.01182		
-Length†	Yes	935	1.1605	.17830	.00583	-.96678	-41.444**
	No	2974	2.1273	1.23176	.02259		
Portion							
-Complete†	Yes	966	1.0000	.00000	.00000	.00667	4.811**
	No	3449	.9933	.08140	.00139		
-Incomplete†	Yes	966	.0000	.00000	.00000	-.00667	-4.811**
	No	3449	.0067	.08140	.00139		
Manufacture							
-Drawn†	Yes	966	1.0000	.00000	.00000	.02725	9.829**
	No	3449	.9727	.16285	.00277		
-Wound†	Yes	966	.0000	.00000	.00000	-.02696	-9.775**
	No	3449	.0270	.16200	.00276		
Shape							
-Torus†	Yes	966	1.0000	.00000	.00000	.03160	10.608**
	No	3449	.9684	.17497	.00298		
-Tube†	Yes	966	.0000	.00000	.00000	-.00232	-2.831**
	No	3449	.0023	.04811	.00082		
-Oval†	Yes	966	.0000	.00000	.00000	-.00232	-2.831**
	No	3449	.0023	.04811	.00082		
-Faceted	Yes	966	.0000	.00000	.00000	-.00087	-.917
	No	3449	.0009	.02948	.00050		
-Cube	Yes	966	.0000	.00000	.00000	-.00029	-.529
	No	3449	.0003	.01703	.00029		
-Spherical†	Yes	966	.0000	.00000	.00000	-.02580	-9.557**
	No	3449	.0258	.15857	.00270		
Luster							
-Dull†	Yes	966	1.0000	.00000	.00000	.22499	31.638**
	No	3449	.7750	.41764	.00711		
-Shiny†	Yes	966	.0000	.00000	.00000	-.22354	-31.507**
	No	3449	.2235	.41668	.00710		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.12. Continued.

Characteristic	Site Name Weinmeister	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	966	.5010	.50026	.01610	.42565	25.470**
	No	3449	.0754	.26405	.00450		
-Opaque†	Yes	966	.4990	.50026	.01610	-.42565	-25.470**
	No	3449	.9246	.26405	.00450		
Exterior Color							
-Yellow†	Yes	966	.0031	.05567	.00179	.00253	1.375**
	No	3449	.0006	.02408	.00041		
-White†	Yes	966	.4720	.49948	.01607	-.14349	-7.936**
	No	3449	.6155	.48654	.00828		
-Violet	Yes	966	.0000	.00000	.00000	-.00029	-.529
	No	3449	.0003	.01703	.00029		
-Royal Blue	Yes	966	.0000	.00000	.00000	-.00029	-.529
	No	3449	.0003	.01703	.00029		
-Red†	Yes	966	.0000	.00000	.00000	-.02667	-9.721**
	No	3449	.0267	.16115	.00274		
-Pink†	Yes	966	.0290	.16785	.00540	.02609	4.762**
	No	3449	.0029	.05378	.00092		
-Orange	Yes	966	.0000	.00000	.00000	-.00058	-1.414
	No	3449	.0006	.02408	.00041		
-Greyish-blue†	Yes	966	.0000	.00000	.00000	-.00116	-2.001*
	No	3449	.0012	.03404	.00058		
-Greenish-blue†	Yes	966	.0000	.00000	.00000	-.01624	-7.544**
	No	3449	.0162	.12640	.00215		
-Green†	Yes	966	.0021	.04548	.00146	-.00344	-1.780**
	No	3449	.0055	.07403	.00126		
-Dark Violet	Yes	966	.0000	.00000	.00000	-.00029	-.529
	No	3449	.0003	.01703	.00029		
-Dark Green†	Yes	966	.0104	.10127	.00326	.01035	3.177**
	No	3449	.0000	.00000	.00000		
-Dark Blue†	Yes	966	.3302	.47054	.01514	.31312	20.466**
	No	3449	.0171	.12969	.00221		
-Bluish-Green†	Yes	966	.0000	.00000	.00000	-.01363	-6.902**
	No	3449	.0136	.11595	.00197		
-Blue†	Yes	966	.1501	.35736	.01150	-.12215	-8.870**
	No	3449	.2723	.44518	.00758		
-Black†	Yes	966	.0031	.05567	.00179	-.02357	-7.192**
	No	3449	.0267	.16115	.00274		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.13. Descriptive Statistics and Independent Samples t-Tests, comparing site Westfall A and all other beads sampled on morphological characteristics.

Characteristic	Site Name Westfall A	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	173	1.9515	.39494	.03003	-.50442	-15.740**
	No	4134	2.4559	.71981	.01120		
-Length	Yes	1	2.2000				
	No	3908	1.8960	1.15425	.01846		
Portion							
-Complete	Yes	173	1.0000	.00000	.00000	.00542	.971
	No	4242	.9946	.07344	.00113		
-Incomplete	Yes	173	.0000	.00000	.00000	-.00542	-.971
	No	4242	.0054	.07344	.00113		
Manufacture							
-Drawn †	Yes	173	.9942	.07603	.00578	.01614	2.603**
	No	4242	.9781	.14645	.00225		
-Wound†	Yes	173	.0000	.00000	.00000	-.02192	-9.750**
	No	4242	.0219	.14645	.00225		
Shape							
-Torus†	Yes	173	.9942	.07603	.00578	.01968	3.141**
	No	4242	.9745	.15754	.00242		
-Tube	Yes	173	.0000	.00000	.00000	-.00189	-.572
	No	4242	.0019	.04339	.00067		
-Oval	Yes	173	.0000	.00000	.00000	-.00189	-.572
	No	4242	.0019	.04339	.00067		
-Faceted	Yes	173	.0000	.00000	.00000	-.00071	-.350
	No	4242	.0007	.02659	.00041		
-Cube†	Yes	173	.0058	.07603	.00578	.00578	1.000**
	No	4242	.0000	.00000	.00000		
-Spherical†	Yes	173	.0000	.00000	.00000	-.02098	-9.533**
	No	4242	.0210	.14334	.00220		
Luster							
-Dull†	Yes	173	.9769	.15073	.01146	.15887	12.315**
	No	4242	.8180	.38588	.00592		
-Shiny†	Yes	173	.0231	.15073	.01146	-.15769	-12.230**
	No	4242	.1808	.38491	.00591		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table A.13. Continued.

Characteristic	Site Name Westfall A	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	173	.3642	.48259	.03669	.20362	5.485**
	No	4242	.1605	.36715	.00564		
-Opaque†	Yes	173	.6358	.48259	.03669	-.20362	-5.485**
	No	4242	.8395	.36715	.00564		
Exterior Color							
-Yellow†	Yes	173	.0116	.10721	.00815	.01085	1.330**
	No	4242	.0007	.02659	.00041		
-White†	Yes	173	.5202	.50104	.03809	-.06652	-1.713*
	No	4242	.5868	.49247	.00756		
-Violet	Yes	173	.0000	.00000	.00000	-.00024	-.202
	No	4242	.0002	.01535	.00024		
-Royal Blue	Yes	173	.0000	.00000	.00000	-.00024	-.202
	No	4242	.0002	.01535	.00024		
-Red†	Yes	173	.0058	.07603	.00578	-.01567	-2.530**
	No	4242	.0215	.14490	.00222		
-Pink†	Yes	173	.0578	.23405	.01779	.05120	2.870**
	No	4242	.0066	.08099	.00124		
-Orange	Yes	173	.0000	.00000	.00000	-.00047	-.286
	No	4242	.0005	.02171	.00033		
-Greyish-blue	Yes	173	.0000	.00000	.00000	-.00094	-.404
	No	4242	.0009	.03070	.00047		
-Greenish-blue	Yes	173	.0173	.13092	.00995	.00485	.558
	No	4242	.0125	.11109	.00171		
-Green†	Yes	173	.0173	.13092	.00995	.01310	1.309**
	No	4242	.0042	.06501	.00100		
-Dark Violet	Yes	173	.0000	.00000	.00000	-.00024	-.202
	No	4242	.0002	.01535	.00024		
-Dark Green	Yes	173	.0000	.00000	.00000	-.00236	-.639
	No	4242	.0024	.04850	.00074		
-Dark Blue†	Yes	173	.3237	.46925	.03568	.24779	6.901**
	No	4242	.0759	.26488	.00407		
-Bluish-Green†	Yes	173	.0000	.00000	.00000	-.01108	-6.893**
	No	4242	.0111	.10469	.00161		
-Blue†	Yes	173	.0347	.18350	.01395	-.21944	-14.185**
	No	4242	.2541	.43542	.00669		
-Black	Yes	173	.0116	.10721	.00815	-.01036	-.921
	No	4242	.0219	.14645	.00225		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.14. Descriptive Statistics and Independent Samples t-Tests, comparing site Westfall D and all other beads sampled on morphological characteristics.

Characteristic	Site Name Westfall D	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Size							
-Outer Diameter†	Yes	199	3.1114	.39654	.02811	.70848	23.438**
	No	4108	2.4029	.71236	.01111		
-Length	Yes						
	No	3909	1.8960	1.15411	.01846		
Portion							
-Complete†	Yes	199	1.0000	.00000	.00000	.00546	4.808*
	No	4216	.9945	.07367	.00113		
-Incomplete†	Yes	199	.0000	.00000	.00000	-.00546	-4.808*
	No	4216	.0055	.07367	.00113		
Manufacture							
-Drawn†	Yes	199	1.0000	.00000	.00000	.02230	9.804**
	No	4216	.9777	.14766	.00227		
-Wound†	Yes	199	.0000	.00000	.00000	-.02206	-9.751**
	No	4216	.0221	.14689	.00226		
Shape							
-Torus†	Yes	199	1.0000	.00000	.00000	.02585	10.577**
	No	4216	.9741	.15872	.00244		
-Tube	Yes	199	.0000	.00000	.00000	-.00190	-.615
	No	4216	.0019	.04352	.00067		
-Oval	Yes	199	.0000	.00000	.00000	-.00190	-.615
	No	4216	.0019	.04352	.00067		
-Faceted	Yes	199	.0000	.00000	.00000	-.00071	-.376
	No	4216	.0007	.02667	.00041		
-Cube	Yes	199	.0000	.00000	.00000	-.00024	-.217
	No	4216	.0002	.01540	.00024		
-Spherical†	Yes	199	.0000	.00000	.00000	-.02111	-9.534**
	No	4216	.0211	.14377	.00221		
Luster							
-Dull†	Yes	199	.0101	.10000	.00709	-.85262	-96.320**
	No	4216	.8627	.34424	.00530		
-Shiny†	Yes	199	.9899	.10000	.00709	.85380	96.580**
	No	4216	.1361	.34299	.00528		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table A.14. Continued.

Characteristic	Site Name Westfall D	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Diaphaneity							
-Translucent†	Yes	199	.0653	.24772	.01756	-.10806	-5.840**
	No	4216	.1734	.37863	.00583		
-Opaque†	Yes	199	.9347	.24772	.01756	.10806	5.840**
	No	4216	.8266	.37863	.00583		
Exterior Color							
-Yellow	Yes	199	.0000	.00000	.00000	-.00119	-.486
	No	4216	.0012	.03442	.00053		
-White†	Yes	199	.3367	.47377	.03358	-.25914	-7.528**
	No	4216	.5958	.49079	.00756		
-Violet	Yes	199	.0000	.00000	.00000	-.00024	-.217
	No	4216	.0002	.01540	.00024		
-Royal Blue	Yes	199	.0000	.00000	.00000	-.00024	-.217
	No	4216	.0002	.01540	.00024		
-Red†	Yes	199	.0704	.25638	.01817	.05185	2.835**
	No	4216	.0185	.13477	.00208		
-Pink†	Yes	199	.0000	.00000	.00000	-.00901	-6.192**
	No	4216	.0090	.09452	.00146		
-Orange	Yes	199	.0000	.00000	.00000	-.00047	-.307
	No	4216	.0005	.02178	.00034		
-Greyish-blue	Yes	199	.0000	.00000	.00000	-.00095	-.435
	No	4216	.0009	.03079	.00047		
-Greenish-blue†	Yes	199	.0000	.00000	.00000	-.01328	-7.533**
	No	4216	.0133	.11450	.00176		
-Green†	Yes	199	.0000	.00000	.00000	-.00498	-4.593*
	No	4216	.0050	.07041	.00108		
-Dark Violet	Yes	199	.0000	.00000	.00000	-.00024	-.217
	No	4216	.0002	.01540	.00024		
-Dark Green	Yes	199	.0000	.00000	.00000	-.00237	-.688
	No	4216	.0024	.04865	.00075		
-Dark Blue†	Yes	199	.0000	.00000	.00000	-.08966	-20.375**
	No	4216	.0897	.28573	.00440		
-Bluish-Green†	Yes	199	.0000	.00000	.00000	-.01115	-6.893**
	No	4216	.0111	.10501	.00162		
-Blue†	Yes	199	.2915	.45558	.03230	.04810	1.459**
	No	4216	.2434	.42916	.00661		
-Black†	Yes	199	.3015	.46007	.03261	.29321	8.982**
	No	4216	.0083	.09075	.00140		

** p<0.01, * p<0.05; † Equal variances not assumed.

Appendix B:

Mean trace element counts for all LA-ICP-MS tested sites.

Table B.1. Mean trace element counts for all LA-ICP-MS tested sites. Data represents totals for all beads and colors combined.

Site Name	Color	N	Mean Trace Element Counts (in ppm) Sodium (Na)	Magnesium (Mg)	Aluminum (Al)	Silicon (Si)
5DA268	Blue	1	70870.12	2064.28	1284.62	294689.38
	White	1	17355.05	1294.36	7471.41	197590.88
5LR53	Blue	1	29829.62	768.19	2765.87	314646.16
	White	1	19183.82	1895.02	3906.39	190924.16
5LR261	Blue	1	7519.16	3141.42	4987.23	333233.28
5LR11724	Blue	2	15761.81±11672.52	2947.40±3141.82	4398.64±3662.57	355734.17±73736.54
	White	1	20414.93	2020.97	4137.52	169532.13
5LR11726	Blue	2	18797.70±3571.45	3536.15±135.28	3205.55±564.52	356395.73±8335.44
	Grayish-Blue	1	40774.25	3336.42	2914.00	324573.28
5LR11819	Blue	2	55543.87±49391.69	4977.97±2171.37	11414.42±102.95	329469.08±13985.27
	White	1	4066.79	2782.66	7956.00	213939.89
5LR11838	Blue	1	114580.94	1176.13	12185.98	310654.22
Biscuit Hill	Blue	1	83232.63	7364.82	11614.33	31177.56
Fort Vasquez	Blue	48	21015.57±23381.38	1460.07±941.29	5742.02±4633.97	313473.96±14913.90
	Greenish-Blue	12	4105.87±2692.79	636.53±174.00	3016.36±1010.63	312241.57±12357.71
	White	40	21125.92±6269.52	1779.38±1337.13	3009.51±3062.17	182420.31±26882.52
Lykins Valley	Blue	47	36648.14±30834.27	2558.85±1542.14	6695.07±4193.30	309691.16±12776.01
	Greenish-Blue	20	8828.55±10626.36	1736.51±815.34	4768.63±3798.33	322543.82±37207.30
	Grayish-Blue	3	81556.18±6501.04	9693.33±628.25	8923.40±406.57	293875.84±7341.05
	White	30	40943.05±23255.11	5338.29±4590.88	7693.43±7003.69	232195.55±51407.50
Weinmeister	White	6	31092.32±2039.62	1309.02±351.53	3054.43±1105.99	191508.15±5085.55

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm) Potassium (K)	Calcium (Ca)	Scandium (Sc)	Titanium (Ti)	Vanadium (V)
5DA268	Blue	1	53211.09	49546.56	17.12	45.03	2.72
	White	1	55652.24	14208.35	13.17	294.47	8.84
5LR53	Blue	1	66870.66	7124.69	19.33	161.31	3.26
	White	1	45707.27	19345.46	12.17	130.39	5.60
5LR261	Blue	1	22176.65	12818.76	4.64	298.78	18.00
5LR11724	Blue	2	46185.04±56232.13	15189.87±14771.26	8.23±2.02	303.512±314.88	4.49±6.34
	White	1	39577.11	25405.86	3.05	143.26	195.97
5LR11726	Blue	2	48480.00±12580.60	39103.72±1259.34	7.44±0.12	106.67±20.03	8.79±0.64
	Grayish Blue	1	85583.13	39706.89	6.68	124.52	8.76
5LR11819	Blue	2	52688.86±2086.83	33368.18±31056.38	6.67±0.39	457.80±158.48	9.97±3.89
	White	1	44032.87	27763.38	4.75	214.11	27.81
5LR11838	Blue	1	15473.18	33563.64	6.30	298.95	9.11
Biscuit Hill	Blue	1	59061.05	61372.58	8.35	343.59	14.54
Fort Vasquez	Blue	48	47435.63±14675.39	14201.27±9200.27	9.48±4.18	216.94±138.19	7.62±3.77
	Greenish Blue	12	46197.41±10040.16	6486.38±1365.75	6.87±4.43	132.87±49.53	7.26±3.16
	White	40	39471.05±8773.20	28584.53±15593.31	5.57±5.56	115.98±139.26	12.65±14.85
Lykins Valley	Blue	47	58985.77±2508.99	23375.32±13282.95	11.75±9.03	252.23±163.30	8.47±4.35
	Greenish Blue	20	29818.64±15527.03	14258.41±5928.35	10.61±11.35	232.73±158.65	19.39±20.22
	Grayish Blue	3	58248.88±27380.38	64569.93±4112.82	11.57±6.92	446.21±107.45	11.05±2.67
	White	40	53321.08±9071.12	43840.84±31050.49	5.94±4.06	355.57±347.26	15.65±11.48
Weinmeister	White	6	40475.07±3982.15	16887.07±4541.43	3.60±0.78	121.43±49.80	35.16±21.78

Table B.1. Continued.

			Mean Trace Element Counts (in ppm)				
Site Name	**Color**	**N**	**Chromium (Cr)**	**Manganese (Mn)**	**Iron (Fe)**	**Nickel (Ni)**	**Cobalt (Co)**
5DA268	Blue	1	0.00	212.68	967.48	12.47	15.47
	White	1	0.00	157.78	6543.20	0.00	1.22
5LR53	Blue	1	0.00	526.25	2124.20	6.81	4.32
	White	1	0.00	101.82	2316.38	0.00	0.73
5LR261	Blue	1	0.00	468.21	3081.65	54.15	41.51
5LR11724	Blue	2	0.00	575.66±459.74	2868.84±190.82	101.09±114.80	119.46±164.33
	White	1	0.00	83.09	1430.02	8.20	0.76
5LR11726	Blue	2	0.00	192.42±26.16	1966.96±246.50	71.61±0.16	66.44±2.57
	Grayish Blue	1	0.00	146.54	1991.80	63.56	57.72
5LR11819	Blue	2	0.00	279.80±150.74	4466.84±727.95	62.90±71.67	77.48±106.53
	White	1	0.00	167.08	2459.85	17.23	1.26
5LR11838	Blue	1	0.00	221.21	2349.03	21.96	63.90
Biscuit Hill	Blue	1	0.00	191.02	5090.42	43.57	28.28
Fort Vasquez	Blue	48	4.72±14.76	419.32±195.31	4540.93±3244.53	38.75±14.03	19.21±12.55
	Greenish Blue	12	0.74±1.97	342.61±227.90	2418.00±553.56	21.87±8.26	5.80±5.66
	White	40	14.38±29.71	102.06±131.14	2042.18±2127.76	4.50±8.19	0.49±0.32
Lykins Valley	Blue	47	0.08±0.53	527.52±493.83	3754.08±2709.16	40.04±17.32	31.87±17.15
	Greenish Blue	20	0.00	536.94±148.07	2015.45±1519.80	52.81±29.44	24.13±17.43
	Grayish Blue	3	0.00	833.93±48.92	3916.00±3169.45	239.51±104.07	206.71±9.46
	White	40	2.59±7.22	201.08±185.38	4235.74±4303.00	4.25±7.01	1.04±0.94
Weinmeister	White	6	0.00	36.77±6.63	1401.67±678.29	1.48±1.97	0.45±0.18

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm) Copper (Cu)	Zinc (Zn)	Arsenic (As)	Rubidium (Rb)	Strontium (Sr)	Yttrium (Y)
5DA268	Blue	1	15775.13	35.27	758.57	73.60	50.09	1.18
	White	1	52.43	37.41	74437.58	45.70	19.95	4.44
5LR53	Blue	1	19706.80	82.34	923.69	49.64	17.88	1.73
	White	1	96.01	89.94	78357.26	33.54	111.74	3.17
5LR261	Blue	1	23520.04	111.99	2578.96	69.56	50.91	3.02
5LR11724	Blue	2	13438.81±3599.38	184.48±171.13	1054.04±533.05	32.60±11.37	128.47±130.05	2.88±2.39
	White	1	77.67	23.23	106553.20	16.32	231.16	10.18
5LR11726	Blue	2	15918.45±1278.90	98.14±8.53	631.75±23.35	118.60±11.92	60.42±1.46	1.50±0.48
	Grayish Blue	1	14180.81	92.38	596.88	139.61	55.41	1.79
5LR11819	Blue	2	10142.54±623.21	78.08±4.69	451.92±296.38	31.27±13.94	201.85±258.46	4.01±0.49
	White	1	75.98	59.17	85208.91	41.20	74.47	6.52
5LR11838	Blue	1	4132.47	77.73	4114.61	46.19	70.96	16.65
Biscuit Hill	Blue	1	9205.76	107.22	1897.55	33.58	255.18	7.27
Fort Vasquez	Blue	48	18560.36±4422.38	60.06±66.83	6853.48±5896.32	23.16±8.07	77.55±71.97	2.99±2.75
	Greenish Blue	12	22976.87±2213.24	36.83±9.39	2616.98±3002.11	24.31±5.25	28.17±6.62	1.78±0.51
	White	40	157.97±248.08	34.90±84.54	130585.37±63678.25	15.33±4.97	251.10±124.17	4.08±5.59
Lykins Valley	Blue	47	15477.60±3613.00	43.54±15.84	4603.23±3770.46	21.77±11.98	125.38±98.35	3.50±1.21
	Greenish Blue	20	19483.90±5265.35	78.04±53.13	4827.42±2689.62	28.68±10.22	60.92±31.49	3.43±2.07
	Grayish Blue	3	78.22±31.42	74.32±34.55	670.04±102.59	10.84±4.79	419.14±59.50	9.61±1.41
	White	40	56.60±67.08	34.85±28.30	44674.48±42987.85	21.48±1853	261.40±190.53	5.04±3.22
Weinmeister	White	6	995.50±1807.04	25.53±13.60	71983.33±2186.62	22.85±7.07	77.27±48.96	5.30±2.89

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm)					
			Zirconium (Zr)	Niobium (Nb)	Tin (Sn)	Antimony (Sb)	Cesium (Cs)	Barium (Ba)
5DA268	Blue	1	6.22	0.28	208.59	12931.88	0.55	124.83
	White	1	20.94	3.95	117.03	438.47	0.75	366.32
5LR53	Blue	1	27.12	0.89	35.64	25023.62	0.77	65.12
	White	1	16.75	0.91	10.45	3893.99	0.08	102.30
5LR261	Blue	1	21.48	1.42	62.53	36077.00	0.85	102.96
5LR11724	Blue	2	22.8±27.69	1.10±1.20	128.60±78.90	19162.12±26747.37	0.49±0.43	82.68±45.76
	White	1	9.61	0.82	13.02	40.17	0.11	94.99
5LR11726	Blue	2	5.09±1.31	0.46±0.07	102.16±3.55	28326.93±314.24	0.97±0.13	66.69±27.37
	Grayish Blue	1	3.82	0.39	84.33	25059.85	0.73	31.82
5LR11819	Blue	2	29.90±8.63	2.76±0.98	79.04±48.35	17845.11±24921.63	1.14±1.61	263.41±97.26
	White	1	20.17	1.60	352.42	106.15	0.69	204.51
5LR11838	Blue	1	67.72	2.26	62.56	12029.35	1.68	575.30
Biscuit Hill	Blue	1	43.80	2.58	11.89	212.57	0.74	146.99
Fort Vasquez	Blue	48	32.61±15.70	1.63±1.22	3033.86±4499.05	28249.37±9165.92	0.32±0.18	114.73±165.09
	Greenish Blue	12	20.83±10.71	0.96±0.35	64.83±19.94	40017.57±10540.70	0.39±0.10	527.17±1052.10
	White	40	17.39±15.26	0.84±0.80	18.38±35.51	1535.12±9206.30	0.15±0.13	352.85±1447.85
Lykins Valley	Blue	47	36.03±17.94	1.67±1.19	2165.50±281.82	17564.81±11815.81	0.21±0.15	253.69±598.03
	Greenish Blue	20	29.22±15.31	1.22±1.22	44.14±1419.96	28552.90±10461.39	0.43±0.26	106.96±105.79
	Grayish Blue	3	80.05±9.32	2.71±0.25	14.14±10.78	46276.67±11956.53	0.20±0.26	206.67±70.94
	White	40	47.08±40.94	2.32±2.30	6.59±11.88	18341.34±22809.23	0.21±0.12	2146.44±3043.31
Weinmeister	White	6	13.40±1.72	0.84±0.21	52.00±52.66	153.84±111.00	0.29±0.12	104.86±52.35

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm)						
			Lanthanum (La)	Cerium (Ce)	Praseodymium (Pr)	Neodymium (Nd)	Samarium (Sm)	Europium (Eu)	Gadolinium (Gd)
5DA268	Blue	1	1.24	1.26	0.21	0.76	0.88	0.29	0.12
	White	1	8.67	10.89	1.50	6.16	1.85	0.48	0.99
5LR53	Blue	1	2.04	2.59	0.36	1.34	0.80	0.32	0.30
	White	1	3.65	4.86	0.65	2.98	0.84	0.18	0.71
5LR261	Blue	1	4.54	7.69	0.90	2.32	3.11	1.59	0.64
5LR11724	Blue	2	3.89±2.40	6.47±3.35	0.77±0.57	3.11±2.85	1.44±0.94	0.54±0.16	0.62±0.37
	White	1	35.27	32.78	6.72	27.73	5.92	1.13	4.09
5LR11726	Blue	2	3.98±0.91	6.81±1.77	0.66±0.08	2.15±0.16	0.84±0.12	0.22±0.07	0.42±0.39
	Grayish Blue	1	3.21	6.21	0.59	2.39	0.76	0.24	0.29
5LR11819	Blue	2	7.37±0.75	11.55±2.75	1.41±0.21	4.71±0.95	1.88±0.01	0.37±0.01	0.57±0.29
	White	1	24.74	28.03	4.58	16.41	3.41	0.54	2.08
5LR11838	Blue	1	10.58	15.09	1.91	8.37	3.47	1.62	1.83
Biscuit Hill	Blue	1	10.37	13.04	1.83	8.25	2.81	0.54	1.73
Fort Vasquez	Blue	48	3.25±1.47	5.00±2.51	0.61±0.30	2.45±1.24	0.72±0.43	0.22±0.18	0.42±0.18
	Greenish Blue	12	3.24±2.69	3.75±1.43	0.60±0.56	2.33±2.37	1.25±1.48	0.51±0.71	0.31±0.19
	White	40	3.35±4.24	4.11±4.42	0.60±0.70	2.52±2.95	0.76±0.82	0.21±0.23	0.58±0.83
Lykins Valley	Blue	47	3.70±1.24	5.12±1.72	0.69±0.25	2.83±0.91	1.97±4.91	0.82±2.40	0.55±0.22
	Greenish Blue	20	4.36±2.28	6.43±3.24	0.89±0.46	3.46±1.85	1.05±0.66	0.31±0.27	0.65±0.46
	Grayish Blue	3	7.59±1.22	10.45±0.27	1.48±0.26	6.33±0.70	3.13±1.36	1.16±0.82	1.47±0.27
	White	40	7.34±7.04	8.40±7.27	1.31±1.14	5.14±4.05	1.32±1.17	0.36±0.36	1.06±0.73
Weinmeister	White	6	8.81±7.12	9.62±7.98	1.52±1.20	6.72±5.20	1.24±1.00	0.20±0.20	1.40±0.82

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm) Terbium (Tb)	Dysprosium (Dy)	Holmium (Ho)	Erbium (Er)	Thulium (Tm)	Ytterbium (Yb)	Actinium (Lu)
5DA268	Blue	1	0.01	0.18	0.01	0.00	0.00	0.01	0.00
	White	1	0.15	0.71	0.10	0.35	0.02	0.11	0.05
5LR53	Blue	1	0.05	0.29	0.05	0.19	0.00	0.13	0.04
	White	1	0.11	0.51	0.12	0.27	0.04	0.28	0.05
5LR261	Blue	1	0.06	0.18	0.00	0.00	0.03	1.49	0.50
5LR11724	Blue	2	0.00	0.38±0.53	0.0±0.08	0.12±0.17	0.03±0.04	0.45±0.34	0.13±0.13
	White	1	0.32	2.45	0.43	1.08	0.06	0.97	0.16
5LR11726	Blue	2	0.00	0.00	0.01±0.01	0.00	0.00	0.00	0.00
	Grayish Blue	1	0.00	0.00	0.00	0.00	0.00	0.10	0.00
5LR11819	Blue	2	0.00	0.01±0.01	0.08±0.04	0.01±0.01	0.00	0.00	0.00
	White	1	0.35	1.49	0.23	0.47	0.06	0.94	0.09
5LR11838	Blue	1	0.32	1.89	0.41	0.81	0.11	1.18	0.38
Biscuit Hill	Blue	1	0.15	0.92	0.17	0.70	0.06	0.48	0.06
Fort Vasquez	Blue	48	0.05±0.03	0.36±0.22	0.08±0.04	0.23±0.18	0.02±0.02	0.23±0.16	0.02±0.02
	Greenish Blue	12	0.04±0.04	0.22±0.18	0.05±0.03	0.10±0.06	0.03±0.03	0.14±0.11	0.01±0.01
	White	40	0.08±0.12	0.54±0.70	0.10±0.15	0.30±0.46	0.04±0.07	0.31±0.41	0.05±0.07
Lykins Valley	Blue	47	0.07±0.04	0.52±0.20	0.09±0.04	0.25±0.10	0.03±0.02	0.28±0.13	0.05±0.04
	Greenish Blue	20	0.09±0.06	0.58±0.38	0.07±0.06	0.25±0.23	0.04±0.03	0.35±0.32	0.07±0.09
	Grayish Blue	3	0.25±0.08	1.88±0.63	0.30±0.13	0.88±0.12	0.12±0.05	1.06±0.34	0.24±0.19
	White	40	0.16±0.11	0.87±0.60	0.16±0.10	0.39±0.30	0.07±0.06	0.45±0.29	0.07±0.05
Weinmeister	White	6	0.18±0.11	1.06±0.61	0.18±0.10	0.49±0.28	0.07±0.05	0.40±0.22	0.06±0.03

Table B.1. Continued.

Site Name	Color	N	Mean Trace Element Counts (in ppm) Hafnium (Hf)	Tantalum (Ta)	Lead (Pb)	Thorium (Th)	Uranium (U)
5DA268	Blue	1	0.11	0.01	88666.13	0.59	0.87
	White	1	0.61	0.29	315983.84	3.14	0.53
5LR53	Blue	1	0.71	0.04	119457.38	0.94	0.52
	White	1	0.47	0.08	334254.75	1.93	0.38
5LR261	Blue	1	0.69	0.01	125052.17	1.28	1.92
5LR11724	Blue	2	0.73±0.79	0.04±0.05	73642.53±96948.71	0.76±0.29	3.78±4.57
	White	1	0.29	0.04	344090.41	1.71	0.80
5LR11726	Blue	2	0.22±0.16	0.06±0.08	26187.92±308.50	0.58±0.00	2.28±0.00
	Grayish Blue	1	0.22	0.00	25896.66	0.46	1.86
5LR11819	Blue	2	1.22±0.36	0.03±0.04	33821.31±47698.16	1.85±0.43	3.47±3.59
	White	1	0.41	0.09	284788.09	2.94	1.31
5LR11838	Blue	1	2.53	0.36	55103.55	1.83	0.83
Biscuit Hill	Blue	1	1.43	0.18	5551.74	2.57	1.21
Fort Vasquez	Blue	48	0.83±0.43	0.11±0.11	122735.44±46440.43	1.40±0.65	1.55±0.72
	Greenish Blue	12	0.38±0.28	0.02±0.02	157026.17±22088.12	1.16±0.17	1.51±1.26
	White	40	0.44±0.38	0.08±0.08	284059.97±58235.05	1.66±0.74	1.43±.93
Lykins Valley	Blue	47	0.92±0.45	0.12±0.07	102392.12±63733.03	1.34±0.36	1.60±0.81
	Greenish Blue	20	0.81±0.35	0.10±0.07	148116.56±81512.38	1.15±0.56	1.34±0.54
	Grayish Blue	3	2.26±0.46	0.32±0.16	1721.32±649.00	2.06±0.29	9.08±1.68
	White	40	1.23±1.04	0.20±0.20	192787.64±1.72	2.22±0.86	0.44±0.14
Weinmeister	White	6	0.37±0.04	0.06±0.02	341880.76±15891.05	2.75±0.81	1.24±1.12

Appendix C:

Descriptive Statistics and Independent Samples t-Tests comparing sites with five or more glass beads (Fort Vasquez, Lykins Valley, and Weinmeister) tested for chemistry and all other beads sampled for chemistry.

Table C.1. Descriptive Statistics and Independent Samples t-Tests, comparing site Fort Vasquez and all other beads sampled for trace element counts (ppm).

Chemical Element	**Site Name Fort Vasquez**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**Mean Difference**	**t**
Sodium †	Yes	100	19030.5441	17507.52416	1750.75242	-14957.83088	-4.765**
(Na)	No	122	33988.3750	28778.77530	2605.50789		
Magnesium†	Yes	100	1488.9694	1118.43262	111.84326	-1796.65405	-6.003**
(Mg)	No	122	3285.6235	3066.56985	277.63419		
Aluminum †	Yes	100	4321.9388	3985.26055	398.52606	-2097.74188	-3.510*
(Al)	No	122	6419.6807	4918.49861	445.29994		
Silicon†	Yes	100	260904.6105	67493.72506	6749.37251	-23911.47982	-2.839**
(Si)	No	122	284816.0903	55657.22612	5038.96849		
Potassium†	Yes	100	44101.2121	12583.80045	1258.38004	-6451.13734	-2.855**
(K)	No	122	50552.3495	20733.15671	1877.09181		
Calcium†	Yes	100	19028.7848	14263.25430	1426.32543	-9333.88209	-3.813**
(Ca)	No	122	28362.6669	21974.50064	1989.47781		
Scandium	Yes	100	7.6020	5.11050	.51105	-1.73415	-1.857
(Sc)	No	122	9.3361	8.10754	.73402		
Titanium	Yes	100	166.4651	139.21246	13.92125	-104.30687	-4.232
(Ti)	No	122	270.7720	224.64165	20.33810		
Vanadium†	Yes	100	9.5911	10.05505	1.00551	-5.47029	-2.542*
(V)	No	122	15.0614	21.01420	1.90254		
Chromium†	Yes	100	8.1049	21.90110	2.19011	7.43924	3.357**
(Cr)	No	122	.6657	3.71845	.33665		
Manganese†	Yes	100	283.2108	230.92232	23.09223	-115.63141	-2.804*
(Mn)	No	122	398.8422	377.33632	34.16242		
Iron	Yes	100	3286.6799	2880.13549	288.01355	-81.68541	-.206
(Fe)	No	122	3368.3653	2975.43548	269.38327		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.1. Continued

Chemical Element	Site Name Fort Vasquez	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Nickel† (Ni)	Yes	100	23.0232	19.65040	1.96504	-13.79844	-2.984**
	No	122	36.8216	46.22799	4.18529		
Cobalt† (Co)	Yes	100	10.1100	12.57941	1.25794	-17.56721	-4.401**
	No	122	27.6772	41.83934	3.78796		
Copper† (Cu)	Yes	100	11729.3865	10095.12513	1009.51251	1148.61965	.901**
	No	122	10580.7668	8588.46938	777.56348		
Zinc (Zn)	Yes	100	47.2075	71.41319	7.14132	-5.79865	-.756
	No	122	53.0061	41.24383	3.73404		
Arsenic† (As)	Yes	100	55837.8544	73342.06062	7334.20606	35782.54820	4.527**
	No	122	20055.3062	32536.14599	2945.68425		
Rubidium† (Rb)	Yes	100	20.1677	7.71970	.77197	-7.08607	-3.341**
	No	122	27.2538	21.81948	1.97544		
Strontium (Sr)	Yes	100	141.0441	130.11445	13.01144	-9.72180	-.520
	No	122	150.7659	145.00871	13.12847		
Yttrium (Y)	Yes	100	3.2805	4.06323	.40632	-.96491	-2.108
	No	122	4.2454	2.72458	.24667		
Zirconium† (Zr)	Yes	100	25.1087	16.58113	1.65811	-10.66212	-3.591**
	No	122	35.7708	27.20355	2.46289		
Niobium† (Nb)	Yes	100	1.2316	1.05784	.10578	-.48463	-2.756**
	No	122	1.7162	1.55158	.14047		
Tin† (Sn)	Yes	100	1471.3826	3447.69822	344.76982	546.86105	1.393**
	No	122	924.5216	2072.64126	187.64812		
Antimony (Sb)	Yes	100	18975.8528	17432.24631	1743.22463	-147.74056	-.064
	No	122	19123.5934	16707.71245	1512.64521		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table C.1. Continued.

Chemical Element	Site Name Fort Vasquez	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Cesium† (Cs)	Yes	100	.2618	.17539	.01754	-.05935	-1.755**
	No	122	.3211	.31936	.02891		
Barium† (Ba)	Yes	100	259.4694	992.01619	99.20162	-415.49683	-2.219**
	No	122	674.9662	1753.66258	158.76915		
Lanthanum† (La)	Yes	100	3.2874	2.98755	.29875	-2.48186	-4.282**
	No	122	5.7693	5.48666	.49674		
Cerium† (Ce)	Yes	100	4.4919	3.34069	.33407	-2.73966	-4.496**
	No	122	7.2316	5.62951	.50967		
Praseodymium† (Pr)	Yes	100	.6006	.51960	.05196	-.44604	-4.408**
	No	122	1.0466	.95893	.08682		
Neodymium† (Nd)	Yes	100	2.4642	2.18691	.21869	-1.73375	-4.310**
	No	122	4.1980	3.72895	.33760		
Samarium† (Sm)	Yes	100	.7997	.78950	.07895	-.85841	-2.875**
	No	122	1.6581	3.18056	.28795		
Europium† (Eu)	Yes	100	.2488	.32088	.03209	-.32005	-2.256*
	No	122	.5689	1.52615	.13817		
Gadolinium† (Gd)	Yes	100	.4719	.54597	.05460	-.34408	-4.308**
	No	122	.8160	.64402	.05831		
Terbium† (Tb)	Yes	100	.0620	.08064	.00806	-.04398	-3.801**
	No	122	.1060	.09167	.00830		
Dysprosium† (Dy)	Yes	100	.4160	.48270	.04827	-.27015	-3.969**
	No	122	.6861	.53010	.04799		
Holmium (Ho)	Yes	100	.0860	.10034	.01003	-.02859	-2.185
	No	122	.1146	.09417	.00853		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table C.1. Continued.

Chemical Element	Site Name Fort Vasquez	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Erbium	Yes	100	.2423	.32229	.03223	-.06909	-1.786
(Er)	No	122	.3114	.25394	.02299		
Thulium	Yes	100	.0306	.04707	.00471	-.01366	-2.265
(Tm)	No	122	.0443	.04270	.00387		
Ytterbium†	Yes	100	.2491	.28731	.02873	-.12574	-3.164*
(Yb)	No	122	.3748	.30319	.02745		
Actinium†	Yes	100	.0292	.04902	.00490	-.04178	-4.695**
(Lu)	No	122	.0710	.08203	.00743		
Hafnium †	Yes	100	.6217	.44365	.04436	-.34141	-4.387**
(Hf)	No	122	.9631	.70613	.06393		
Tantalum†	Yes	100	.0872	.09807	.00981	-.04665	-3.077*
(Ta)	No	122	.1339	.12768	.01156		
Lead†	Yes	100	191380.1401	91171.86707	9117.18671	47273.69256	3.267*
(Pb)	No	122	144106.4476	1.24124E5	11237.62897		
Thorium†	Yes	100	1.4782	.66830	.06683	-.15147	-1.545**
(Th)	No	122	1.6297	.79273	.07177		
Uranium	Yes	100	1.4957	.87627	.08763	.02840	.158
(U)	No	122	1.4673	1.60943	.14571		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table C.2. Descriptive Statistics and Independent Samples t-Tests, comparing site Lykins Valley and all other beads sampled for trace element counts (ppm).

Chemical Element	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Sodium† (Na)	Yes	100	33719.9361	28932.61539	2893.26154	11772.04641	3.410**
	No	122	21947.8897	20803.36716	1883.44837		
Magnesium† (Mg)	Yes	100	3442.2465	3262.85037	326.28504	1757.66988	5.052**
	No	122	1684.5766	1334.06051	120.78016		
Aluminum† (Al)	Yes	100	6676.1389	5149.07934	514.90793	2186.13046	3.497*
	No	122	4490.0084	3914.30698	354.38470		
Silicon† (Si)	Yes	100	288538.5520	50255.57778	5025.55778	26373.23351	3.302**
	No	122	262165.3185	68572.83948	6208.29318		
Potassium† (K)	Yes	100	51430.8316	21092.25912	2109.22591	6886.36699	2.805**
	No	122	44544.4646	13884.97812	1257.08685		
Calcium† (Ca)	Yes	100	28927.4325	23140.63706	2314.06371	8678.41131	3.250**
	No	122	20249.0212	14716.13781	1332.33652		
Scandium† (Sc)	Yes	100	9.7720	8.65897	.86590	2.21454	2.268*
	No	122	7.5575	4.98938	.45172		
Titanium† (Ti)	Yes	100	285.1520	236.93451	23.69345	111.66438	4.154**
	No	122	173.4876	140.24114	12.69684		
Vanadium (V)	Yes	100	12.7945	12.07285	1.20729	.35884	.155
	No	122	12.4357	20.45965	1.85233		
Chromium† (Cr)	Yes	100	.8121	4.09626	.40963	-5.83126	-3.133**
	No	122	6.6434	20.05586	1.81577		
Manganese† (Mn)	Yes	100	440.6668	393.91701	39.39170	170.88688	3.843**
	No	122	269.7799	227.73719	20.61836		
Iron (Fe)	Yes	100	3555.7124	3181.56761	318.15676	220	1.003
	No	122	3147.8469	2699.20689	244.37471		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.2. Continued

Chemical Element	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Nickel† (Ni)	Yes	100	37.8423	46.48403	4.64840	13.16746	2.521*
	No	122	24.6748	26.32085	2.38298		
Cobalt (Co)	Yes	100	26.3199	37.34350	3.73435	11.92949	2.697
	No	122	14.3904	28.54020	2.58391		
Copper† (Cu)	Yes	100	11190.5787	8678.40362	867.84036	168.16622	.135**
	No	122	11022.4125	9803.53173	887.57006		
Zinc (Zn)	Yes	100	48.7549	34.37724	3.43772	-2.98289	-.389
	No	122	51.7378	70.12817	6.34911		
Arsenic† (As)	Yes	100	16551.4477	29869.19184	2986.91918	-35705.83129	-5.169**
	No	122	52257.2790	68790.86306	6228.03211		
Rubidium (Rb)	Yes	100	22.7398	14.14372	1.41437	-2.40569	-1.030
	No	122	25.1455	19.52823	1.76800		
Strontium (Sr)	Yes	100	162.1059	151.94931	15.19493	28.60377	1.538
	No	122	133.5021	125.13922	11.32957		
Yttrium (Y)	Yes	100	4.1343	2.45281	.24528	.58873	1.278
	No	122	3.5456	4.03416	.36524		
Zirconium† (Zr)	Yes	100	39.3045	27.95706	2.79571	15.16958	4.785**
	No	122	24.1349	16.51086	1.49482		
Niobium† (Nb)	Yes	100	1.8062	1.63627	.16363	.56095	2.966**
	No	122	1.2452	1.04697	.09479		
Tin (Sn)	Yes	100	1109.0167	2249.08563	224.90856	-112.52609	-.299
	No	122	1221.5428	3164.27779	286.48025		
Antimony† (Sb)	Yes	100	20856.7402	16726.36495	1672.63650	3274.85782	1.435*
	No	122	17581.8824	17146.85512	1552.40332		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.2. Continued.

Chemical Element	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Cesium†	Yes	100	.2535	.19239	.01924	-.07445	-2.189*
(Cs)	No	122	.3280	.30976	.02804		
Barium†	Yes	100	790.7604	1918.36655	191.83665	551.27859	2.645**
(Ba)	No	122	239.4818	899.92603	81.47547		
Lanthanum	Yes	100	5.1621	4.42756	.44276	.92948	1.473
(La)	No	122	4.2326	4.87567	.44142		
Cerium	Yes	100	6.5246	4.62041	.46204	.95919	1.449
(Ce)	No	122	5.5654	5.13292	.46471		
Praseodymium	Yes	100	.9366	.72861	.07286	.16537	1.498
(Pr)	No	122	.7712	.88545	.08016		
Neodymium	Yes	100	3.7519	2.65960	.26596	.60944	1.397
(Nd)	No	122	3.1425	3.63692	.32927		
Samarium†	Yes	100	1.6272	3.45908	.34591	.64736	1.812*
(Sm)	No	122	.9798	.99021	.08965		
Europium†	Yes	100	.5904	1.67429	.16743	.30155	1.769*
(Eu)	No	122	.2889	.35361	.03201		
Gadolinium	Yes	100	.7515	.53305	.05331	.16470	1.968
(Gd)	No	122	.5868	.68383	.06191		
Terbium	Yes	100	.1036	.08264	.00826	.03171	2.666
(Tb)	No	122	.0719	.09251	.00838		
Dysprosium	Yes	100	.6800	.47715	.04772	.21025	3.019
(Dy)	No	122	.4698	.54629	.04946		
Holmium	Yes	100	.1111	.08528	.00853	.01708	1.297
(Ho)	No	122	.0940	.10674	.00966		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.2. Continued.

Chemical Element	Site Name Lykins Valley	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Erbium (Er)	Yes	100	.3095	.23404	.02340	.05319	1.371
	No	122	.2563	.32487	.02941		
Thulium (Tm)	Yes	100	.0453	.04305	.00431	.01309	2.167
	No	122	.0322	.04611	.00417		
Ytterbium (Yb)	Yes	100	.3675	.27076	.02708	.08971	2.221
	No	122	.2778	.32095	.02906		
Actinium (Lu)	Yes	100	.0674	.06837	.00684	.02773	2.899
	No	122	.0397	.07291	.00660		
Hafnium† (Hf)	Yes	100	1.0349	.71310	.07131	.41047	4.946**
	No	122	.6244	.46906	.04247		
Tantalum† (Ta)	Yes	100	.1461	.13153	.01315	.06053	3.831*
	No	122	.0856	.09666	.00875		
Lead (Pb)	Yes	100	135635.5378	1.17925E5	11792.49434	-54163.20669	-3.659
	No	122	189798.7445	1.02530E5	9282.62555		
Thorium (Th)	Yes	100	1.5856	.73054	.07305	.04396	.439
	No	122	1.5416	.75282	.06816		
Uranium (U)	Yes	100	1.4228	1.58390	.15839	-.10425	-.581
	No	122	1.5270	1.07765	.09757		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.3. Descriptive Statistics and Independent Samples t-Tests, comparing site Weinmeister and all other beads sampled for trace element counts (ppm).

Chemical Element	**Site Name Weinmeister**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**	**Mean Difference**	**t**
Sodium† (Na)	Yes	6	31092.3197	2039.61850	832.67077	3948.42042	2.034**
	No	216	27143.8992	25766.64709	1753.19827		
Magnesium (Mg)	Yes	6	1309.0200	351.52858	143.51094	-1199.72482	-1.137
	No	216	2508.7448	2579.05374	175.48238		
Aluminum (Al)	Yes	6	3054.4333	1105.98921	451.51820	-2487.54963	-1.300
	No	216	5541.9830	4675.08255	318.09908		
Silicon† (Si)	Yes	6	191508.1536	5085.55339	2076.16848	-84829.69423	-18.143**
	No	216	276337.8479	61572.11587	4189.45184		
Potassium (K)	Yes	6	40475.0716	3982.15413	1625.70761	-7370.56458	-1.001
	No	216	47845.6362	17989.79166	1224.05028		
Calcium (Ca)	Yes	6	16887.0667	4541.42688	1854.02976	-7473.12511	-.929
	No	216	24360.1918	19639.48563	1336.29774		
Scandium (Sc)	Yes	6	3.5983	.77803	.31763	-5.09435	-1.777
	No	216	8.6927	7.00496	.47663		
Titanium (Ti)	Yes	6	121.4333	49.80048	20.33096	-105.19671	-1.289
	No	216	226.6300	199.36715	13.56522		
Vanadium (V)	Yes	6	35.1567	21.77791	8.89079	23.18602	3.338
	No	216	11.9706	16.64642	1.13265		
Chromium (Cr)	Yes	6	.0000	.00000	.00000	-4.12824	-.648
	No	216	4.1282	15.56697	1.05920		
Manganese† (Mn)	Yes	6	36.7733	6.63222	2.70759	-318.59329	-14.319*
	No	216	355.3666	324.57131	22.08428		
Iron (Fe)	Yes	6	1401.6700	678.28988	276.91068	-1983.50844	-1.644
	No	216	3385.1784	2947.25769	200.53549		

** $p<0.01$, * $p<0.05$; † Equal variances not assumed.

Table C.3. Continued

Chemical Element	Site Name Weinmeister	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Nickel (Ni)	Yes	6	1.4767	1.96795	.80341	-29.93861	-1.952
	No	216	31.4153	37.47987	2.55018		
Cobalt (Co)	Yes	6	.4517	.18357	.07494	-19.84884	-1.446
	No	216	20.3005	33.55935	2.28342		
Copper† (Cu)	Yes	6	995.4967	1807.04429	737.72274	-10383.29596	-10.702**
	No	216	11378.7927	9261.37386	630.15667		
Zinc (Zn)	Yes	6	25.5333	13.59862	5.55161	-25.55139	-1.088
	No	216	51.0847	57.37773	3.90406		
Arsenic† (As)	Yes	6	71983.3294	2186.61914	892.68352	36804.47374	9.098**
	No	216	35178.8557	57991.56226	3945.82603		
Rubidium (Rb)	Yes	6	22.8500	7.06601	2.88469	-1.24551	-.173
	No	216	24.0955	17.52173	1.19220		
Strontium (Sr)	Yes	6	77.2700	48.95947	19.98762	-71.03662	-1.243
	No	216	148.3066	139.50290	9.49197		
Yttrium (Y)	Yes	6	5.2967	2.89060	1.18008	1.52718	1.080
	No	216	3.7695	3.42933	.23334		
Zirconium† (Zr)	Yes	6	13.4000	1.71969	.70206	-18.05606	-10.255*
	No	216	31.4561	23.73220	1.61477		
Niobium (Nb)	Yes	6	.8383	.20999	.08573	-.67792	-1.196
	No	216	1.5162	1.38444	.09420		
Tin† (Sn)	Yes	6	51.9950	52.65648	21.49692	-1149.93981	-5.964*
	No	216	1201.9348	2816.29280	191.62445		
Antimony† (Sb)	Yes	6	153.8367	110.99745	45.31452	-19428.29597	-16.848**
	No	216	19582.1326	16934.74474	1152.26343		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table C.3. Continued.

Chemical Element	Site Name Weinmeister	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Cesium	Yes	6	.2850	.12438	.05078	-.00968	-.088
(Cs)	No	216	.2947	.26852	.01827		
Barium	Yes	6	104.8583	52.35226	21.37272	-393.58458	-.645
(Ba)	No	216	498.4429	1491.23018	101.46536		
Lanthanum	Yes	6	8.8100	7.12475	2.90867	4.27421	2.221
(La)	No	216	4.5358	4.57708	.31143		
Cerium	Yes	6	9.6167	7.97706	3.25662	3.71972	1.836
(Ce)	No	216	5.8969	4.79974	.32658		
Praseodymium	Yes	6	1.5200	1.20406	.49156	.69301	2.055
(Pr)	No	216	.8270	.80369	.05468		
Neodymium	Yes	6	6.7217	5.19515	2.12091	3.39648	2.564
(Nd)	No	216	3.3252	3.13931	.21360		
Samarium	Yes	6	1.2350	1.00397	.40987	-.03745	-.037
(Sm)	No	216	1.2725	2.47892	.16867		
Europium	Yes	6	.1983	.20124	.08216	-.23264	-.484
(Eu)	No	216	.4310	1.17559	.07999		
Gadolinium	Yes	6	1.4033	.82396	.33638	.76296	3.005
(Gd)	No	216	.6404	.60774	.04135		
Terbium	Yes	6	.1750	.11256	.04595	.09130	2.496
(Tb)	No	216	.0837	.08773	.00597		
Dysprosium	Yes	6	1.0550	.61060	.24928	.50417	2.340
(Dy)	No	216	.5508	.51819	.03526		
Holmium	Yes	6	.1750	.09586	.03914	.07532	1.871
(Ho)	No	216	.0997	.09731	.00662		

** p<0.01, * p<0.05; † Equal variances not assumed.

Table C.3. Continued.

Chemical Element	Site Name Weinmeister	N	Mean	Std. Deviation	Std. Error Mean	Mean Difference	t
Erbium (Er)	Yes	6	.4850	.28162	.11497	.21042	1.773
	No	216	.2746	.28687	.01952		
Thulium (Tm)	Yes	6	.0717	.04622	.01887	.03449	1.857
	No	216	.0372	.04486	.00305		
Ytterbium (Yb)	Yes	6	.3983	.22076	.09013	.08236	.658
	No	216	.3160	.30408	.02069		
Actinium (Lu)	Yes	6	.0567	.03204	.01308	.00463	.155
	No	216	.0520	.07291	.00496		
Hafnium† (Hf)	Yes	6	.3700	.03521	.01438	-.45153	-10.003*
	No	216	.8215	.62887	.04279		
Tantalum (Ta)	Yes	6	.0617	.01722	.00703	-.05259	-1.083
	No	216	.1143	.11865	.00807		
Lead† (Pb)	Yes	6	341880.7604	15891.04712	6487.49282	1.81382E5	18.282**
	No	216	160498.6854	1.10319E5	7506.26591		
Thorium (Th)	Yes	6	2.7517	.81168	.33137	1.22329	4.128
	No	216	1.5284	.71361	.04855		
Uranium (U)	Yes	6	1.2417	1.11519	.45528	-.24505	-.445
	No	216	1.4867	1.33454	.09080		

** p<0.01, * p<0.05; † Equal variances not assumed.