Geochemical Characterization of Brown Chalcedony during the Besant/Sonota Period

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Abstract

Suitable lithic material for toolmaking is fairly common across the Northern Plains and often can be found within the glacial till that still blankets the area. However, high quality toolstone tends to be limited to specific and well-known quarry locations such as the Knife River flint quarries of North Dakota. Archaeologists have long identified high-quality brown chalcedony found in archaeological sites as Knife River flint (KRF) based on a visual inspection. This material has been found throughout the Northern Plains region and is believed to have been a highly desired trade item. However, the discovery of local sources of high-quality brown chalcedony that is macroscopically identical to KRF has called into question whether this material was traded as widely as previously assumed. Samples of visually identical brown chalcedony from source locations across the Northern Plains, specifically Alberta, Saskatchewan, Manitoba, Montana, North Dakota, and South Dakota, along with KRF from the Primary Source Area in North Dakota, were collected in order to undergo geochemical characterization. This analysis was designed to determine if these source areas could be distinguished from one another and what elements aid in this differentiation. It was found that while similarities between a number of source locations exist, certain source areas such as the KRF Primary Source Area and source areas in Alberta, North Dakota and South Dakota can be distinguished from one another. For this reason, further analysis into the archaeological implications of local varieties of high-quality brown chalcedony material were undertaken.

The use of high-quality brown chalcedony seemed to have peaked during the Besant/Sonota time period (c. 2100 – 1100 BP) on the Northern Plains. Artifacts from well-known Besant/Sonota archaeological sites across Alberta, Saskatchewan, and Manitoba were selected to undergo geochemical characterization using laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS). This analysis has resulted in the discovery that local source areas of brown chalcedony were being exploited by Precontact groups rather than the KRF quarries in North Dakota. The implications of this are discussed in terms of trade and exchange relationships, ethnic/cultural landscapes, and economic efficiency.

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List of Abbreviations

% m/m – Mass Percent

BP – Before Present

c. – circa

CARD – Canadian Archaeological Radiocarbon Database

Cd – Cadmium

cm – centimetres

Cs – Caesium

DA – Discriminant Analysis

DNA – Deoxyribonucleic Acid

Ga - Gallium

GPSr – Global Positioning Systems Receiver

$HClO_4$ – Perchloric Acid

Hf - Hafnium

HF – Hydrofluoric Acid

HNO_3 – Nitric Acid

HS – Hard Siliceous Bed

Hz - Hertz

ICP-MS – Inductively-Coupled Plasma Mass Spectrometry

IMA – International Mineralogical Association

INAA – Instrumental Neutron Activation Analysis

K - Kelvin

km - kilometres

KRF – Knife River flint

K-T – Cretaceous-Tertiary

LA-ICP-MS – Laser Ablation Inductively-Coupled Plasma Mass Spectrometry

lb. – Pound

MnO – Manganese oxide

ms - millisecond

MURR - University of Missouri Research Reactor Facility

NAA – Neutron Activation Analysis

NIST – National Institute of Standards and Technology

NRHP – National Register of Historic Places

P_2O_5 – Phosphorus pentoxide

PAST - Palaeontological Statistics

PC – Principal Component

PCA – Principal Component Analysis

ppb – parts per billion

ppm – parts per million

PSA – Primary Source Area

REE – Rare Earth Element

SiO_2 – Silicon dioxide

SPSS – Statistical Package for the Social Sciences

SRC – Saskatchewan Research Council

Ta - Tantalum

TiO_2 – Titanium dioxide

UV – Ultraviolet

W – Tungsten

WRGS – White River Group Silicates

wt % - Weight percent

XRF – X-Ray Fluorescence

Chapter 1 - Introduction

The occurrence of lithic tools in Precontact sites on the Northern Plains is both well-known and well-documented. Typically, in the archaeological literature, lithic tools are identified on the basis of function, size, shape, knapping patterns, and raw material type in order to help determine site function, time period, and group behavioural systems. While raw material type is identified in the literature when it comes to lithic tools, not as much attention has been paid to conclusively identifying individual source areas. While a number of source areas yielding stone suitable for toolmaking by Indigenous groups have been located across the Plains region, and efforts have been made to understand trade and mobility by linking tools made of visually distinctive stone to specific sources, many linkages have been made based on identifying macroscopic characteristics alone or with basic microscopy. Despite this common practice there are no lithic materials that can be definitively linked to source areas based on visual criteria alone.

In the past, a variety of brown chalcedony found in archaeological contexts was regarded as sufficiently visually distinctive to confidently identify it as Knife River flint (KRF), which originates from multiple quarry locations in the Dunn and Mercer Counties of North Dakota (Ahler 1986; Clayton et al. 1970; Gregg 1987). Due to the extensive documentation of this material, it is all too often assumed by archaeologists when brown chalcedony is found in archaeological sites that it is KRF. This type of lithic toolstone was widely thought to be traded throughout the Precontact period with extensive usage of it during specific time periods including Cody Complex, Pelican Lake and Besant/Sonota. However, it reached a zenith during the Besant/Sonota c. 2100-1100 Before Present (BP) period, with high percentages of artifacts made from brown chalcedony (Dyck 1983; Johnson and Johnson 1998; Peck 2011; Peck and Hudecek-Cuffe 2003; Reeves 1983). A number of Besant/Sonota archaeological sites on the Northern Plains, such as Muhlbach (FbPf-1) in Alberta and Fitzgerald (ElNp-8) in Saskatchewan possess high concentrations of brown chalcedony in their lithic assemblages (Gruhn 1971; Hjermstad 1996; Kevinsen 2013).

Due to the widespread presence of what is thought to be KRF, hypotheses regarding Precontact trading networks and mobility patterns were created based on the toolstone's distinctive nature. Artifacts and debitage composed of brown chalcedony found in archaeological sites throughout the Northern Plains region were identified as KRF based on visual inspection \

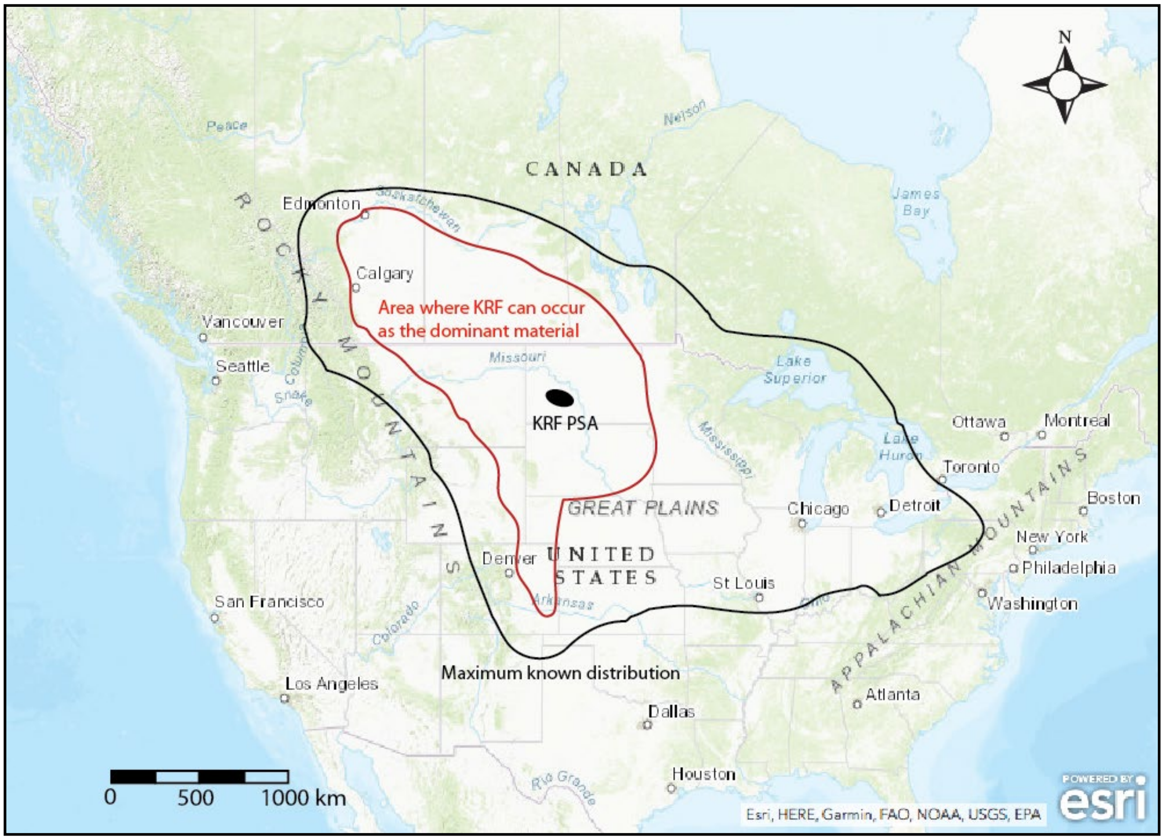

Figure 1.1: KRF Distribution in North America According to Ahler (1986)

alone. The supposed appearance of this material in archaeological sites implied an extensive trading network throughout the Great Plains and beyond (Figure 1.1). For example, the presence of brown chalcedony identified as KRF in archaeological sites in the Ohio River Valley was seen as indicating the exchange of this material into the region during the period of the Hopewell Interaction Sphere (Boszhardt 1998). It was also felt that mobility patterns of some Precontact groups were based on the procurement of this material either through intermediaries or by direct access to the KRF quarries in North Dakota. Many hypotheses and beliefs regarding toolstone acquisition and trade were based on KRF being one of the most highly desirable and tradable types of brown chalcedony found on the Northern Plains.

It has also been long assumed that KRF is macroscopically unique enough to be identified solely on visual inspection, usually involving holding the artifact up to the light to examine it based on its colour and the presence of both dark and light inclusions. However, visually similar varieties of brown chalcedony occur in the South Saskatchewan River valley, in the Souris gravels of Manitoba, in the Hand Hills of Alberta, in some Montana cherts (e.g., Smith River quarries), in the White River Group outcrop of South Dakota, and as Root Beer flint from Texas to name a few (Ahler 1977; I. Dyck, personal communication 2009; Hlady 1965; Hoard et al. 1993; D. Meyer, personal communication 2008; Roll et al. 2005; E. Walker, personal communication 2008). With the discovery of visually similar lithic material, what was assumed to be widespread trade and exchange networks as well as Precontact group mobility patterns to and from quarry areas used by Besant/Sonota groups must be called into question. An analysis of different brown chalcedony source areas and artifacts from Besant/Sonota sites containing high percentages of this material is necessary to determine whether or not KRF classifications are truly accurate or if perhaps the material represents another type of brown chalcedony.

Due to the fact that most of the brown chalcedony materials listed above are macroscopically indistinguishable from KRF, more in-depth chemical analyses examining elemental and mineral composition are necessary to determine if previous conclusions based upon the distribution of this material are correct. The first step in this analysis is to chemically identify how brown chalcedony from different source areas across the Northern Plains compares to KRF from the North Dakota quarries. Trace element analysis of chalcedonic materials using techniques such as x-ray diffraction, inductively-coupled plasma mass spectrometry, stable isotope analyses, and scanning electron microscopy (Curran et al. 2001; Evans et al. 2007; Malyk-Selivanova et al. 1998; Pretola 2001; Quinn 2008; Roll et al. 2005; Shackley 2008; Tang et al. 2001) can link archaeological toolstones to source areas. Often silica-rich stones such as chert and chalcedony have a very heterogeneous microstructure that inhibits trace element analysis from sufficiently determining properties that can be used to identify source areas (Luedtke 1992; Rapp 2002). Inductively-coupled plasma mass spectrometry (ICP-MS) is a technique known for its ability to rapidly detect concentrations of elements in the parts per billion range and is useful in determining trace element analysis of samples that are very similar to one another based on its high degree of precision. As a result of these increased detection limits, ICP-MS may be able to elucidate minute differences in elemental composition in heterogeneous rocks. Unfortunately, many geochemical techniques, including ICP-MS, can be destructive to the materials being analysed. While this is not an issue when studying unmodified raw materials from possible quarry locations, the use of destructive techniques on artifacts is typically seen as unpopular because they result in irreversible damage to the artifact. Since the second step of this research is to compare these results with those obtained from select Besant/Sonota sites across the Northern Plains to determine if assumptions on trade and resource use are accurate, finding geochemical techniques that are non- or minimally-destructive to archaeological samples are vitally important. For this reason, laser ablation in ICP-MS as a minimally-destructive method for elemental characterization is incorporated.

1.1 Dissertation Approach

The goal of this dissertation is to chemically analyse sources of brown chalcedony on the Northern Plains and reassess trade patterns of this type of toolstone among Besant/Sonota archaeological groups and the potential impact of this implied trade on the social customs and lifeways of the groups involved. The existence of trade networks not only allows for the exchange of goods, but also the exchange of ideas and cultural beliefs. By understanding the role that brown chalcedony played in Precontact exchange systems, an insight into the flow of ideas and cultural experiences between Precontact peoples on the Northern Plains can become evident. The primary objective of this study is to verify and to collect from additional source areas of visually-similar brown chalcedony in areas such as the Hand Hills of Alberta, the Souris gravels of Manitoba, the South Saskatchewan River valley and other localities on the Northern Plains (Ahler 1977; I. Dyck, personal communication 2009; Hlady 1965; Hoard et al. 1993; D. Meyer, personal communication 2008; Roll et al. 2005; E. Walker, personal communication 2008). Much of what has been termed "Knife River flint" from sites in Alberta, Saskatchewan, Manitoba, Montana, North and South Dakota may actually be material derived from local sources. If so, the knowledge of additional source areas of visually similar brown chalcedony calls into question the idea that all brown chalcedony found on the Northern Plains can be traced back to the KRF quarries of North Dakota.

Once brown chalcedony from a number of source areas is analysed using geochemical techniques and compared to KRF, a comparative analysis of archaeological sites dating to the Besant/Sonota time period is necessary to determine if what has been identified as KRF in lithic archaeological assemblages from these sites has been correctly identified. Brown chalcedony artifacts and debitage from archaeological sites will be geochemically compared to KRF to determine a positive or negative identification. If a positive identification is found, it can be likely concluded that the inhabitants of a particular Besant/Sonota site did partake in the trade and exchange of KRF or structured their seasonal round around procuring this lithic material. Discussions surrounding what is currently known about Besant/Sonota groups' usage of KRF can be confirmed. If a negative identification for KRF in a Besant/Sonota site is found, further analysis into identifying what type of brown chalcedony is being used and where its source area is located is undertaken. Based on the results of the chemical analyses, comparison of archaeological site lithics to brown chalcedony sources is possible. This would substantially call into question the current scholarship regarding the trade and exchange of KRF by Besant/Sonota groups. It would require a readjustment and a reanalysis of what archaeologists have previously constructed for social relationships and behavioural choices of these groups.

Numerous studies involving the trade and distribution of KRF in the United States attribute this particular trade material to the Sonota complex during the Middle Woodland Period (Clark 1984; Neuman 1975; Syms 1977). Sonota habitation sites are found throughout North and South Dakota and extend north into Canada (Clark 1984). From an analysis of chipped stone raw material from Sonota sites, KRF accounts for over 80% of tools (Clark 1984:181; Syms 1977:90). Sonota sites found in Saskatchewan and Alberta with quantities of KRF in their lithic assemblages are sometimes referred to as Besant in the archaeological literature because they lack some of the distinguishing characteristics of typical Sonota complex sites (D. Meyer, personal communication 2009). I will focus on those archaeological sites in Alberta, Manitoba, and Saskatchewan that include cultural material from identified Besant and Sonota groups as they tend to exhibit high percentages of artifacts made from brown chalcedony (Johnson and Johnson 1998; Peck and Hudecek-Cuffe 2003; Reeves 1983). This research is designed to re-examine what archaeologists have assumed about trade and exchange of KRF amongst Besant/Sonota groups. The geochemical analysis will either confirm or refute previously held beliefs that are deeply entrenched in the archaeological literature and often taken as accurate without the background data (e.g., geochemical sourcing) to support them. Should KRF not be represented in the archaeological sites analysed for this research, it will necessitate an overhaul of how archaeologists refer to and name lithic material in archaeological sites and introduce further questions into how lithic procurement strategies are socially constructed and carried out. At its core this project and dissertation is interdisciplinary as it utilizes archaeometric and geochemical techniques to determine lithic raw material source areas across the Northern Plains and from this infer the social behaviour of Besant and Sonota groups.

1.2 Dissertation Organization

This dissertation is organized into nine chapters which provide: an overview of the research, an analysis of archaeological and raw materials, and elucidates some aspects of social behaviour, specifically lithic raw material selection, believed to have been displayed by Besant/Sonota groups. Chapter two is devoted to a theoretical overview with relevant archaeological and ethnographic examples to lithic procurement strategies. A discussion of relevant archaeological theories and how they do and do not relate to stone tools studies and raw material procurement is provided. A number of questions are posed as to how raw material selection may fit into the wider social ethos of Besant/Sonota groups on the Canadian Plains. Chapter three is an archaeological overview of what is currently known for Besant and Sonota groups during the Late Precontact Period with a discussion of how they are defined outside of Canadian archaeology and their ties to the Hopewell Interaction Sphere. This overview and discussion is important in terms of understanding a number of facets, including what constitutes Besant and Sonota, how these two constructs relate to one another, how lithic material procurement relates to proposed trade and exchange networks, and if there are cultural values in procuring lithic toolstone. Throughout the dissertation, Besant and Sonota will be referred to as "Besant/Sonota" in order to simplify the terminology used to describe the human populations that occupied the Northern Plains from c. 2100-1100 BP. The literature is inconsistent in how it refers to the archaeology from this time period in that it fluctuates between combining the two terms, separating them into distinct cultural complexes, and at times adds various projectile point typologies in reference to specific cultural expressions that may or may not refer to the larger archaeological cultures of the period. For the sake of consistency, referring to groups from this time period as "Besant/Sonota" incorporates the cultural and temporal designations used in the research for the archaeological sites that are analysed in this dissertation. A more comprehensive discussion of taxonomy can be found in chapter three. A discussion of select Besant/Sonota archaeological sites from across the Canadian Plains that were used in this study is provided in chapter four. Chapter five includes an overview of chemical analyses and provenance studies associated with chert and chalcedony materials, including a geological overview of the source areas selected for this study. A review of geochemical analyses including potential problems that may arise when chemically characterizing silica-rich lithic material is included, and the chapter ends with a discussion of the multivariate statistics used in this study. The research methodology used in this study, including how source areas were sampled, how basic petrographic analyses were undertaken, and how samples were prepared for geochemical analysis are presented in chapter seven. A discussion of the results of the petrographic analyses and the results of the geochemical analyses of both the source area and archaeological site samples appears in chapter eight. Finally, chapter nine provides a summary and final discussion on the research undertaken, with suggestions posed for future research directions as well as the impacts that this research has on Besant/Sonota archaeology.

Chapter 2 – A Discussion of Theory in Plains Archaeology

Utilitarian and economic aspects of lithic raw material procurements can be taken into consideration when attempting to reconstruct past human behaviour. However, looking at a wider range of sociocultural behaviours that may have been factors in procurement strategies is equally of value. One of the purposes of this research is to determine which lithic raw material procurement strategies are at play with regards to Besant/Sonota groups and their acquisition of brown chalcedony. Based on the geochemical signatures of brown chalcedony found in archaeological sites, Besant/Sonota groups could have acquired the toolstone from the KRF quarries within the Primary Source Area of North Dakota in terms of ethnic and/or ritual landscapes such as ownership or ceremonial or symbolic connotations. The acquisition of brown chalcedony could have been a matter of solely procuring raw lithic sources to manufacture tools and hunting implements. Or there could have been multiple decisions and traditions occurring. By examining one rock type, evidence may be provided that can help with the evaluation of some of these ideas. Determining whether there was a difference in the lithic procurement strategies between Besant and Sonota groups may be understood based on their lithic raw material source areas. In order to determine any answers to these statements, an overview of a number of theoretical paradigms and how they can and have been used with lithic artifacts is presented in this chapter.

2.1 Plains Archaeology and Theory

"Culture is multifaceted … to appreciate all the facets of culture, it must be examined in a variety of settings … through the light of different paradigms" (Connor 1995). Theory is pervasive throughout disciplines dealing with the social sciences and archaeology is no different. Numerous books and journals are devoted to theory building in order to better understand human behavior, both past and present. This growth of theory building in archaeology is common in many geographical areas (e.g., Europe, the Middle East, etc.), but is perceived as being rare within the Plains region of North America. An examination of the development of archaeological and social theory for Plains cultures however, shows this assumption to be false, as a rich body of literature developed over the past fifty years is available to social scientists attempting to reconstruct past lifeways for groups within this geographic region. Before hypotheses regarding how raw material selection influenced past human behaviour can be made, an overview of this previous research is necessary.

2.2 Projectile Points in Plains Theory Building

Projectile points are felt to be time-sensitive and therefore diagnostic of past cultural groups according to Walker (1992:132), which helps to explain their prevalence as an analysis tool when it comes to determining human behaviour. However, using projectile points alone to build cultural chronologies can be problematic. Recent re-analysis of projectile point forms coupled with new information in building a Yukon projectile point database has shown that factors such as degree of skill, individual knapping style, reworking or recycling of points and even the purported importance of point base shape can influence how archaeologists construct point typologies (Hare et al. 2008). In fact, Hare et al. (2008) noted that having multiple point styles in use during the same time period does not necessarily indicate distinct cultural groups but may have more to do with individual skill and style. This may help to explain the large number of projectile point types (e.g., Bratton, Sandy Creek, Sonota, Outlook, Bracken, etc.) described in chapter three.

The large quantity of projectile points in archaeological contexts on the Plains makes them easier to begin to infer meaning from and the degree of sophistication and care that goes into creating some artifacts suggest more than simple utilitarian functions such as hunting. This is not to say that other stone tool types are not useful in making inferences about past human behaviour. Much focus has been placed on projectile points because of their unique and carefully constructed forms and their capability as a diagnostic in determining time depth in archaeological sites. Lithic tools, such as scrapers, knives, bifaces, and other ground stone tool types, are useful in reconstructing past behaviour when they are found in well-dated contexts and have been used to make inferences about groups in the past through multiple archaeological theses, dissertations, and peer-reviewed articles and will continue to be studied. It appears that projectile points, likely based on their changing forms and styles, have been the subject of more debate and speculation in terms of ritual and/or ceremonial contexts.

Bradley (2010) uses projectile points in an attempt to uncover possible ceremonial meaning within Folsom groups. The question as to why some Folsom projectile points are fluted and others are not is an ongoing debate. By analysing a large number of fluted and unfluted

Folsom points, Bradley (1982; 2010) looked for intentional breakage patterns. He (2010) proposed that fluting was a ritual behaviour designed to determine the outcome of a hunting foray. If a Folsom point was successfully fluted, it may have signified the upcoming success of a hunt (Bradley 2010:481). By looking past point typologies and utilitarian functions of lithic tools, Bradley attempted to tap into cognitive and ritual behaviour of past groups such as Folsom.

Warburton and Duke (1995) also used projectile points to gain insight into ritual and symbolic behaviour. By analysing the ethnographic record, Warburton and Duke (1995) documented how the Blackfoot saw and invested power and ritual into these objects. They then compared this to Precontact examples and try to infer how they were viewed by past cultures. The study of ethnographic examples of lithic raw material procurement and production of stone tools and its application to archaeological contexts has been a growing field of research over the past 40 years. This objective to look beyond the artifact and situate it within a broader context of human behaviour usually involves situating both artifacts and the humans who made and used them as agents on the landscape they occupied. Coupled with the use of ethnography, the field of landscape archaeology has evolved as a theoretical construct used by modern archaeologists.

2.3 Landscape Archaeology

Landscape archaeology deals with how human culture and the environment interact and influence one another and not solely with how humans adapt to their environmental surroundings as seen through cultural ecology. "Landscapes are not synonymous with natural environments" according to Anschuetz et al. (2001:160). In fact, they are created by people for their interactions with the natural environments, they are subjective, a cultural product and constantly changing through time. For these reasons, landscapes allow archaeologists to look beyond the archaeological site, which can be seen as restrictive. The archaeological site is only a single entity that shows a small microcosm of what occurred in the past – this can allow for inaccurate patterns to be created. According to Anschuetz et al. (2001) landscape archaeology can be broken down into three main areas of inquiry: settlement ecology, ritual landscapes and ethnic landscapes. Settlement ecology represents a revival of cultural ecology, which was prevalent in archaeology in the 1960s and 1970s, with an acknowledgement of cultural perception influencing cultural change in past human groups. Ethnic and ritual landscapes take into account the reaffirmation on a group's identity as well as how people may have viewed certain places on the landscape beyond resource potential respectively. All three can exist as single entities or build upon one another to further contribute to the creation and maintenance of a past group's sociocultural identities and behavioural processes.

2.3.1 Ethnic Landscapes

Ethnic landscapes help to establish or reaffirm sociocultural identities amongst people and groups (Anschuetz et al. 2001:179). These identities can involve both inclusive and exclusive behaviours, and this can potentially be seen through the archaeological record. These behaviours can include access to specific areas as well as common artifacts or materials used to make objects, so spatial extent is not always a factor. Examples of ethnic landscapes can be seen in a number of archaeological contexts including during the Neolithic period in northwestern Europe, in which specific felsite deposits on islands were exploited over two thousand years in order to reinforce an ethnic identity and create a symbolic landscape (Cooney 1998; Cooney et al. 2013).

Furthermore, in North America, Gillespie's (2007) study of purported Clovis age caches used landscape archaeology to extract ideological and social aspects of Clovis culture. By using a phenomenology-based approach to study these caches, he suggested that mobile Clovis groups, uncertain of their place on the landscape, created their own spaces at select geographical locations by burying or caching their distinctive Clovis points. Both of these case studies illustrate how archaeological cultures may have created and maintained an identity on a local landscape scale. These practices can be seen as inclusionary in that they are creating cultural traditions through identifiable places or features. Alternatively, examples of the reaffirmation of sociocultural behaviour through exclusionary tactics can involve the concept of ownership.

2.3.1.1 Ownership

The concept of ownership is not a modern one or one that evolved out of increasing social complexity and the growth of statehood societies. Whenever human groups occupy discrete areas the idea of "belonging" becomes prevalent, a pattern that can be seen in the above examples. As shown by Basso (1996:33-34), repeated use of certain areas, even on a seasonal basis, may certainly point toward proprietary rights. This creates for the group a narrative associated with the location that can transcend Western concepts of space and where social actions and events can be divorced from the location from which they occur (Basso 1996:33-34). Contrasting this perspective is that of the Apache, who associate locations with cultural narratives and everyday life activities. This construction serves to not only document group history and identity to a location, but to form the basis for proper cultural behavior and identity through a relationship with a specific site and the narrative that is associated with it (Basso 1996:134-138). In this light, First Nations would feel a connection to a particular location or quarry site after repeated use as narratives are developed surrounding the location. Whether this is ownership over that resource by past groups depends on the individual group and any other considerations that may have been taken into account, such as the presence of competing groups.

Dowd and Vlcek (2013) explored ownership of the Tosawihi (White Knife) Quarry in northern Nevada by the Western Shoshone Tosawihi band. These families "owned" the quarry locations but since they did not occupy the location at all times, other groups could "poach" raw material when the quarry was unoccupied. However, other groups, specifically the Shoshone, Bannock and Paiute, were given access to the quarry, likely through reciprocal agreements such as fishing rights on the nearby Snake River.

Root (1992) discussed usage of the KRF quarries within the Primary Source Area (PSA) of North Dakota and how access to these quarry locations was highly regulated through time. Extensive quarrying activities of low quality lithic raw material suggested that access to the high-quality KRF was restricted when Sonota groups occupied the Middle Missouri subarea and further restricted during the Plains Village Period when horticultural groups may have exerted even more control over access to the quarries in general (Root 1992:294-296). While some groups were still allowed to visit and procure lithic materials for stone tool manufacture at certain times, Root (1992) argued that Precontact groups within the Middle Missouri Subarea held strong ownership and control over this lithic resource.

These examples show how fluid the concept of ownership over archaeological resource areas can be and how it can change between groups and also through time. The creation of cultural identities through identification with and narrative construction at specific locations contributes to the creation of ethnic landscapes amongst archaeological cultures. As such, once an ethnic landscape has been created, the adoption of ritual landscapes at that same site can take place.

2.3.2 Ritual Landscapes

Ritual landscapes involve a deeper understanding of the social and symbolic significance of places. Basso (1996) states that wisdom is tied to specific landscapes and as such all landscapes, according to Anschuetz et al. (2001:178), are full of "history, legend, knowledge, and power that help structure activities and organize relationships." Howey and O'Shea (2009:194) believe that ritual practice is "necessarily patterned and repetitive; producing material signatures that are readily (and uniquely) open to us as archaeologists for investigation." How then do archaeologists determine a ritual landscape? Ethnographic accounts, oral tradition, and oral histories can help to create analogies to the past. Taking account of the spatial arrangement of archaeological sites can also help in determining what ritual aspects may be associated with them. Just as an actual object may have a symbolic connotation to it, it is not outlandish to suspect that specific source areas of lithic raw material were also spiritually or symbolically important to past cultural groups. Lithic studies may be combined with postprocessual approaches and settlement pattern analysis to identify potential areas of symbolic significance. Archaeologists already consider that past cultural groups believed certain features on the landscape to have been imbued with power.

Research by Richard Bradley (2000; Bradley and Edmonds 1993) in Britain and Norway found that at some sites lithic material that was easily accessible and of good knapping quality was ignored in favour of material found in nearly inaccessible outcrops. They suggested that these hard to access and dangerous quarry areas may be part of a ritual landscape. With the occurrence of archaeological sites in difficult to access areas or areas of topographical significance (e.g., mountains), hypothesizing the idea of a ritual landscape is not an unwarranted idea. However, what happens when the resource is more readily accessible or does not occur in an area of topographic significance? Again, we can turn to the example of the Tosawihi Quarry in northern Nevada.

The Tosawihi Quarry was also considered a "religious power spot" with the white opalite material believed to contain both healing and destructive powers (Dowd and Vlcek 2013). This was also an area where medicine men went to gain power. Access rights to the quarry were restricted on the basis of ownership, on membership to a group that had quarry rights, and on the spiritual right of the individual. If the wrong person handled the wrong rocks, negative complications could arise for that individual (e.g., sickness or death) (Rusco and Raven 1992). Here the ritual landscape is not only the quarry location but also the raw material.

MacKay et al. (2013) geochemically characterized several quarries used by the Mackenzie Inuit in the Mackenzie valley of the Northwest Territories. They (2013) also built upon past research by archaeologists to determine the social and cultural implications of quarries amongst the Mackenzie Inuit (Andrews et al. 2012; Andrews and Zoe 1997; Pokotylo and Hanks 1989). Based on oral traditions a few of the quarries were known to be sacred and the home of spirits, MacKay et al. (2013) were able to use their research to help explain how procurement strategies for lithic raw material were influenced in terms of avoidance or exclusive usage as well as how they changed through time. They also hypothesized that changes in procurement strategies may reflect social changes to the ritual landscape over time (MacKay et al. 2013:497).

Sundstrom (2003; 2004) documented rock art sites in the Black Hills and noted their relationship to recognized sacred places. She also noted that many sacred areas are in association with resource areas that would provide for groups engaged in ritual activities (Sundstrom 2003:285-287). Likewise, some resource areas, such as lithic sources, may be seen as sacred places in their own right to Precontact cultural groups. An excellent example of an area having both ethnic and ritual aspects can be seen in Gould’s (1977; 1978; 1980) study of Australian Aborigines’ lithic raw material procurement as contrasted against a more settlement ecology approach, as seen in Binford’s (1977; 1979) study of the Nunamiut.

2.4 An Ethnographic Example of Ethnic and Ritual Landscapes

During the late 1970s and into the mid-1980s, the archaeological literature was filled with a debate between Lewis Binford and Richard Gould over lithic raw material procurement, hunter-gatherer mobility and settlement systems. The fight over the accuracy of the “righteous rocks” debate has had wide-reaching implications for hunter-gatherer studies within North America, especially with respect to lithic material procurement and human behavioural systems. To better understand the extent to which this debate has influenced archaeology, principally Paleoindian studies, an overview of the debate and its main tenants is necessary, followed by a discussion of how precisely archaeological research into lithic materials, social behaviour and mobility studies has changed since then.

Both Binford and Gould believed in the value of ethnographic analysis applied to archaeological problems. Research undertaken by both scholars attempted to elucidate archaeological problems surrounding lithic raw material procurement, mobility, settlement patterns, subsistence strategies and cognitive worldview through the use of ethnographic analogies. In the late 1970s, Binford (1977) published an article concerned with determining material distribution as a result of behavioural patterns of a modern hunter-gatherer group, the Nunamiut, and comparing them with distribution patterns of archaeological remains. In the same volume, Gould (1977) used ethnographic data from Australian Aborigines to elucidate human behaviour through lithic tools in archaeological sites.

Binford (1977) distinguished between curated and expedient tools in the lithic assemblages of modern Nunamiut and indicated that correlations could be made with archaeological examples. He further described how lithic procurement was "embedded" within subsistence practices as seen through the Nunamiut (Binford 1979). Based on observations of everyday practices among the Nunamiut, Binford (1979) devised a number of categories and sub-categories into which tools were classified including active gear, passive gear, situational gear, personal gear and site furniture. These categories and sub-categories helped to distinguish between tool functions, but also explained how the Nunamiut moved across the landscape. Caching tools and equipment in certain areas influenced what tools were regularly carried with an individual, what subsistence practices were taking place and gave insight into the mobility patterns and raw material procurement among this group of hunter-gatherers. Overall, the Nunamiut were portrayed as a group that was well invested in having contingency plans in place in case of future uncertainty. As seen through Binford's research, some tools were cached for future use, some were modified for multiple uses and the culture, as a whole, was one that elevated efficiency to a high status. Binford (1979:259; italics in original) stressed that the Nunamiut did not actively procure lithic raw material on its own, but acquired lithic raw material in conjunction with subsistence practices: "*Very rarely, and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw materials for tools*". This observation is in direct contrast to how Gould saw lithic raw material procurement among Australian Aborigines.

Gould (1977) undertook an in-depth analysis of lithic raw material procurement in the Western Desert of Australia. He distinguished where lithic raw material was gathered (quarried and non-quarried stone), the types of tools made in each of these locations, and what their archaeological signatures would look like (e.g., chipping stations). Quarrying activities produced flakes and cores that were minimally reduced and were typically taken to other areas to be further fashioned into tools. The main type of tool produced via this process was a hafted adze used to shape mulga (*Acacia aneura*) wood (Gould 1977:164). In non-quarry locations, the stone was used for immediate tasks at hand. This was seen in tools that were rarely retouched, were used without modification, were discarded soon after use, and were not curated (Gould 1977:164). Through his analysis of the types of tools found among the Australian Aborigines, Gould (1977:167) generated several predictions that were tested against archaeological examples. These predictions included what types of tools were made from quarried versus non-quarried stone, where these tools were found (i.e., in a habitation site versus other site types), what the relative amount of quarried versus non-quarried stone was in habitation sites based on their proximity to source locations were, and the prevalence of quarried stone classified as exotics in archaeological sites.

Gould (1977) examined frequencies of local versus non-local (exotic) stone used by modern Australian Aborigines and compared it to an archaeological example from Puntutjarpa Rockshelter and their source locations. From this analysis, he proposed some ideas regarding hunter-gatherer mobility associated with lithic raw material procurement. Gould (1977) identified source locations for both local and non-local stone and compared the utility of each lithic raw material type in terms of hafted adze edge retention on mulga wood. He confirmed that a local lithic raw material type (white chert) was preferred in the manufacture of hafted adzes both in the archaeological lithic assemblage and among modern Aborigines due to its ability to maintain a sharp edge through continued use (Gould 1977:827). However, exotic lithic materials occur in the archaeological assemblage as hafted adzes as well, despite suitable local raw material, "though statistically of less importance than white chert, the continuous low-level use of exotic cherts cannot be explained by simple utilitarian arguments of efficiency of use or ease of procurement and thus constitute a subpattern that is of equal or greater anthropological interest" (Gould 1978:830). From this occurrence, Gould (1977; 1978; 1980) came up with his "argument by anomaly" and "exotic stone hypothesis" approaches.

It appears that many archaeological studies do not try to determine why some lithic raw materials that are inefficient technically are still used to make particular tool types. The occurrence of mechanically less-efficient stone is noted as part of archaeological assemblages but is rarely discussed or attributed to the high mobility supposedly characteristic of hunter-gatherer groups. It is possible that archaeologists quickly discount low-level uses of lithic material as anomalies within the archaeological record and do not attempt to place low quality stone into the larger context of social relationships and tool function as Gould did in his studies. By beginning with a technological and utilitarian analysis of stone tools, outliers or "anomalies" can be noticed by the archaeologist and further explained. Gould attempted to explain the presence of less efficient exotic lithic raw materials as part of archaeological assemblages in the Western Desert of Australia. Due to the time and energy required to quarry suitable lithic raw material and transport it back to habitation sites, white chert was preferred among Aborigines not only due to its ability to retain a sharp working edge, but also because it was found locally (Gould 1978:830). Gould noted "special efforts were made by aborigines to visit quarry localities, but only when the lithic raw material had something special about it" (1978:830). Lithic raw material considered "special" to Australian Aborigines was usually from quarry sites that were associated with totemic 'dreaming' places (Gould 1977). Certain male individuals believed themselves descended along patrilineal lines from particular totemic beings associated with or near quarry locations and would therefore make special trips to the location in order to procure lithic raw material. This totemic-associated stone material was highly valued and as such was transported over large distances. Gould (1978:831) noted that exchange of lithic raw material from totemic-associated quarry locations was present in the ethnographic record, and regardless of whether a male individual directly procured the raw material himself or not, could name where the stone had come from and its totemic association. As such, exotic stone could be present in lithic assemblages due to its symbolic associations among similar patrilineal descent lines. In later published literature, Gould (1980) continued in a similar vein with the social significance of exotic lithic materials among Australian Aborigines. In this case, the presence of exotic stone in sites far removed from source locations reflected wide-ranging kinship networks. Gould (1978; 1980) believed that these social networks were in effect to cope with changing climate and resources particularly during times of stress (i.e., increased aridity). The presence of wide-ranging kinship networks, possibly established along totemic association or marriages, was supported by the presence of exotic lithic materials in sites far removed from source locations. His evidence for such social networks was based on ethnographic data and current environmental conditions as well as the presence of exotic materials among modern Aborigines. Since palaeoenvironmental reconstruction indicated a climate and resource base similar to modern ones over the past 10,000 years, Gould combined the evidence (modern kinship systems, archaeological assemblages, palaeoenvironmental data, lithic sourcing, etc.) to come up with an alternative explanation for mobility and lithic raw material procurement among both past and present Australian Aborigines. "By looking at the totality of human behaviour relating to residues, we can discover anomalies … These anomalies cannot be dismissed as 'mere idiosyncrasies' or 'particularist exceptions'. They demand an explanation, and the explanation of these deviations or idiosyncrasies may prove more interesting than explanations for dominant patterns or 'behavior in the aggregate'" (Gould 1980:139).

Binford (1979) rejected Gould's ideas on the "argument by anomaly" and "exotic stone hypothesis". Rather than exotic materials in archaeological assemblages indicating symbolic affiliations or kinship systems, Binford (1979:261) argued they may solely imply a wide-ranging mobility pattern for that group of hunter-gatherers with no extra effort being invested in lithic raw material procurement. Hunter-gatherers would not make special trips solely to acquire more lithic material from source locations and instead would acquire material in conjunction with other subsistence-based tasks (Binford and Stone 1985). Additionally, lithic raw material procurement had much in common with how tools were organized in the Nunamiut worldview – either as situational gear, site furniture or personal gear (Binford and Stone 1985). Gould and Saggers (1985) championed a non-utilitarian approach to the study of stone tools to look for all possible variations in tool form, type and material and by examining the "anomalies" present in the form of exotics as something beyond utilitarian explanation such as symbolic or totemic association or evidence of social networks.

Ethnic and ritual landscapes may be harder to see archaeologically but the above examples show that numerous cases can be made to explain the more hidden sociocultural aspects of past human groups that do not necessarily preserve in the archaeological record. Other aspects of human behaviour such as settlement patterning, economics, efficiency, and maintaining ethnic identity are equally as important as ritual or symbolic aspects. However, even with economic considerations considered for past human behavioural systems, inter- and intra-group relationship paradigms affected how these decisions on resource procurement were made.

2.5 Optimal Foraging Theory and Sharing

Optimal foraging theory became a popular theoretical paradigm during the 1960s and 1970s and sought to understand adaptation by specifically looking at how hunter-gatherers maximized their "returns" or how efficient they were. Typically, this was applied to subsistence strategies and looked at variables such as time, caloric intake, energy and how they were most efficiently used to understand behaviour (Winterhalder 1981). However, critics of optimal foraging theory felt that it was incompatible with archaeological data since it emphasized group behavior, rather than individual choices, and avoided social phenomena (Conkey 1984:256; Keene 1983). In fact, the redefinition of culture as human adaptation to the environment viewed social phenomena as being an adaptation to the environment as well (Binford 1965; Conkey 1984). Later archaeologists accounted for these limitations by developing new theoretical paradigms such as landscape archaeology as previously discussed in section 2.3.

The role of sharing within human groups can take on a number of dimensions. Typically, items shared among other individuals or groups include food, yet other items can include materials goods as well as land and knowledge. Using methods such as optimal foraging theory, researchers endeavored to understand sharing among hunter-gatherer groups through several approaches including reciprocity, trade and exchange and kinship systems. "The centrality of sharing to the way of life of human hunter-gatherers is a matter of general agreement" (Ingold 1991:282). Cooperation or sharing among hunter-gatherers helps to cement cohesion among and between groups and helps to create and maintain social relations. Sharing is a social relation that makes hunting and gathering a social action (Ingold 1991).

2.5.1 Sharing, Exchange and Kinship Systems

Sharing is important in the maintenance of social relations between and within hunter-gatherer groups. Ethnographic research undertaken by R.A. Gould among the Australian Aborigines demonstrates how sharing reaffirms kinship ties to combat times of stress (see Section 2.4). The presence of non-local lithic raw materials in toolkits belonging to modern Aborigines according to Gould (1978) implies that long-distance social networks are in existence. Resource sharing, seen through the exchange of lithic raw materials, is a means to overcome difficulties associated with a fluctuating resource base. In times of economic stress within one region, human groups, based on long-established and wide-ranging kinship networks, could move to better resource areas inhabited by different groups. Gould (1978:833) stated, "the more unpredictable these fluctuations are, the more widely these social networks will extend from any given point within the region." The exchange of non-local lithic raw materials within modern Aborigine habitation sites may imply the same social relations are at work when similar artifacts are found in archaeological sites. The ethnographic data acquired by Gould (1978; 1980) also looked at lithic materials as having totemic associations based on their source locations. By imbuing the stone with a patrilineal totemic association, it created a bond between males and these quarry locations. Again, this comes into play when maintaining social relations between groups. Not only are hunter-gatherer groups exchanging toolstone with other groups to maintain kinship networks, but a particular stone may be associated with a totem that binds certain individuals to one another. By sharing stone with each other, kinship systems are maintained.

MacDonald (1998; 1999) explored whether the presence of exotic lithic materials in archaeological sites and the widespread distribution of Folsom projectile point technology were the result of cultural transmission through social relationships between different hunter-gatherer groups on the North American Plains. Through his analysis, he believed that there was cultural transmission in the form of knowledge sharing between elders and younger individuals in terms of projectile point formation (MacDonald 1998:232). MacDonald (1998) suggested that by retaining this knowledge and passing the information along to the next generation of projectile point manufacturers, elder individuals could remain as participants in subsistence practices even if they could not procure food themselves. An example of this type of replacement of knowledge for physical labour is known through ethnographic research among the Mardujarra Aborigines of Australia as well (see Allen 1996). Additionally, MacDonald (1998:232) believed that Folsom groups were organized along patrilineal lines with a higher proportion of males present to hunt bison, referred to as an "optimal subsistence choice." He felt that as a result of a high population of males, large mating distances were necessary and as such long distance social ties were maintained through marriages (the sharing of people) and lithic raw material exchange (the sharing of material goods) (MacDonald 1998).

In the previous examples, sharing, whether through people, knowledge, or raw material, is an important facet of hunter-gatherer social relations. In the archaeological and ethnographic literature, sharing was a co-operative strategy in that it involved more than one individual and theoretically worked for the benefit of the group.

2.5.2 Sharing as Reciprocity

One of the conditions of sharing among hunter-gatherer groups is the concept of reciprocity. In some cases, the sharing of material goods through trade and exchange brings about an immediate reciprocal agreement. For example, the presence of established kinship networks among Australian Aborigines provides for relief from economic stress and the exchange of non-local lithic raw materials (Gould 1978; 1980).

Sharing has implied some sort of egalitarianism between human populations. However, sharing is not always beneficial to hunter-gatherer groups. Kelly (1995) maintains that sharing can strain social relations. Even Winterhalder (2001) notes cases where sharing can create cheating, lying and theft among hunter-gatherers. Despite the pressure that reciprocity be returned, not all individuals or groups will bend to social pressures and instead will "cheat" the group that shared out of their return (Winterhalder 2001:26).

2.5.3 The Other Side of Sharing

Hawkes (1993) proposes another aspect of sharing within human social relationships. In the "show-off model" males, who are typically the hunters, seek out the most desirable, yet usually unpredictable food source in order to increase their reproductive fitness and potential for mates. The "show-off model" appears to be related to an earlier proposal by Jochim (1981) of prestige among hunter-gatherer groups. Jochim (1981) indicated that prestige is bestowed upon the hunters through the sharing of food, the acquisition of difficult and/or scarce prey, and the size of the prey. By acquiring a prestige prey, the hunters distinguish themselves from other hunters and may also acquire higher social status within the group. Following Hawkes (1993), this too might increase the reproductive fitness of the hunter. In both situations, sharing is not necessarily egalitarian. People are not sharing for sharing's sake; they are sharing in order to gain some benefit for themselves or their group.

Kelly (1995) described "demand sharing" and its commonality among hunter-gatherer groups. This is the insistence or demanding of sharing by one individual or group towards another. Studies undertaken by scholars such as Lee (1979) and Marshall (1976) describe how "demand sharing" is prevalent in modern hunter-gatherer groups like the Ju/'hoansi of Namibia. In order to maintain reciprocity, the individual or group who originally required another group or individual to share (the "sharee") are obligated to give the sharer what they ask for in return. For this reason, hunter-gatherers may avoid sharing relationships so that they are not beholden to another and can evade the negative aspects of sharing. Avoidance of sharing can cause perjury to occur. In order to prevent a sharing relationship from being created, an individual or group may lie about how successful or how well off they are. Ethnographic accounts exist that document lying among hunter-gatherers (see Altman 1987; Altman and Peterson 1988; Myers 1988) and how it avoids further social relations. The degree of sharing can also be markedly different based on the sex and age of hunter-gatherers and the type of meat being shared (Kelly 1995). Typically, older individuals and males tend to receive better cuts of meat than younger individuals and females and smaller game can be shared more readily or less readily than larger game (Hill and Kaplan 1993; Kelly 1995).

Sharing does not imply egalitarianism among hunter-gatherers. When the benefits outweigh the costs, individuals and groups choose to enter social relationships with one another through sharing. "It is also clear that the costs and benefits of sharing are analysed over some period of time, taking into account past experiences and future expectations" (Kelly 1995:202). Sharing can be found throughout the social relationships of hunter-gatherer groups whether it is through the exchange of material goods, the human-human or human-animal relationships and/or prestige. Despite the niceties of the word, sharing does not always imply equality and can in fact be seen as a negative relationship.

2.6 Is Hunter-Gatherer Behaviour Unique?

Hunter-gatherer behaviour allows an individual or group access to a wide-range of resources rather than a limited number depending on the mobility practices of that individual or group. Hunter-gatherers with large mobility ranges are less likely to deplete resources in one area as opposed to a group that is more sedentary. When compared to agriculturalists or pastoralists, hunter-gatherers are unique in that their resource base is more diversified and their foraging range is larger. Analysis of ethnographic hunter-gatherers has demonstrated that these groups can guard against times of stress and scarcity because of their subsistence practices. The analysis of optimality and risk management in hunter-gatherers to reduce scarcity is documented (Kelly 1995; Winterhalder 1986). When compared to diet-breadth, hunter-gatherers also reduce scarcity by having access to a wider-resource base than non- hunter-gatherers.

By having an increased foraging range, the potential for contact with other groups is greater among hunter-gatherers. While more sedentary populations may have well-established trade and exchange networks in effect, hunter-gatherers can directly procure items by visiting a source area themselves or choose to enter into reciprocal arrangements with trade partners. However, by entering into a reciprocity agreement with another group or individual, hunter-gatherers create social relationships that require maintenance. By foregoing reciprocity and acquiring materials themselves, hunter-gatherers can choose to opt-out of social relations that do not suit them. The subsistence strategy of hunter-gatherers is more flexible than that of non-foragers. Increased access to resources, diversity in their resource base, and the ability to be highly mobile can give hunter-gatherers a competitive advantage in adapting to the environment around them.

2.7 Potential Areas of Research

The potential for theory to be applied when it comes lithic studies is far ranging. A point is not just a tool and stone is not just a resource. Every object that is collected or uncovered from an archaeological site is imbued with some form of meaning. This meaning may only be functional and therefore, plainer, or it can be symbolic and require extra effort to try and ferret out the answer. However, ascribing an entire past group's behaviour to a small portion or type of artifact is precarious. That said, studying lithic artifacts can help us create ideas and hypotheses about human behaviour in the past.

By properly and accurately undertaking geochemical characterization of brown chalcedony materials in Besant/Sonota archaeological sites across Alberta, Manitoba, and Saskatchewan, this research can begin to start answering the questions posed at the beginning of this chapter. With a proper source identification of lithic raw material, determining settlement ecology, ritual, and ethnic landscapes of Besant/Sonota groups is possible. Doing this helps archaeologists better understand the mindset of human groups in the past and thereby more fully explore and learn from their decisions and actions. Further, correlations and analogies can be constructed that may help elucidate behavioural systems amongst other Plains groups, all of which contribute to a better understanding of the archaeological past.

Based on the previous theoretical overviews, the results of the geochemical investigations into brown chalcedony artifacts found in select Besant/Sonota archaeological sites coupled with the data from source areas will be used to start answering several questions about Besant/Sonota behavioural systems, specifically, looking at aspects such as:

- Trade:
    - Are Besant and Sonota groups the same or different in how they acquire lithic raw material? Are they distinct cultural entities from one another or merely separated by time and/or space?
    - Are there the establishment or maintenance of relationships between and/or within Besant groups and other Plains cultures during this period? Secondarily to this, are more northern and western Besant/Sonota groups maintaining kinship ties with ancestors in the Middle Missouri Cultural Subarea?
    - What about the Hopewell Interaction Sphere? Is KRF a part of it or are there other local sources of brown chalcedony? Do the local sources negate the power of the traditional trading network idea?
- Ritual:
    - Are certain source areas (e.g., KRF quarries of North Dakota) places of "power" on the landscape? Are they symbolically "special" to Besant/Sonota groups?
- Efficiency:
    - Are Besant/Sonota groups maximizing their returns by exploiting local source areas of brown chalcedony based on their seasonal round and only procuring KRF from North Dakota on an intermittent basis?

By examining the mineralogical and elemental composition of lithic raw material samples from specific source areas across the Northern Plains region and comparing the results to geochemically characterized samples from archaeological sites, these questions can begin to be answered. The results of the geochemical analyses are compared with the previous research done by archaeologists into lithic procurement strategies and quarry studies described in this chapter to ferret out answers to the above questions in terms of Besant/Sonota behavioural choices. In this way, the theoretical research into hunter-gatherer procurement strategies, specifically for lithic raw material, coupled with geochemical characterization of brown chalcedony materials, can finally determine if the brown chalcedony found in Besant/Sonota archaeological sites on the northern Plains is the result of trade relationships with groups in North Dakota, the result of seasonal forays into North Dakota to procure stone, or something else entirely.

Chapter 3 - Archaeological Overview of Besant and Sonota

The usage of brown chalcedony and/or Knife River flint (KRF) in the lithic assemblages of Northern Plains archaeological sites occurs throughout the Precontact era in varying quantities. However, its usage appears to peak during specific periods including Cody Complex, Pelican Lake and Besant/Sonota (Loendorf et al. 1984; Root 1992; 1997). The archaeological sites used in this research have been limited to those with Besant/Sonota components that contain high percentages of brown. Additionally, this transitional time phase, from the Late Middle Precontact Period to the Early Late Precontact Period, is one of change. The identification of numerous projectile point typologies has created a bit of confusion in how archaeologists classify and describe Besant/Sonota-aged archaeological sites. This period is felt to be one of extensive trade networks across the Northern Plains, of which KRF was believed to be a major constituent. For this reason, an examination of the toolstone used during the Besant/Sonota period is necessary to determine if the trading of KRF was as extensive as previously assumed. In order to begin to determine if any patterns exist in terms of past behavioural systems, an overview of the Late Precontact Period is warranted. Due to the fact that behaviour is complex and interrelates with many aspects of human culture, a brief discussion of subsistence and mortuary practices is also necessary rather than just describing lithic materials, tool types, and temporal ranges.

3.1 Late Precontact Overview

The Late Precontact Period on the Northern Plains is one of substantial change and cultural development. A discussion of the major innovations that arose during this period would not be complete without an overview of currently known Besant and Sonota archaeology. Where Besant and Sonota fit into the Precontact Period timeline has been debated. At times, Sonota has been subsumed within Besant and both listed as the first cultural complex of the Late Precontact Period or the terminal cultural complex of the Middle Precontact Period. Others see Besant and Sonota as different manifestations of Plains Woodland cultures (Gregg et al. 1996). Along with this, various other types of projectile points have either been included or excluded in Besant and Sonota analyses. These additional types are Bracken Phase, Bratton, Sandy Creek, Outlook, Bratton, and Samantha (Cloutier 2004; Dyck 1983; Dyck and Morlan 1995; Kehoe 1974; Peck 2011; Varsakis 2006; Wettlaufer 1955). Other archaeologists believe that Besant is representative of the terminal Middle Precontact Period or even transitional between the Middle and the Late Precontact Periods (Dyck 1983; Dyck and Morlan 1995; Kehoe 1974; Kevinsen 2013; Peck 2011; Reeves 1983, 1974; Wettlaufer 1955). Outside of Canada, American archaeologists have adopted slightly different terminology in naming temporal periods of the archaeological past. The Middle Precontact Period is often referred to as the Middle Archaic Period and the Late Precontact Period includes the Plains Woodland and Plains Village Periods (see Figure 3.1).

Complicating the archaeological interpretation of this time period is the co-existence of Besant/Sonota groups with Avonlea groups. The rise of Avonlea cultures has been generally accepted as involving the first true bow and arrow technology (Peck 2011; Vickers 1994). In 1960, Wettlaufer and Mayer-Oakes (1960) recognized the presence of a new projectile point type at the Long Creek site in southern Saskatchewan. They called it Avonlea after the nearby town of Avonlea, Saskatchewan. At the same time, Forbis (1960) was excavating at the Upper Kill site in Alberta, where he found the same type of point and called it an "Upper Kill" point. Both the Besant and Avonlea complexes occurred during a climatic event known as the Medieval Warm Period, which saw periods of high moisture interspersed with periods of low moisture (Vance 1991). Peck (2011:335) placed the temporal range for Avonlea culture at c. 1350-1100 BP, which overlaps with both Besant and Sonota complexes. Much discussion has been generated over whether the three complexes co-existed (Cloutier 2004; Morlan 1988; Peck and Hudecek-Cuffe 2003; Walde et al. 1995). More recent scholarship by Cloutier (2004) suggested that there is no geographic co-existence between Besant, Sonota and Avonlea. Cloutier (2004) also stated that while date ranges overlap, Besant and Sonota remained in the east and Avonlea occurred in the west on the Northern Plains. Distribution of the Avonlea complex is found throughout the Northern Plains; however, it also occurs in the mountains, foothills and parkland ecotones of Alberta (Peck 2011) and the parklands and boreal forest edges of Saskatchewan (Meyer et al. 1998; Smith and Walker 1988). Archaeological sites for Avonlea include a wide range of different types such as kill sites, campsites, processing sites and ceremonial sites as seen at Ramillies, Majorville Medicine Wheel and Cairn and Manyberries Medicine Wheel in Alberta, Garratt, Gull Lake, Long Creek, Avonlea, Sjovold and Lebret in Saskatchewan, Avery, Stott and Miniota in Manitoba and Corey Ranch and Timber Ridge in Montana.

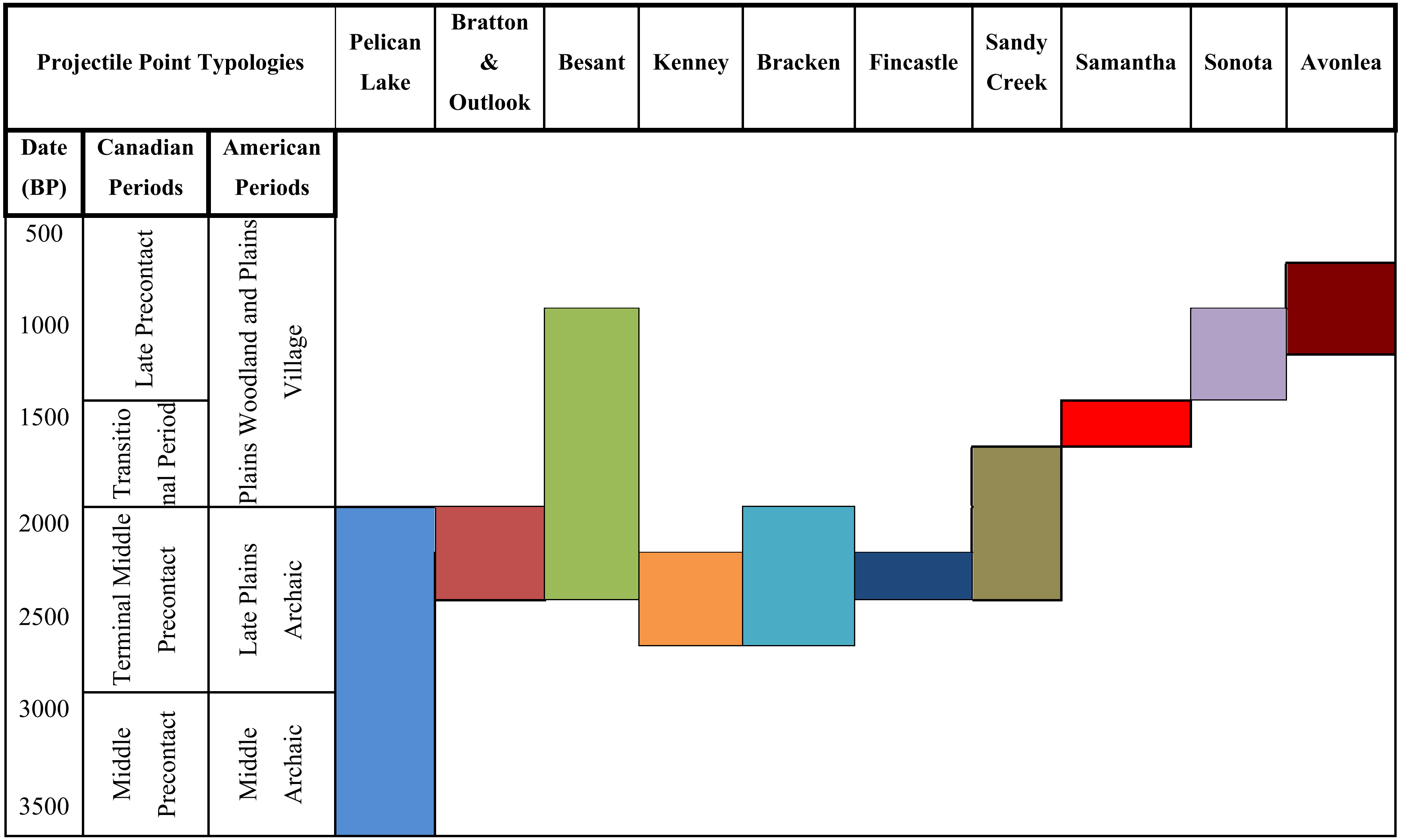

Figure 3.1: Time Ranges and Associated Cultural Chronologies Based on Projectile Point Typologies for the Northern Plains

(Adapted from Dyck 1983, Dyck and Morlan 1995, Johnson and Johnson 1998, Kevinsen 2013, Peck 2011, Reeves 1983, Toom 1996, Wettlaufer 1955, and Varsakis 2006)

3.1.1 Culture Histories

3.1.1.1 Besant

Typically, archaeologists on the Northern Plains (Kornfeld et al. 2010; Peck 2011; Peck and Hudecek-Cuffe 2003; Reeves 1983; Vickers 1986) place Besant at the end of the Middle Precontact Period. However, Dyck (1983) feels that it belongs at the start of the Late Precontact Period. Besant occurs from c. 2100-1500 BP (Peck 2011:282). Dyck's (1983:113) date range of c. 2000-1100 BP is comparable to Peck's (2011) despite extending into the Late Precontact Period an extra 400 years. Date ranges for complexes within the Precontact Period are constantly being revisited and updated based on the inclusion of newly found archaeological sites or reanalysis of previously excavated ones. For this reason, a number of different temporal ranges exist for Besant (Morlan 1988; Reeves 1983; Walde et al. 1995; Vickers 1986, 1994). The Besant name comes from Wettlaufer's (1955) excavations at the Mortlach site, located in the Besant Valley of southern Saskatchewan. Besant distribution is across the Northern Plains in sites such as Muhlbach, Old Women's Buffalo Jump and Ross Glen in Alberta; Mortlach, Elma Thompson, Walter Felt, and Long Creek in Saskatchewan; and Herdegen's Birdtail Butte and the Boarding School Bison Drive in Montana and the Ruby site in Wyoming to name a few.

3.1.1.2 Sonota

Some archaeologists prefer to group Sonota with Besant (Dyck 1983; Walde et al. 1995; Vickers 1986), while others see them as two geographically and culturally distinct groups within the Late Precontact Period on the Northern Plains (Syms 1977). Peck (2011:309) believes that Sonota is a transition between Late Middle Precontact Period Besant and Early Late Precontact Period Avonlea with date ranges of c. 1500-1350 BP. Neuman (1975) was one of the first to separate Sonota from Besant and defined Sonota based on archaeological sites found in the Middle Missouri area of North and South Dakota. Sonota is similar to Besant in terms of lithic technology and pottery; yet, major distinctions between the two are found in the presence of earthen burial mounds and possible contacts with Hopewellian cultures to the east (Neuman 1975; Syms 1977). The geographic distribution of Sonota culture tends to be limited to North Dakota, South Dakota and southern Manitoba. Since Sonota is often combined with Besant, archaeological sites for this culture can include traditionally recognized Besant sites in Alberta and Saskatchewan such as Fincastle, Fitzgerald, Muhlbach, Walter Felt, Mortlach, Long Creek and the Crane site, the Ruby site in Wyoming, Wahkpa Chu'gn and Kobold in Montana, and many sites throughout southern Manitoba, North Dakota and South Dakota. Based on similarities and differences between Besant and Sonota, it appears that Besant is a northern and western equivalent of Sonota without the presence of earthen mounds. Date ranges for Sonota and Besant as well as archaeological sites with combined cultural occupations have been used as evidence to suggest a possible co-existence period between Besant, Sonota and Avonlea (Dyck 1983; Walde et al. 1995; Peck 2011).

3.2 Lithic Technology

Diagnostically, the use of projectile points is one of the major determinants between Besant and Sonota groups as well as most other groups currently known in the Precontact Period of North American Plains archaeology. The period between the end of the Middle Precontact Period and the beginning of the Late Precontact Period is one of transition from atlatl dart technology to bow and arrow technology. Besant straddles this transitional period and based on projectile point recoveries, there is debate over whether it exhibits hunting technology related to the atlatl, to the arrow, or to elements of both. For this reason, there have been numerous projectile point types attributed to and then later removed from Besant, including Bracken, Bratton, Sandy Creek, Outlook, Samantha, and Sonota (see Figure 3.2). Further complicating this issue is the inclusion of some of these projectile point types within late Pelican Lake assemblages. Kevinsen (2013) gives the most recent analysis of this problem with data acquired from morphometrics on projectile points to distinguish between dart and bow and arrow technology. Morphometrics is a type of analysis that compares shapes between objects using mathematical variables (Kevinsen 2013:1). Hamza (2013) also attempted to separate between Sonota, Besant, and Outlook on the basis of variability in projectile point morphology. She felt that if projectile points were indicative of a particular culture there should be clear differences in the point morphology (Hamza 2013:4). She analysed the projectile points from six northern Plains bison kill sites (including Fincastle, EgPn-111, Happy Valley, Muhlbach and Fitzgerald) and found that the projectile points were highly variable both within and between the sites (Hamza 2013). The results from both of these studies indicates that projectile point metrics alone cannot distinguish between the Sonota, Besant and Outlook label determinations placed on projectile points found in Besant/Sonota archaeological sites.

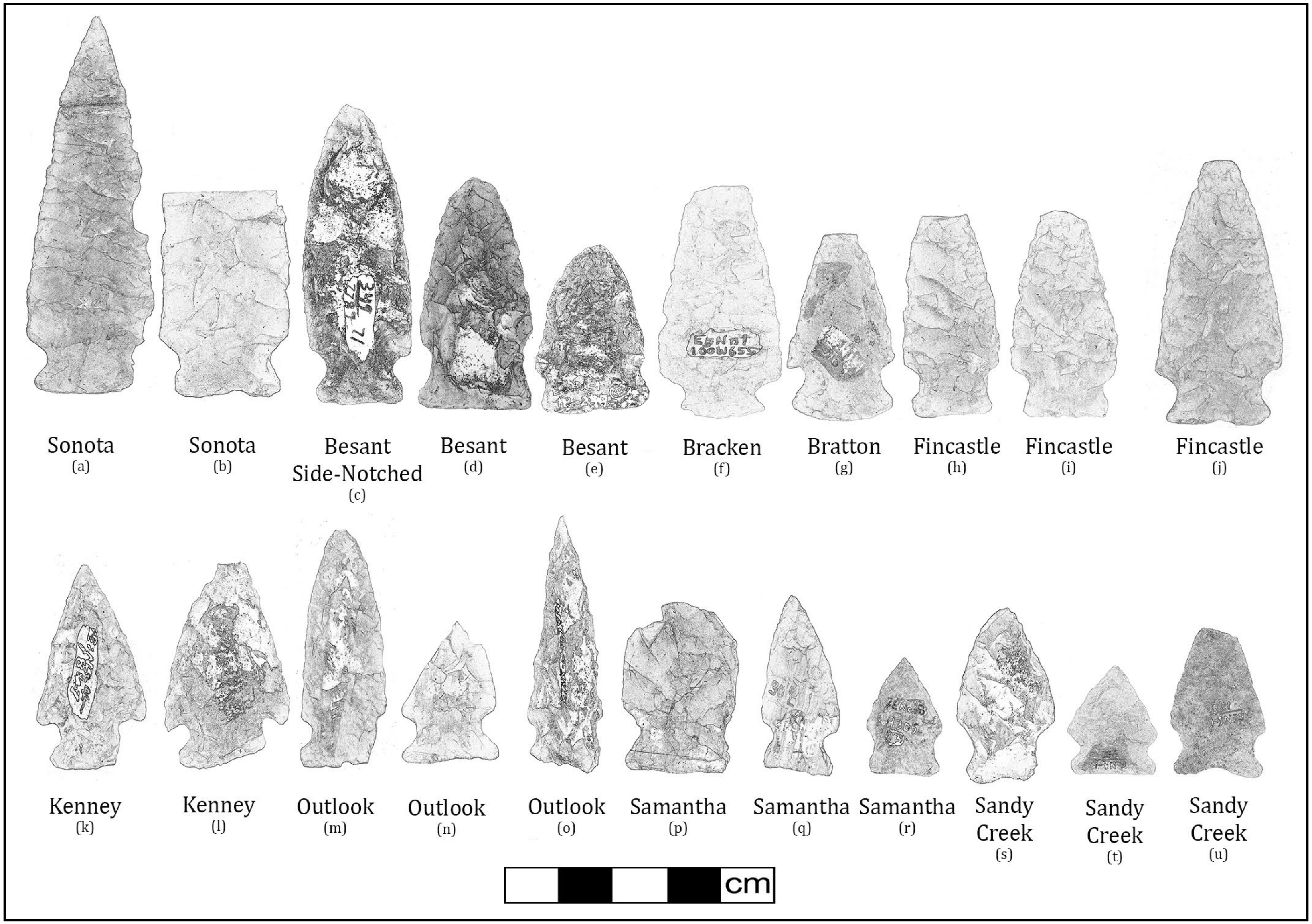

Figure 3.2: Projectile Point Typologies Used during the Besant and Sonota Timeframe

(a, b Long Creek [DgMr-1]; c--g, s-u Mortlach [EcNl-1]; h-j Fincastle [DlOx-5]; k-o Sjovold [EiNs-4]; p-r Walter Felt [EcNm-8])

While Kevinsen's (2013) and Hamza's (2013) analyses help the issue, they do not solve the underlying problem of what cultural groups are where and when. Ramsay (1991) puts it correctly when she states that projectile point metrics can separate out technology, but do not determine cultural affiliation. An additional problem lies in the use of semantics with the interchangeable use of terms such as "phase", "subphase", "culture", "complex", and "series". For this reason, these terms need to be properly defined, consolidated and adhered to on a consistent basis.

3.2.1 Complex, Phase, Subphase, Tradition, Horizon, Series or Type?

Are all these projectile points types representative of one or many complexes, series, or cultures, types or phases? The usage of these archaeological units is rife throughout the literature. However, overtime they have been redefined and reinterpreted from Willey and Phillips (1965) original scheme. Willey and Phillips (1965) separated a number of terms into basic archaeological units and integrative units to better define Plains prehistory. A *component* is the basic unit, which is a manifestation of a phase within a site (Willey and Phillips 1965:21). A *phase* possesses "traits sufficiently characteristic to distinguish it from all other units similarly conceived"; therefore, it includes reoccurring components across space (Willey and Phillips 1965:22); for example, a number of archaeological sites that date to the same time period with the same components within a geographical area. Within a phase, there can be *subphases,* which are strictly temporal and are related to the larger phase (Willey and Philips 1965:24). A *horizon* is a large-scale integrative unit, which includes specialized artifact types, new technologies, and different behavioural patterns that arise over wider geographic areas. "The archaeological units linked by a horizon are thus assumed to be *approximately* contemporaneous" (Willey and Phillips 1965:33). Therefore, it is useful for understanding external relationships over a geographical area. A *tradition* is composed of phases and is one in which social and behavioural patterns that are shared over time are reflected in the archaeological record through specific artifact types.

Reeves (1983) also used the Willey and Phillips archaeological taxonomic scheme but removed the geographic delimiter, feeling that the Plains region allows for widespread mobility of groups over large areas. Syms (1977) and Neuman (1975) introduced the idea of a *complex* to replace Willey and Phillips' (1965) archaeological unit, *subphase*. A *complex* includes all artifacts, assemblages, sites, etc., left by a particular group within a limited time period (Syms 1977:70). There can be minor changes but the overall "remains of the group with a shared lifestyle, the same overall toolkit, the same technological skills and preferences, and the same typological and technical attributes" remains the same (Syms 1977:70). A *series* is often used interchangeably with *complex* in the literature. Dyck and Morlan (1995:41) define a *series* as "a temporary classificatory unit for an archaeological grouping whose existence has been demonstrated, but whose various aspects are poorly known". Their definition of a *complex* indicates similarities with Willey and Phillips' original definition of a *horizon*.

Finally, *type* refers to a specific artifact form such as a particular projectile point style and can be used as the lowest archaeological unit. As noted previously, a problem arises when researchers use these terms interchangeably and without proper definition. What one term means to a specific archaeologist does not necessarily mean the same to another. For this reason, each archaeological unit must be properly defined at the outset before any conclusions can be made. What is clear is that an archaeological group cannot be defined on a single technology, behavioural system, or artifact type alone.

Is Sonota truly a *subphase* or something else entirely? Neuman (1975:96) saw it as "a regional segment of a cultural tradition" as well. The majority of researchers tend to label it as a *subphase* of Besant. Syms (1977:90) noted that sites classified as Sonota in Alberta tend to be of a younger age than those found in the Middle Missouri region and represent "a group which manufactured Sonota Complex material culture". Vickers (1983:85) followed Reeves (1983) and Dyck's (1983) suggestion that Sonota should be considered a regional *subphase* within Besant. Pettipas (1983:103) described Sonota as being predominantly confined to the Missouri River Valley in South Dakota, but with some northward expansion into Canada between 1750-1200 BP. When it comes to the previously discussed projectile point types, Dyck and Morlan (1995:398, 405) feel that the term Besant should be used to refer to a "series" and should be "abandoned" as a single descriptive name for a projectile point. Instead, the projectile points called Outlook, Sandy Creek and Bratton are included within the Besant "series". Varsakis (2006:360) used Willey and Phillips' (1965) archaeological units to determine a Besant *phase* with associated archaeological cultures (e.g., Kenney, Sonota, Wyoming, Montana, Fincastle) that interact within what she labeled a "Besant Interaction Sphere". While Varsakis' (2006) analysis is one of the more recent forays into determining what all these separate archaeological assemblages mean, it still relies predominantly on projectile point data. Hamilton et al. (2011:106) consider Besant to be a "complex" over a *series* and separated Sonota into a separate *complex* from Besant.

Whichever system is chosen (e.g., Willey and Phillips 1958, Dyck 1983, Reeves 1983, Peck 2011), a proper and complete explanation of the terminological etiologies used must be laid out in advance. For the purposes of this research, the above terms will be used as they are recorded in the archaeological literature. The goal is not to determine how these different names and projectile point typologies fit within the larger issue of the Besant and Sonota, but to determine where raw material is coming from and placing its movement within a cultural context. In order to fully determine the who, what, where and when of this time period, more than stone tools need to be looked at. This research is designed to contribute to those bigger questions. Regardless of this issue, a brief overview of the above-mentioned projectile point typologies and their associated terminology is warranted in order to clarify the typological issues that archaeologists face when working with artifact assemblages from these groups and begin the process of determining the relationships between Besant and Sonota groups.

3.2.2 Besant

The Besant phase is characterized by its distinctive projectile point, the Besant point, which is "short and broad with shallow side-notches and a slightly concave base" as described in Levels 4A-D at the Mortlach site (Wettlaufer 1955:44). Reeves (1983) and Peck (2011) both agreed with Wettlaufer's original description of the Besant projectile point, but feel that it is indicative of a dart point rather than an arrow point. Reeves (1983) also classified arrow points known as Samantha as part of Besant phase assemblages. Both Reeves (1983) and Wettlaufer (1955) described Besant project points as representing atlatl dart technology. Kehoe (1974) believed that there were three varieties of Besant phase atlatl dart points and two varieties of projectile points, called Samantha arrow points, based on excavations at the Walter Felt site in Saskatchewan. Kehoe's point typology for Besant is rarely used according to Vickers (1994), while Syms (1977) believed that the Walter Felt site materials are Sonota, (discussed below) not Besant. Others describe the Besant projectile point as being lanceolate in shape with side-notches and bases that can range from convex to straight to concave (Kevinsen 2013:10). In the past, Outlook, Bratton, and Sandy Creek projectile points have been associated with Besant as have

Samantha, and an additional type known as Besant Side-Notched (Cloutier 2004, Dyck and Morlan 1995, Kehoe 1974, Reeves 1983). Dyck and Morlan agreed with other archaeologists (Dyck 1983; Johnson 1970, 1977; Kehoe and Kehoe 1968; Reeves 1970, 1983) that Besant could "represent a fusion of Woodland traits with a pre-existing Plains bison hunting technology" (Dyck and Morlan 1995:446).

Materials used to make lithic tools from the Besant archaeological assemblages tend to be either of local origin or exotics such as KRF or porcellanite, according to Peck (2011:284). Unfortunately, this description is not very helpful when determining which lithic resources were used by Besant groups and might instead suggest extreme variability in lithic raw material selection among Besant sites on the Northern Plains. Vickers (1994:134) and Walde et al. (1995:19) noted high frequencies of KRF in Besant assemblages found in Alberta, which may suggest regular forays into North Dakota to procure lithic material. Syms (1977:27) and Leonoff (1970) observed an increased usage of KRF in Late Precontact period sites and an "overwhelming preference" for it in Sonota-age sites in southwestern Manitoba. Whether this is truly indicative of Besant behaviour or if more local sources of brown chalcedonies are being exploited remains to be seen. At the same time, Vickers (1994) and Peck and Hudecek-Cuffe (2003) also noted lithic assemblages often showcase a dominance of locally available raw materials.

By using both metric and non-metric attributes, Varsakis (2006) attempted to differentiate between atlatl dart and arrow technology in Besant/Sonota groups in Alberta. She noted the similarities in the projectile point morphology recovered from Alberta sites such as Fincastle, Muhlbach, and Smith-Swainson versus those recovered from other Besant occupations as seen at EgPn-111 (Varsakis 2006). Sites that contain longer points (e.g., Fincastle, Smith-Swainson, and Muhlbach) tend towards increased KRF usage whereas smaller points found in these sites were made from cherts. Dart points from Fincastle, Smith-Swainson and Muhlbach also were dominated by KRF as a raw material selection. She also noted that when KRF is used to construct projectile points, these points exhibit high-quality workmanship (i.e., bifacially and skillfully worked with parallel and symmetrical flaking as well as an overall symmetry to the point) (Varsakis 2006:306-307).

Varsakis (2006:331) believed that Besant is not homogenous across the northern Plains. Instead, there are shared traits including projectile point morphology, a tendency towards communal bison hunting and extensive trade networks (Varsakis 2006:331). She proposed that Besant be subdivided into 3 separate groups: Sonota subphase, Fincastle complex, and Kenney subphase (discussed in sections 3.2.2, 3.2.3.1, and 3.2.3.2 respectively). She also felt that Besant points tended to be mixed with Pelican Lake assemblages (2006:307), something that Sonota sites (e.g., Fincastle, Muhlbach, and Smith-Swainson) were not.

Peck (2011:282) described Besant as a *phase* and suggested it represents the terminal Middle Precontact period in Alberta. Projectile points tend to be short and broad, made of local toolstone and date between 2100 and 1500 BP. Those larger projectile points and those made on flakes typically date slightly later at 1500 and 1350 BP (Peck 2011:303). According to Peck (2011:307), the Besant phase ends abruptly at c. 1500 BP with the arrival of Sonota groups from the Middle Missouri via southeastern Saskatchewan.

Reeves (1983) proposed two possible origins for Besant; the first hypothesis is that Besant developed out of Pelican Lake or a regional subphase under his Tunaxa cultural tradition. Groups belonging to Reeves' Tunaxa cultural tradition are considered to be a "widespread hunting-gathering cultural tradition of the Northern Plains" (Reeves 1983:184). Archaeological cultures included in this classification are Pelican Lake, Avonlea and a number of local phases and subphases.

Reeves (1983) believed that mixed Besant and Pelican Lake components in some archaeological sites along with a gradual point change between Besant and Pelican Lake components indicated an association between these two groups. According to Reeves, sites with proper stratigraphic control indicated a clear separation between Besant and Pelican Lake components. Contact between the two groups may be indicated where there is an intermixing of archaeological components. In terms of potential for regional subphases, Reeves did not feel that enough evidence existed to indicate that Besant is related to his Tunaxa cultural tradition.

The second hypothesis suggested that Besant is unrelated to any Tunaxa cultural traditions and is either related to some other Plains tradition or is intrusive into Canada and the Plains from elsewhere (Reeves 1983:141). He did not feel that enough evidence existed to consider Besant to be a "discrete plains cultural tradition" (Reeves 1983:149). He posited that it could represent an intrusion onto the Plains from either the Boreal Forest or the Eastern Woodlands. An analysis of a number of sites from these areas indicates that there was likely contact between Besant and Eastern Woodlands groups based on similarities in some artifact types as well as in the presence of ceramics and mortuary behaviour (Reeves 1983). With regards to the boreal forest, Reeves did not see evidence of Besant in this area. As a result, he proposed that Besant is a distinct entity and one that is part of his Napikwan cultural tradition (Reeves 1983:161).

The Napikwan cultural tradition was composed of a group of archaeological cultures that appeared around the same time as the Tunaxa cultural tradition (Reeves 1983:185). Archaeological phases included by Reeves in his Napikwan cultural tradition included Besant and were considered to have been produced by nomadic hunter-gatherers, with distinct lithic artifacts as well as different cultural behaviours including mortuary traditions as seen through burial mounds and the presence of ceramics, which they acquired through contact with Middle Woodland groups. Over time Besant peoples expanded onto the Canadian Plains as a result of their involvement in the Hopewell Interaction Sphere (see section 3.6.1). Reeves (1983:192) believed that this involvement gave Besant groups an advantage over Tunaxa groups in terms of access to resources including, toolstone, bison, and trade goods that led to their dominance in the area for a time. Napikwan groups attempted to displace Tunaxa groups on the Northern Plains but were relatively unsuccessful as seen in the rise of Avonlea groups during and preceding Besant (Reeves 1983). Over time Tunaxa groups regained control over resources such as obsidian and adopted a new hunting technology, the bow and arrow. For this reason, there appeared to have been co-existence between Besant and Avonlea groups for a time. Eventually, Tunaxa groups were seen to focus in the Missouri River basin area, with Napikwan groups focused in the Saskatchewan River basin area (Reeves 1983:185).

Vickers (1986:80) has posited a possible relationship between Besant and terminal Pelican Lake as a result of similar shared tool forms including, but not limited to, corner-notched bifaces, ovate perforators, notched gravers, notched end scrapers, unifacial spokeshaves, cobble choppers, scraper planes, pièces esquillées, abraders, polishing stones, hand stones and grinding slabs as well as the intermixed layers of Besant and Pelican Lake projectile points at sites such as Old Women's Buffalo Jump in Alberta. Both Vickers and Reeves (1983) included Sandy Creek projectile point forms within Besant which further supports Vickers' argument of a relationship between Besant and Pelican Lake as seen in sites such as Head-Smashed-In Buffalo Jump and Bow Bottom in Alberta, and Sjovold, Mortlach, and Walter Felt in Saskatchewan. Kevinsen (2013) believed that Besant is a separate entity from Pelican Lake and did not evolve out of it.

Instead, Pelican Lake and Besant co-occupied the Canadian Plains and Pelican Lake may have influenced Besant technology in Saskatchewan (Kevinsen 2013:63-64).

Cloutier (2004:17) analysed a number of radiocarbon dates from the Canadian Archaeological Radiocarbon Database (CARD) that were attributed to Besant archaeological sites and found that Besant appears at approximately 2600-1535 BP and 2500-1410 BP in Alberta and Saskatchewan respectively. In contrast Besant/Sonota archaeological sites date to 2000-1070 BP in North Dakota (Morlan 2003). These date ranges may indicate a Canadian Plains origin rather than a North Dakota one. However, Cloutier (2004) did note that this conclusion depends on how Besant, Sonota and Sandy Creek sites were classified in CARD. If Sandy Creek is included within Besant archaeological components it may account for earlier dates ranges being reported (Cloutier 2004:17).

Another issue with Besant projectile points is their geographical range. Cloutier (2004) and Dyck (1983) noted that early side-notched points may be misidentified as Besant side-notched varieties as well as stylistically similar Woodland projectile points. Both Reeves (1983) and Scribe (1997) have also acknowledged that some projectile point forms from the Lake Athabasca area of northern Alberta and Southern Indian Lake in northern Manitoba respectively were originally identified as Besant and some continue to be so. Whether or not these sites are truly indicative of Besant is unknown, although scholars such as Reeves (1983) are unconvinced. This brings in the issue of describing an entire archaeological culture based upon one diagnostic artifact alone. Cloutier (2004:19-20) is of a similar opinion in taking issue with assigning a cultural affiliation based upon one artifact type. For this reason, the more northern "Besant" assigned sites are excluded from this analysis because of their geographic location and the lack of other typical Besant features (e.g., a heavy reliance on bison and increased usage of brown chalcedony). For the purposes of this research, the geographical range of Besant archaeological sites is recognized across the Canadian Plains region (Alberta, Saskatchewan, and Manitoba) to a northern limit of the parkland and boreal forest boundary, south to northern Wyoming and South Dakota, and west to the foothills/montane transition zone (sensu Cloutier 2004 and Frison 1978).

3.2.3 Sonota

Research by Neuman in the 1960s and the archaeological assemblages recovered from the Stelzer Village site and the Arpan, Boundary, Grover Hand, and Swift Bird mounds in South

Dakota helped to define Sonota (Neuman 1975). To be considered Sonota, Neuman (1975) suggested the archaeological assemblage had to reflect an emphasis on bison, high quantities of KRF, the presence of bone uprights in archaeological sites, the presence of mounds that included bundle burials along with bison remains, and side- and corner-notched projectile points. Syms (1977:134) hypothesized that southern Manitoba could be considered part of the Sonota core area (primarily northern South Dakota, and western and central North Dakota). Other sites found outside of this geographic range in Alberta and Saskatchewan indicate secondary activities such as winter campsites (Syms 1977:134).

Lithic technology within Sonota is similar to that found with Besant archaeological assemblages. In fact, Sonota has been described as being a southern expression of Besant in terms of projectile point technology and raw material usage (Hjermstead 1996; Walde 2006). Sonota projectile points tend to be elongated, triangular, broad and convex-sided with low and broad side-notches and bases that can be slightly convex or concave or straight (Neuman 1975; Peck 2011). According to Syms, there are also a large number of projectile points made on flakes in Sonota sites (1977).

Peck (2011:307) believed that Sonota is the first cultural expression of Middle Missouri groups moving into Alberta via southeastern Saskatchewan around 1500 BP. It first originates in North Dakota, South Dakota and southeastern Saskatchewan at approximately 2100 BP before expanding into Wyoming, Montana and southern Alberta by 1500 BP where it intrudes upon Besant groups already in the area (Peck 2011:331). Peck (2011:332) believed that Sonota projectile points are indicative of atlatl dart technology. Kevinsen's (2013) analysis of these projectile points opposed the viewpoint expressed by Peck. He (Kevinsen 2013:62) postulated that Besant predates Sonota on the Canadian Plains, as originally suggested by Reeves (1983) and Dyck (1983), and that Sonota should only refer to the burial mound complex. Kevinsen (2013) also found that the longer Sonota points did not indicate any cultural differences, but instead were the product of higher quality lithic material and as such there was not much difference between Sonota and Besant projectile points.

Through analysis of sites such as Muhlbach (FbPf-1) and Smith-Swainson in Alberta, Peck (2011) felt that Sonota can be distinguished by its elongated projectile points, flake points, its intense usage of KRF, and its time period (c. 1500-1350 BP). Unlike typical Sonota sites in other parts of the Middle Missouri and Canadian Plains, Alberta Sonota sites are unique in their absence of burial mounds and campsites and instead tend to be processing and kill sites (Peck 2011:321).

The Sonota subphase (as termed by Varsakis 2006) is noted for having a heavy reliance on KRF as a raw material, a lack of mixing between different cultural affiliations (namely Besant and Pelican Lake), and high-quality skilled workmanship on the projectile points as seen at Alberta sites such as Fincastle, Muhlbach, Smith-Swainson; and Leavitt (in Montana) (Varsakis 2006:308). Varsakis' definition of the Sonota subphase followed Neuman's original (1975) and included archaeological sites such as Fitzgerald and Melhagen in Saskatchewan. Neuman (1975) noted the similarity between Sonota and Besant projectile points; however, Syms (1977) saw a distinction in the two-point styles. Sonota lithic materials tend to have large quantities of KRF, which is not surprising given the culture's geographic range in the Dakotas. Large, ovoid bifaces or knives are common in Sonota archaeological sites in the Middle Missouri area (Peck 2011). Peck (2011) felt that side scrapers are rare in North and South Dakota sites and that the Sonota projectile points represent atlatl dart points over arrow points. He also noted the similarities between Sonota projectile points and earlier Outlook projectile point forms and indicated that there may be a relationship, albeit tenuous and unconfirmed, between the two.

One issue that arises with Sonota is the sometimes co-occurrence with Avonlea cultural materials. Sites in Manitoba and Saskatchewan, including Layer 12 at Walter Felt (EcNm-8), include a mixing of Avonlea and Sonota projectile points made out of KRF. Peck suggested that since KRF is thought to be uncommon in Avonlea sites (Vickers 1994:15), Sonota groups may have been supplying Avonlea groups with the toolstone in a cooperative fashion. Overtime, these Avonlea groups began replacing Sonota groups in an east-to-west direction (Peck 2011:332).

3.2.4 Other Projectile Points and Subphases Associated with Besant and Sonota

An issue that archaeologists often encounter in the literature on Besant and Sonota is the abundance of subphases and projectile point typologies that have been included as well as discarded regarding their archaeological assemblages. As Hare et al. (2008) found, a large number of different projectile point typologies may not indicate distinct cultural groups but instead may be the result of factors such as point re-use and reworking, individual skill, and individual style. The archaeological sites that were used as part of this research include some of these subphases and projectile point typologies as a label for the diagnostic artifacts. As such, a brief overview of these additional typologies should be added in order to clarify what previous archaeological researchers have labeled and why they have given these artifacts the terminology that they have (see Figure 3.2).

3.2.4.1 Fincastle

Varsakis proposed that her Sonota subphase include a Fincastle *complex* to document a hypothesized appearance of Sonota in Alberta at c. 2500 BP. From this she suggested that the Fincastle complex indicated the earliest representation of Sonota on the Northern Plains travelling northward for trading purposes out of the Dakotas. The Fincastle complex includes sites such as Fincastle and Layer XIV at the Sjovold site in Saskatchewan. Varsakis (2006:363) includes Dyck and Morlan's (1995) Layer XIV "Outlook Side-Notched" in her complex on the basis of the early date as well as projectile point similarities to Fincastle artifacts and KRF usage as a raw material.

3.2.4.2 Kenney

The Kenney subphase is an Alberta manifestation of Besant and is related to Pelican Lake; in fact, it replaces an earlier naming of the Pelican Lake II Phase (Varsakis and Peck 2005). Dates for the Kenney subphase range from 2800-2300 BP and include a range of lithic raw material types, a lack of arrow points made of flakes as well as shorter body length on the projectile points, a co-occurrence of Pelican Lake projectile points, and an established trading network with people belonging to the Sonota subphase (Varsakis 2006:360-362).

3.2.4.3 Bracken

It was Kehoe (1974) who originally coined the term "Bracken" to describe early Pelican Lake projectile points. He described these points as having wide corner-notches and straight shoulders that were transitional between late Pelican Lake and Besant (Kehoe 1974:111). Peck's (2011:275) analysis of the Bracken Phase in Alberta and Saskatchewan resulted in a date range of 2800 to 2100 BP. Early projectile points in the Bracken Phase exhibit more similarities with Pelican Lake projectile points, but slowly transition in morphology towards Besant forms at the end of the date range (Peck 2011).

3.2.4.4 Bratton

Projectile points classified as belonging to the Bratton type have been found in small numbers in other Besant archaeological sites on the Northern Plains (Gruhn 1971; Ramsay 1991; Reeves 1983; Wettlaufer 1960). Wettlaufer (1960) considered straight-sided projectile points with convex bases to be another variation of "Besant Side-Notched" as did Reeves (1983). Other archaeologists have called these types of projectile points both "Sonota" and "Samantha" although the majority tends to include it into Reeves' and Wettlaufer's definitions (Gruhn 1971; Ramsay 1991). However, Dyck and Morlan prefer to group these separately as Bratton projectile points (Dyck and Morlan 1995:378). Dyck and Morlan's (1995:379) "Bratton" type dates to approximately 3000-1300 BP and can be found in both Besant and Pelican Lake contexts which further adds to the confusion. These projectile points retain Reeves' and Wettlaufer's definition of having convex bases as well as notches along the lateral edges that can either be side- or corner-notches (Dyck and Morlan 1995:379)

3.2.4.5 Sandy Creek

The Sandy Creek *complex* was first identified at the Mortlach site by Wettlaufer in 1955. Dyck gives dates of 2450 to 1950 BP for Sandy Creek (1983:107-109). The Sandy Creek projectile point is described as being medium-sized with side-notches and having a concave base (Dyck 1983:108-109). Both Peck (2011:254) and Wettlaufer (1955:49,52) described Sandy Creek projectile points "short, thick, and rather misshapen, with shallow side notches and indented bases forming lugs or ears". Dyck and Morlan (1995) felt that Sandy Creek as well as Bratton and Outlook are early manifestations of the Besant *series* based on their presence in Besant assemblages at other sites and the dominant usage of KRF as a raw material.

3.2.4.6 Outlook

First named at the Sjovold site on the basis of a seemingly new projectile point form found in a layer between a probable Besant and an unknown cultural layer, Dyck (1983) classified this layer as "Unnamed Complex" and later this new projectile form as "Outlook Side-Notched" (Dyck 1983; Dyck and Morlan 1995). Dyck (1983) felt that these projectile points represented an influx of Early Woodland groups onto the Canadian Plains from Minnesota, Illinois, and/or Ohio. These projectile points are characterized by low "u-shaped" side-notches close to the base and straight or slightly concave bases (Dyck and Morlan 1995:433). The sides of the body are relatively straight and taper towards the tip.

Layer XIV from the Sjovold site was radiocarbon dated to an uncalibrated age of 2500 ± 85 BP (S-2060) (CARD 2016). This time period may be contemporaneous with Sandy Creek which can showcase similar projectile point morphology to "Outlook Side-Notched" projectile points (e.g., side notches and concave bases); however, Dyck and Morlan (1995:435) believed that Sandy Creek represents a type of projectile point and not an entire series or complex so overlapping time periods then do not present an issue.

3.2.4.7 Samantha

Samantha projectile points are very similar to Besant points with their only major differences lying in a smaller size and apparent function as arrow points (Kooyman 2000; Reeves 1983; Vickers 1994). Kehoe (1974) and Duke (1988) noted the similarities between Samantha points from the Besant Complex and those side-notched points that appear with the Old Women's Phase in the subsequent Late Precontact. Kehoe believed that Samantha projectile points were transitional to Avonlea projectile points and could be used for either dart technology or bow and arrow technology (1974:111-113). He also felt that Samantha projectile points could be dated to approximately 1535 BP (see Figure 3.1).

3.3 Pottery

Although discussions over when it first appeared are still debated, pottery production is another important feature of the Late Precontact Period on the Northern Plains. Similar in importance to bow and arrow technology, pottery would have provided new storage methods, cooking pots and might even have denoted group membership and cultural identity through styles and decoration.

3.3.1 Besant and Sonota

Discussions of the presence of pottery within Besant groups are contentious. Reeves (1983) and Quigg (1986) are both proponents of the existence of Besant pottery. Reeves (1983:96) described Besant pottery as containing conoidal vessels with vertically or horizontally corded surface impressions and bosses or punctates as decoration. However, this type of pottery was believed to have been restricted to the Middle Missouri area of North and South Dakota and not the more

Northern Plains region (Reeves 1983). Based on Reeves' (1983) distribution of so-called Besant pottery, it is undetermined whether it can truly be classified as Besant or represents another cultural manifestation such as Sonota. Quigg (1986) believed that Besant pottery occurred on the Northern Plains outside of the Middle Missouri area. Excavations at sites such as Ross Glen, One-Eleven and EhPc-105 in Alberta have produced Besant pottery in association with Besant projectile points (Quigg 1986). In Saskatchewan, Besant pottery has been recovered at sites such as Long Creek, Garratt and Walter Felt (Dyck 1983; Walde et al. 1995). Conversely, Byrne (1973) considered Besant to be an aceramic culture. He also stated that the appearance of pottery labeled as Besant in Saskatchewan sites such as Walter Felt and Long Creek were wrong because of stratigraphic disturbance within those sites.

At the Avery site in Manitoba, Dennis Joyes (1970) analysed the pottery sherds recovered from the excavations and determined a number of different ceramic wares were present including Laurel. While the Laurel pottery associated with the Besant occupation was considered puzzling, Joyes (1970:214) felt that Avery Corded ware was indicative of Besant based on its similarities to pottery sherds (coarse, grit tempered and cord-impressed with straight, plain rims) described by Kehoe that were found at the Walter Felt site (EcNm-8) in Saskatchewan and pottery from similar Besant-age sites in North Dakota and Nebraska. For this reason, he suggested a derivation of Besant archaeological sites on the Canadian Plains from Woodland cultures out of the American Plains that gave up pottery as they moved northward onto the Canadian Plains thus explaining the shortage of Besant pottery in Canadian archaeological sites (Joyes 1970:214). This hypothesis was based on ethnographic research undertaken by John C. Ewers among the historic Blackfoot (1945).

Sonota pottery has been described as "conoidal vessels with smoothed or cord-roughened surfaces consistent with general early Plains Woodland vessel forms" (Hamilton et al. 2001:115). Similar to other pottery found in Besant contexts, Sonota pottery also has punctates and bosses for decoration (Neuman 1975; Syms 1977). Pottery in Sonota archaeological sites is uncommon according to Pettipas (1983). In fact, Peck (2011) noted presence of pottery at only one Sonota site in Alberta, EgPn-111. The geographic range of Sonota pottery is concentrated in North Dakota with gradually decreasing occurrences further northward and westward (Cloutier 2004).

3.4 Subsistence Practices

Bison remained a dominant food resource for all Late Precontact groups on the Northern Plains, including Besant. For the entire Precontact Period, Besant groups are viewed as being the epitome of bison hunters on the Northern Plains (Kornfeld et al. 2010:125, 344). This was accomplished through the efficient use of a number of techniques to procure bison in large quantities. The use of jumps, corrals, and pounds is prevalent during the Besant period and this large-scale communal bison hunting indicates significant economic activity (Kornfeld et al. 2010:602). This intense usage of communal kills often resulted in large quantities of butchered bones in middens (Dyck 1983; Gruhn 1969; Hjermstead 1995; Ramsay 1991).

Within Sonota archaeological sites, bison was again the most prevalent faunal species (Neuman 1975). Peck (2011:322) analysed a number of Sonota sites in Alberta and found that canid remains were present in almost all of them as well. The most common archaeological site type for Sonota in Alberta is the kill site according to Peck (2011). Peck (2011:331) felt this either indicated that Sonota groups were moving onto the Alberta Plains at approximately 1500 BP to exploit bison populations present there or were moving to the peripheries of the Plains for other reasons, possibly including winter encampments, abandonment of the Middle Missouri region due to population pressures or economic issues.

Throughout the Precontact Period, bison were heavily selected as a dominant food resource. Its continuity into and throughout the Late Precontact Period on the Northern Plains demonstrates this with large-scale communal hunting and mass kill sites reaching their pinnacle during this period. Knowledge of the geographic landscape, such as sand dunes and cliffs, contributed to the success of these Late Precontact Period bison hunters. However, other faunal species, such as fish, pronghorn, moose and waterfowl, as well as floral species, were procured to supplement a group's diet.

The use of communal mass kills suggests increasing social complexity during this time period since it would necessitate coordinating the activities of larger groups of people through hierarchical organization (Walde 2006:299). Boyd's (2002) research in the Glacial Lake Hind basin of southwestern Manitoba indicated an increased presence of burnt grass phytoliths during the Besant and Sonota time periods. He suggested anthropogenic burning was occurring during this period to draw in bison herds by manipulating plant growth in the area (Boyd 2002:480-481). The usage of anthropogenic burning was compared to similar practices in the "Eastern

Agricultural Complex" of Eastern Woodlands groups (Boyd 2002; Cowan 1985). Both Boyd (2002) and Walde (2006) believed that anthropogenic burning by Besant and Sonota groups in southwestern Manitoba was influenced by the spread of Eastern Woodland traits.

3.5 Mortuary Practices and Ceremonial Traditions

Mortuary practices can provide a great deal of information regarding the behavioural mindset of Precontact groups and a better understanding of cultural practices and religious or ceremonial customs may be uncovered. The earliest examples of mortuary practices in the Late Precontact Period on the Northern Plains can be found with Besant and Sonota. Not a great deal is known about burial customs from this period, although some burials have been identified. Reeves (1983:97) noted the practice of secondary internments beneath earthen mounds in log-covered pits. These internments contain varying grave goods as well as bison skeletal remains (Peck 2011:282). Whether this is truly indicative of Besant burial customs remains to be seen, as earthen mounds do not occur on the Northern Plains in Saskatchewan or Alberta according to Peck (2011:323). Reeves (1983) remarked that this practice is only found in the Middle Missouri area of North and South Dakota. For this reason, this particular burial practice might better reflect those of Sonota groups in the Middle Missouri area. However, research by Dawson (1987) revealed the existence of three burial mounds in southeastern Saskatchewan. The Moose Bay and Glen Ewen mounds are believed to be of Avonlea age while the Sisterbutte mound remains undated (Dawson 1987:2). Truly, earthen burial mounds are more characteristic of Sonota than Besant. They are common in North and South Dakota and extend upwards into Sonota sites in Manitoba. These mounds are typically used for burials and tend to be low-domed with a number of secondary burials and associated burial goods (Neuman 1975). Analysis of burial goods found with Sonota mounds suggested contacts with groups to the east. Based on the presence of exotic shells, obsidian and catlinite, centrally located pits and multiple human burials with similarities to Hopewellian practices within Sonota burial mounds, Peck (2011) and Neuman (1975) suggested wide-ranging trade contacts between Sonota groups and Hopewell groups to the east as well as Plains groups to the west.

3.6 Besant and Sonota Outside of the Canadian Plains

The majority of research into Besant and Sonota groups has focused on the Middle Missouri subarea of North and South Dakota. Lehmer (1971) originally separated the area surrounding the Missouri River valley into six divisions: Big Bend, Bad-Cheyenne, Grand-Moreau, Cannonball, Knife-Heart, and Garrison. Later Johnson (2007) added the Fort Randall region in southern South Dakota. It is from archaeological work in this region that Neuman (1975) and others have formulated their ideas about Besant and Sonota groups.

In the United States, Toom (1996:66) recommends referring to the Late Precontact period as the "Plains Woodland" in order to differentiate it from the "Eastern Woodlands" even though it shares eastern traits as a result of Hopewell influences. In the west, Besant can be considered a part of the Late Plains Archaic with the co-occurrence of Besant and Pelican Lake points in some archaeological sites; yet, in the east, specifically the Middle Missouri subarea, Besant points are considered diagnostic of Plains Woodland cultures like Sonota (Toom 1996: 67). Burial mounds first appear during the Plains Woodland period with linear mounds occurring more commonly in the north and conical mounds in the central and south portions of the Middle Missouri subarea (Chomko and Wood 1973; Neuman 1975). While mounds appear to be more numerous than habitation sites, this could be a result of site visibility as mounds tend to be easier to see and habitation sites could be buried under alluvial deposits in the Missouri River valley (Toom 1996:67). There could have been semi-permanent camps or even small villages according to Hoffman (1968) and Neuman (1975), which may indicate increasing sedentism and a move away from the highly mobile hunter-gatherer lifestyle of previous groups. However, much of the past research into Besant and Sonota groups in North and South Dakota has focused on mound sites, not habitation sites, and this may have skewed the data and hypotheses surrounding Plains Woodland groups in the Middle Missouri. In the Northeastern Plains, which includes portions of southeastern Saskatchewan, southern Manitoba, eastern North and South Dakota, western Minnesota, and the extreme northwestern corner of Iowa outside of Missouri River Valley (Gregg et al. 1996), Besant and Sonota are considered to be part of the Plains Middle Woodland Period along with Laurel groups.

Vehik and Baugh (1994) suggested that Besant and Sonota straddle the boundary between the Middle and Late Woodlands Periods. Johnson and Johnson (1998) stated that the Plains Middle Woodland Period begins on the Northern Plains c. 2000 BP with the appearance of

Besant projectile points, ceramics and burial mounds. They (1998) agreed that Besant can be subsumed as part of Reeves' (1983) Napikwan tradition and can include those Middle Plains Woodland sites with burial mounds and Woodland pottery.

Research by a number of archaeologists have found that many stone features in Montana and North Dakota were produced by Besant groups dating to 2000 – 1100 BP (Deaver and Deaver 1988; Gregg 1985; Frison et al. 1996). However, Deaver and Deaver (1988) have expanded the date range from 2300-800 BP in eastern areas of the Northern Plains, which can overlap the time spans of both Pelican Lake and Avonlea. Gregg (1985; 1987a) sees a transition from Pelican Lake to Besant in North Dakota c. 2500 years ago but perhaps not until 2000 years ago elsewhere on the western Plains. Frison et al. (1996:26) asserted that Besant groups expanded quickly across the Plains based on the number of known tipi ring sites with Besant diagnostics. It is believed that Besant persists in the Dakotas after other Plains groups have adopted smaller projectile point forms (e.g., Avonlea) in the west (Deaver and Deaver 1988).

Johnson and Johnson (1998) also noted that pottery usage and burial mounds decrease in frequency with geographic distance outside of the Middle Missouri area and are likely the result of contact with groups on the Central Plains and in the Midwest instead of being a local adaptation. They did not see a distinction between Besant and Sonota as separate entities but rather that Sonota just had additional burial practices as seen in sites such as Stelzer on the Missouri River. When discussing the burial practices of Sonota groups, there is a focus on the liberal usage of red ochre, the inclusion of trade items such as obsidian, Gulf Coast conch shell, *Dentalium*, and artifacts with Hopewellian features such as carved human palates and mandibles as well as worked bear maxillae (Johnson and Johnson 1998; Neuman 1975).

3.6.1 Trading Practices and Influences

Neuman (1975) was the first to conclusively demonstrate that trading ties between Sonota groups in the Middle Missouri subarea and groups further to the east existed, based on the presence of exotic goods found in burial mounds. Johnson and Johnson (1998) saw Sonota pottery as reminiscent of Hopewell ceramics with its complex decorations and they proposed that the burial mounds reflected Hopewell influences despite being geographically distant from Hopewell centres in Iowa. To them and other archaeologists, these Hopewellian influences do not suggest migration of peoples out of the east into the Middle Missouri subarea but rather an adoption of selected traits into Sonota practices (Benn 1990; Johnson and Johnson 1998:221; Michlovic 1991; Sundstrom 1989). In addition to this, Neuman (1975:85) felt that while Sonota groups adopted eastern traits in their mortuary practices, pottery production, etc., they integrated these into their traditional cultural practices, which included secondary internments in burials as opposed to the more commonly seen primary internments in Illinois Hopewell sites, the addition of Trempealeau Focus (a Hopewell complex found in Wisconsin) components on pottery, the continued focus on bison as seen in the addition of offerings such as hides and skulls in burial contexts (McKern 1931; Schleiser 1987), the usage of uprights, and the predominance of scrapers as well as bone fleshers and awls. The latter are suggestive of intensive bison procurement and preparation.

Evidence of long-distance trade networks in effect in the Middle Missouri subarea is evidenced in the archaeological recovery of exotic shell trade materials including *Olivella* from the West Coast and *Dentalium* from either the Northwest Coast or the Caribbean as well as small quantities of copper (Gregg and Picha 1989; Neuman 1975:92; Picha 1995). Nevertheless, this trade relationship was not unidirectional. In fact, an east-west trading pattern was likely established during the Late Archaic Period according to Vehik and Baugh (1994:256). It has been suggested that in the east, as Hopewell groups moved north along the Mississippi River Valley system, they may have extended their contacts into the Northern Plains-Great Lakes trading network and as such would have made contact either directly or indirectly with groups further to the west such as Sonota (Baugh and Nelson 1988). Clark (1984:173) noted that KRF from North Dakota can be found in the Hopewell Mound Group during the Middle Woodland Period making it an "exotic raw material in the Hopewell Interaction Sphere". It was during the mid-1940s that archaeologist in the Midwestern United States first identified the presence of KRF in Hopewell burial mounds. In the 1960s, Joseph Caldwell (1964) described his concept of a Hopewell Interaction Sphere whereby materials, ideas, and trade goods flowed into and out of independent regional settlements located in the Mississippi River Valley of the Eastern Woodlands region. Since that time, the concept of the Hopewell Interaction Sphere has been used to describe extensive and far-ranging trading networks across the continental United States and Canada. It has suggested a level of cultural complexity that has not yet been found in archaeological sites dated prior to the Woodland Period. Moorehead (1922) noted the presence of Yellowstone obsidian in Hopewell burial mounds that may have entered the Hopewell area as a result of travel from west to east along the Missouri River system. Clark (1984) suggested that the presence of both KRF and Yellowstone obsidian in Hopewell sites indicates that these two trading materials were linked to each other and due to concentrations in Wisconsin sites may have moved overland through North Dakota across Minnesota and Wisconsin and then southwards rather than through the Missouri River system. Clark (1984) studied the assemblages from the Trempealeau Mounds of southwestern Wisconsin, which is considered a Hopewell variant. She also compared Sonota to the contemporaneous Malmo and Laurel groups in Minnesota and the Great Lakes region and the usage of KRF in each. Sonota groups in North and South Dakota had high quantities of KRF due to their proximity to the Primary Source Area (PSA) in North Dakota and the usage of this material did not drop off with distance from the source area. Instead, KRF dropped off drastically with an eastward movement into Malmo and Laurel sites, but still appeared in small quantities amongst the lithic assemblages indicating that some trading of material into these groups was occurring. As well, there was a larger quantity of debitage in Malmo and Laurel sites indicating that KRF was being traded in order to use (i.e., turn into functional tools) (Clark 1984). Hopewellian sites were unique in that there is little to no KRF debitage or tools present and almost all artifacts made from KRF were found in burial mound contexts and usually as large bifaces, which Clark (1984:185) believed may indicate some sort of ceremonial context. These Hopewell sites tend to be clustered in southwestern Wisconsin with the occasional occurrence in southern Ohio. Altogether, Clark (1984) felt that two different exchange systems were at work during the Middle Woodland Period: one for utilitarian tools (Malmo, Laurel and Sonota) and one for ceremonial/ritual usage (Hopewell).

Boszhardt (1998a) drew upon Clark's (1984) analysis of Hopewell mounds and the belief that KRF and obsidian were traded together. From an analysis of artifacts from Hopewell sites in the Trempealeau area of Wisconsin, he found that other materials from western North America, including Dendritic Madison Formation chert and grey orthoquartzite, were also being traded eastward into the Hopewell Interaction Sphere as ceremonial tools, such as large bifaces (Boszhardt 1998a). He also noted a lack of these materials as debitage or tools at local habitation sites (Boszhardt 1998a). While it remains unknown whether the bifaces found in Hopewell sites were manufactured in Wisconsin or out west, Boszhardt (1998a:283) proposes that the KRF bifaces in Hopewell mounds are stylistically similar to Besant/Sonota points with straight bases and side-notching.

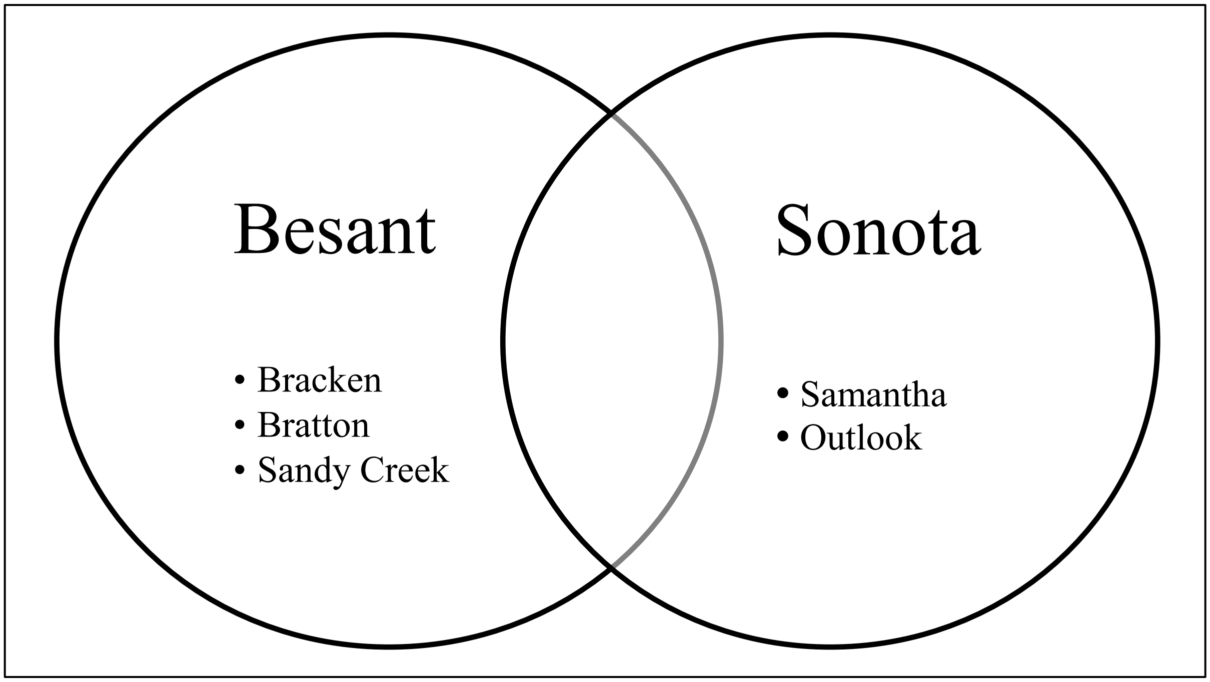

Figure 3.3: Relationships between Besant, Sonota and Associated Projectile Point Types from c. 2100-1070 BP

3.7 Discussion

Through an analysis of the pre-existing literature on these archaeological assemblages, it appears that Besant and Sonota can be considered separate entities that are in some way related through time, space and shared cultural traits (Figure 3.3). The main characteristics to distinguish between the two, besides date ranges, appear to be: (1) the presence of burial mounds in archaeological sites classified as Sonota; (2) eastern influences as seen in the presence of exotic shells and other trade goods; and (3) stylistic decorations on Sonota pottery. The projectile point types listed above can only be described as *types* at this time. There is not yet enough data to determine which *phases, subphases, complexes,* or *series* they are characteristic of. They all are found in similar archaeological assemblages (e.g., raw material type, date ranges, geographic ranges) and can be seen as changing artifact forms through time and interaction with other groups (e.g., Pelican Lake and Avonlea). The movement of KRF by Sonota groups out of North Dakota and to the east into Hopewellian contexts appears to be well supported in the archaeological literature. However, until these Hopewellian bifaces constructed from KRF undergo geochemical characterization, this will remain an assumption. Whether this same material is moving northward into Besant and Sonota sites on the Canadian Plains remains to be seen. The only way to definitively demonstrate the movement of KRF into northern contexts is to test whether artifacts made of brown chalcedony on the Canadian Plains are a product of quarries in North Dakota or not. If it is determined that the brown chalcedony in select Besant and Sonota sites in Alberta, Manitoba and Saskatchewan is not KRF, archaeologists will need to seriously amend what is currently believed about KRF as a trade item across the Plains region and even in Hopewellian contexts. This research will either begin the process of reaffirmation of an age-old assumption of KRF trade and exchange systems or force Plains archaeologists to completely reassess what is known about Besant and Sonota groups and lithic procurement strategies. The research conducted will also help to further elucidate if and/or how Besant and Sonota groups are related to each other by determining where lithic raw materials are coming from and how these results can be added to the existing body of archaeological knowledge for Besant and Sonota as discussed in the preceding sections.

Chapter 4 - Archaeological Site Comparative Analysis

The archaeological sites used in this study were chosen because of their identifications with Besant or Sonota as well as the presence of high quantities of brown chalcedony artifacts. It is important to note that other lithic materials were utilized for tool production and were found throughout these sites' lithic assemblages. Many of the lithic raw materials utilized in these archaeological sites was easily accessible as part of the glacial drift that covers much of the prairie provinces (i.e., Swan River chert, quartzites, cherts, siltstones, etc.). However, brown chalcedony artifacts tend to dominate the lithic assemblages as discussed below. Ten archaeological sites ranging from kill sites, habitation sites, and processing sites and dating from c. 2100 – 1500 BP, were selected for analysis and their geographic locations can be seen in figure 4.1. Additionally, all artifacts used in the subsequent analyses were from occupation levels (as stated for each site) that did not show mixed stratigraphy or cultural occupations and were considered exclusively Besant or Sonota.

4.1 Alberta Archaeological Sites

Three archaeological sites in Alberta were selected for this study, based on the presence of Besant materials, artifacts made from brown chalcedony, and accessible collections. The majority of the archaeological collections are housed at the Royal Alberta Museum; however, some sites, such as Fincastle (DlOx-5) have portions of their site collection stored in locations other than the provincial repository, such as at universities.

4.1.1 Fincastle - DlOx-5

The Fincastle site is located 3 km south of the Oldman River near Taber, Alberta and was first recorded in 2003 after local residents reported artifact looting occurring in the area. A program designed to assess damage to the site and recover any surface artifacts was instituted that year by the Archaeological Survey Section of the Historic Resources Management Branch, the regulatory body for archaeology in Alberta, and undertaken by the University of Lethbridge and the Archaeological Society of Alberta – Lethbridge Center. Under the direction of Dr. Shawn Bubel from the University of Lethbridge, the site was surveyed, and a shovel-testing program was also undertaken. Projectile points characteristic of Besant and Sonota assemblages were recovered

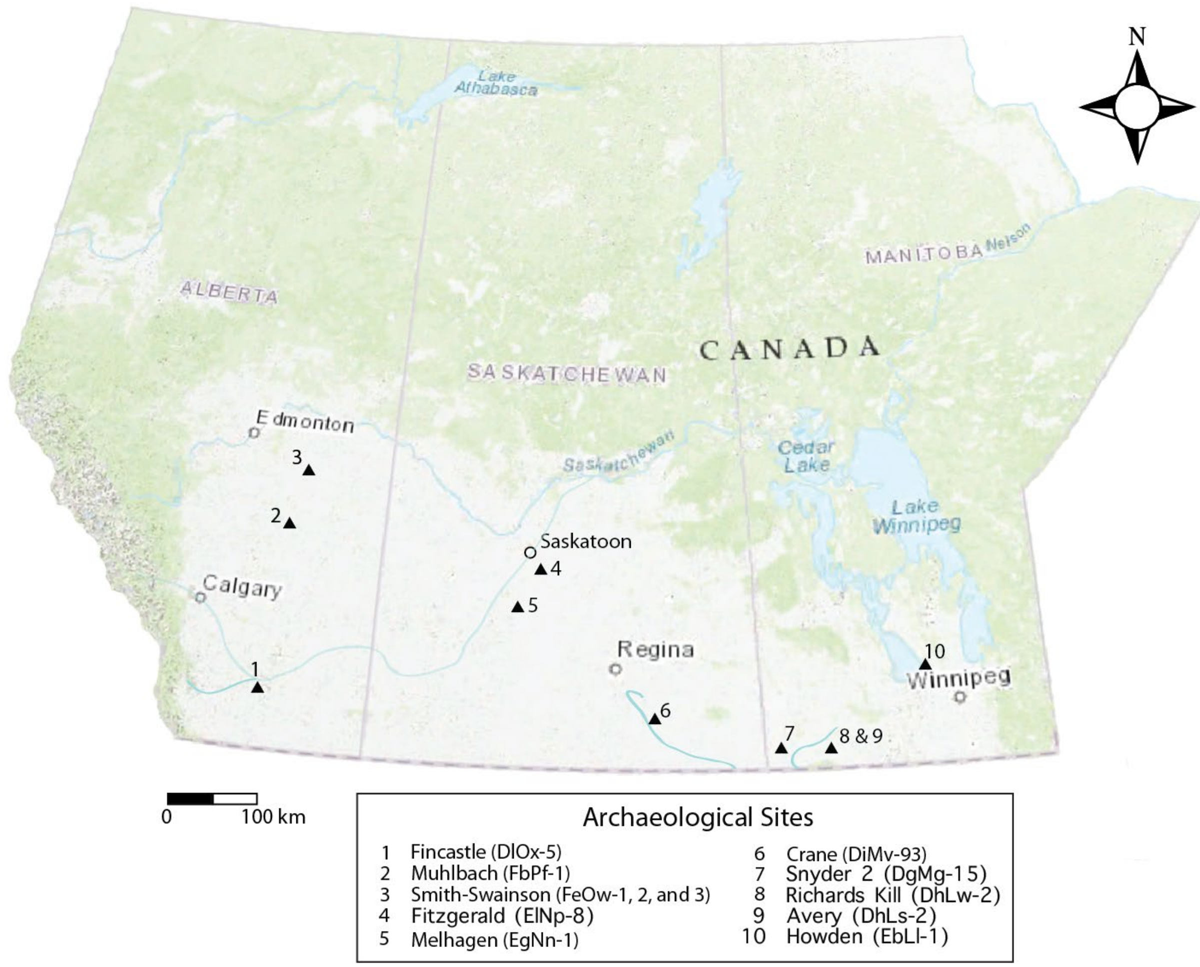

Figure 4.1: Archaeological Site Locations

from the site. Based on the quantity of material recovered in 2003, the site became the location for a University of Lethbridge field school in subsequent years. As of 2007, excavation resulted in an extensive recovery of lithic and faunal remains as well as six bone upright features. Radiocarbon dating has placed the site at c. 2500 BP (Foreman 2010). Of the artifacts recovered to date from the Fincastle site, 91 of the 119 projectile points, 36 of the 75 small tools (including utilized and retouched flakes, scrapers, drills, wedges and knives), and 2479 of the 3401 pieces of debitage were classified as being made of brown chalcedony (Table 4.1). In total, 75% of the lithic material found at Fincastle has been classified as either brown chalcedony or KRF (Bubel 2014). Bubel (2014:226) suggested that the high percentage of KRF within the Fincastle lithic assemblage implied well-established connections with groups in the Middle Missouri subarea.

Table 4.1: Brown Chalcedony and Petrified Wood-Classified Artifacts from the Fincastle (DlOx-5) Site

Artifact Type	Brown Chalcedony (KRF)	Petrified Wood	Assemblage Totals	% of Assemblage Total
Projectile Points	91	2	119	**78**
Small Tools	36	0	75	**48**
Debitage	2479	10	3401	**73**
Totals	**2606**	**12**	**3595**	**73**

Varsakis (2006), using information from the 2004 and 2006 excavations, felt that the projectile point metrics (i.e., elongated point form as found in the Dakotas) and lithic material type suggested a Sonota affiliation. Christine Foreman (2010:172) suggested that the site is a very early manifestation of Besant and may actually be classified as Outlook Complex. Peck (2011) used his own metric analysis and concluded that Fincastle more closely resembled the Outlook or Unnamed Complex identified at the Sjovold Site by Dyck and Morlan (1995).

4.1.2 Muhlbach (FbPf-1)

The Muhlbach site (FbPf-1) is located near the town of Stettler in central Alberta. This bison pound site was brought to the University of Alberta's attention when the landowner, William Muhlbach, uncovered a bison bone bed while installing a fence and corral. However, as there was no archaeologist at the University at the time, no further action was taken. Informal excavations took place at the site by the Muhlbach family and Robert Graham of Stettler prior to 1964. In 1964, the site was brought to the attention of Drs. Alan Bryan and Ruth Gruhn by Robert Graham.

In the summer of 1965, Dr. Gruhn began formal excavations at FbPf-1 under the auspices of the National Museum of Canada. In total, 128 square metres were excavated in 1965 (Gruhn 1971:130). Gruhn believed that more of the site remained intact south of the corral area and estimated the entire site dimensions to be approximately 1200 square metres (Gruhn 1971:135). The excavations revealed a dense bison bone bed with copious amounts of smashed bone.

Preliminary estimates indicated a minimum of 100 animals based on mandible counts. The Muhlbach site is best known for the presence of seven bone upright pits spaced out in two parallel lines trending northwest to southeast in the north area of the site and three additional bone uprights in the east area of the site also trending in a northeast to southwest direction (Gruhn 1971:139).

Artifacts recovered from the site included 61 Besant projectile points of which over 80% were identified as being made from KRF, and the others being made from silicified wood, chalcedony, quartzite, and black chert (Gruhn 1971:142-143). Other artifacts found at the site include a knife and knife fragments (n=2), scrapers (n=2), a perforator, retouched flakes (n=5), utilized flakes (n=2), unmodified flakes and a polishing stone (Gruhn 1971:143-144). Again, the dominant toolstone material type has been identified as KRF. A radiocarbon sample was obtained for the site; however, based on the uncalibrated age of 1270 ± 150 BP (GSC-696) or calibrated to 1522 - 918 BP, the sample was believed to have been contaminated with more recent organic material (CARD 2016). Reanalysis and new accelerated mass spectrometry dating of Muhlbach materials confirmed that contamination did play a role in some of the results; however, subsequent calibrated dates of 1688 and 1410 BP (UCIAMS 89684 to 89687 respectively) indicated that Gruhn's original radiocarbon date is correct (Graham 2014). No further excavation has ever been undertaken on the Muhlbach site although the archaeological materials that were recovered have been used in subsequent analyses (Foreman 2010; Graham 2014; Hamza 2013; Shortt 1993; Varsakis 2006). The most recent reanalysis of the Muhlbach material proposed that the people who occupied the site maintained ties to the Dakotas through the presence of large quantities of KRF (Graham 2014:261).

4.1.3 Smith-Swainson (FeOw-1, 2, and 3)

The Smith-Swainson site is located south of the town of Sedgewick, Alberta. Recoveries included 152 projectile points fashioned from material identified as KRF and similar in form to both Besant and Sonota artifacts (Doll 1974a, 1974b, 1974c; Varsakis 2006:43). The collection consists of both arrow and atlatl dart points and includes those made expediently on flakes as well as those that have been bifacially-worked. In Varsakis' analysis of the projectile points, she noted their similarities to those found at the Fincastle and Muhlbach sites in Alberta as well as the Fitzgerald and Melhagen sites in Saskatchewan (Varsakis 2006:261). The Smith-Swainson site is actually composed of three separate archaeological sites: the Smith site 1 (FeOw-1), the Swainson site (FeOw-2), and the Smith site 2 (FeOw-3), all found within a sand dune environment in the vicinity of each other (Doll 1974a, 1974b, 1974c). The sites were originally recorded by Dr. Alan Bryan in 1964 and later excavated by Maurice Doll in 1973.

The Smith site 1 (FeOw-1) was noted by Bryan as having a large quantity of bison bone and lithic debitage on the surface. Artifacts including projectile points, scrapers and flakes were collected. Doll was unable to excavate this site in 1973 as there was a crop on the field at the time.

The Swainson site (FeOw-2) was excavated in 1973 via three test trenches. The cultural material recovered included articulated and partially articulated bison skeletons, large quantities of smashed and burned bone, two projectile points, and a small quantity of lithic debitage (Doll 1974b). Doll (1974b) noted that the surface collection of projectile points numbered in the hundreds and other artifacts such as scrapers, bifaces, potsherds, and an atlatl weight were collected.

The Smith site 2 (FeOw-3) was excavated by Doll in 1973 via two trenches across an area where there was a surface artifact scatter. Artifacts collected included a large quantity of projectile points. Doll (1974c) noted that the majority of the site was disturbed as a result of cultivation.

All three sites produced large quantities of what has been identified as KRF and the projectile points were classified as Besant. Doll (1974b) theorized that the sites related to a bison kill and processing areas. No radiocarbon dating has been done at any of the three sites that make up Smith-Swainson.

4.2 Saskatchewan Archaeological Sites

Three archaeological sites were selected for analysis from Saskatchewan on the basis of being assigned a Besant age and representing a number of different site types including a campsite, a kill site, and a processing area. All of the artifact assemblages were obtained from the provincial repository at the Royal Saskatchewan Museum except for the Fitzgerald site lithic materials, which are housed in the Department of Archaeology and Anthropology at the University of Saskatchewan.

4.2.1 Melhagen (EgNn-1)

The Melhagen site (EgNn-1) is a Besant bison pound located near the town of Elbow, Saskatchewan. The site was discovered by a group of hunters who noticed bone eroding out of a hillside in the Aiktow Sand Hills (Ramsay 1991). Mel Hagen, one of the hunters, reported the find to a member of the Saskatoon Archaeological Society. Then President of the Saskatoon Archaeological Society, Tom Phenix carried out excavations at the site between 1967 and 1972, with further excavations taking place in 1986 and 1987 by Allyson Ramsay. The results from all the excavations at the Melhagen site formed the core of Ramsay's (1991) Master of Arts thesis on the site. Ramsay (1991) set out to determine the frequency of site usage, the seasonality of the site, and if it was representative of Besant or Sonota groups. Ramsay (1991:15) noted that stratigraphy at the Melhagen site was similar to that found at the Muhlbach site in Alberta. Analysis of the site indicated the presence of kill and processing areas with distinct areas of concentrated bison remains and lithic manufacturing and resharpening stations. However, Ramsay noted that perhaps less than 25% of the site had been excavated at the time her research was concluded (1991:2).

Unfortunately, Ramsay's (1991) thesis did not discuss lithic tools in any great detail beyond projectile point metrics and subsequent artifact analyses from the 1967-1972, 1986, and 1987 excavations. According to Tom Phenix's (1969) report in the *Saskatchewan Archaeology Newsletter*, 57 projectile points, 6 endscrapers, and 3 flake scrapers were recovered from 1967-1969. Of these, 47, 3, and 1 were classified as made of "Knife River chalcedony" respectively (Phenix 1969:19).

In Ramsay's discussions of the different activity areas (e.g., kill and processing) found at the site, mention is made of ground stone tools, debitage, cores, and other small tools, but the lack of an artifact catalogue or more detailed discussions prohibits determining how many and what tools were made of brown chalcedony. Ramsay (1991:70) noted that all the projectile points recovered from the site are of the Besant type except one possible Pelican Lake projectile point made from silicified peat. Walde's (2014:158) statistical analysis of Ramsay's projectile points indicated that 47 are indicative of dart points and only seven represent arrow points. In the lithic analysis discussion on the Melhagen site, Ramsay (1991:134) classified 53% of the lithic collection from the 1986 and 1987 excavations and 78% of the Phenix collections as KRF. In total, 70% of the archaeological material recovered from the Melhagen site is classified as KRF

(Ramsay 1991:111). Radiocarbon dates for the Phenix Besant levels at EgNn-1 include uncalibrated ages of 1910 ± 70 BP (S-1640), 1710 ± 50 BP (S-1641), and 1960 ± 90 BP (S-491) while Ramsay's uncalibrated dates are 1905 ± 110 BP (S-2855) and 1575 ± 115 BP (S-2856) (CARD 2016).

4.2.2 Crane (DiMv-93)

The Crane Site (DiMv-93) was discovered as part of the Souris Basin Heritage Study (SBHS) undertaken to locate and mitigate archaeological sites that would be affected by the construction of the Rafferty dam and subsequent inundation of the Souris River valley. Research was carried out by the Archaeology Department of the Saskatchewan Research Council from 1986-1990. DiMv-93 is located on the east side of the Souris Valley near the confluence of Roughbark/Jewel Creek with the Souris River. It was revealed to be a multi-component (Historic, Late Prehistoric, Besant, and Pelican Lake) campsite with at least 20 occupation levels, of which only the first 11 were excavated (Gibson and McKeand 1992). Based on the presence of diagnostic artifacts, Occupation VIII is attributed to Besant groups. Features such as two hearths and two bone uprights were excavated in addition to large scatters of lithic artifacts. Gibson and McKeand (1992:42) noted that almost 95% of the lithic raw material from Occupation VIII was KRF and of the 110 lithic tools analysed, 100 were crafted from KRF. These include both scraping tools and expedient/retouched tools (Gibson and McKeand 1992:43). Eight of the eleven projectile points recovered were identified as Besant and all the projectile points were made of KRF except for one artifact that was fashioned from petrified wood. Occupation IX included a Besant projectile point and over 75% of the lithic assemblage was identified as KRF. Gibson and McKeand (1992) classified Occupation X as an aberrant level as the recovered projectile points were identified as belonging to both Pelican Lake and Besant time periods. KRF remained the dominant lithic material from this occupation with classifications over 75% (Gibson and McKeand 1992:67). Kevinsen's (2013:63) analysis of the Besant projectile points from this occupation led him to classify them as belonging to the Bratton type. Radiocarbon dating of the Besant occupations produced uncalibrated ages of 1970 ± 70 BP (S-3212) and 1600 ± 70 BP (S-3213) (CARD 2016).

4.2.3 Fitzgerald Site (ElNp-8)

The Fitzgerald Site (ElNp-8) is located in the Moose Woods Sand Hills southeast of Saskatoon, Saskatchewan and was discovered in 1991 while the landowner was digging postholes on the property. Due to the intact subsurface deposits uncovered by the landowner, further excavation was warranted. Hjermstead (1996) excavated 73 m^2 of the site in 1992 and 1993 to form his Master of Arts thesis. ElNp-8 is interpreted as a Besant bison pound and processing area with a lithic raw material assemblage identified as 90% KRF (Hjermstead 1996). Radiocarbon analysis resulted in uncalibrated dates of 1490 ± 90 BP (Beta-69005) and 1270 ± 140 BP (S-3546) from the processing area, and 1340 ± 60 BP (Beta-69004) and 1160 ± 170 BP (S-3547) from the kill site (CARD 2016). Excavations in 1992 and 1993 recovered 143 projectile points, 22 formed tools (including a biface, a pièce esquillèe, endscrapers, sidescrapers and unifaces), utilized and retouched flakes as well as 2030 pieces of debitage from the site (Hjermstead 1996). Projectile points were not separated into Bratton or Outlook point styles and instead Hjermstead choose to classify them as “Besant Side-Notched”. Statistical analysis of 54 of the Fitzgerald site projectile points show that all represent dart points (Walde 2014:158).

4.3 Manitoba Archaeological Sites

Three archaeological sites were selected for analysis from the province of Manitoba based on their affiliation to Besant and/or Sonota groups. A fourth archaeological site was chosen after discussions about visually similar brown chalcedonies in Manitoba with archaeologists (K. Brownlee, personal communication 2015) identified another possible source area producing a material called St. Ambroise chalcedony (see section 5.2.5.1) that is visually similar to other brown chalcedonies found in this study. All archaeological collections were obtained from the Manitoba Museum.

4.3.1 Richards Kill (DhLw-2)

The Richards Kill site (DhLw-2) was recorded by Walter M. Hlady in 1967 and is located northwest of Killarney, Manitoba. The site was discovered during the course of land breaking for agriculture by the landowner, J.C. Richards. Richards found a broken projectile point and proceeded to excavate a portion of the site, 20 x 10 feet (Hlady 1967). This excavation uncovered 23 projectile points, 83 projectile point fragments, 3 sidescrapers, and 14 flakes, as well as bone and tooth enamel (Hlady 1967:3). Hlady undertook another excavation later that year adjacent to the area excavated by Richards and his family. Additional projectile points, lithic flakes, and bone and tooth enamel were recovered leading Hlady to conclude the site was a bison kill. Hlady classified the complete projectile points as Besant and he also noted that 21 were made from a brown chalcedony, 13 of which he called KRF. The projectile point fragments were also dominated by brown chalcedony (n=91) (Hlady 1967:3). Hlady noted that the points from the Richards Kill site tend to be longer than those found in Occupation 4A of the Mortlach site, on average 45.5mm as compared to 37mm at Mortlach. He felt that the Besant projectile points from DhLw-2 better resemble those found in Occupation 4B of the Mortlach site.

4.3.2 Avery (DhLs-2)

The Avery site was first excavated by Chris Vickers from 1944 to 1948 and later by the University of Manitoba in 1966 under the auspices of Dr. William J. Mayer-Oakes and the Glacial Lake Agassiz Survey (Joyes 1970). This site was the first "prehistoric occupation site to be extensively excavated in the province of Manitoba" (Joyes 1970:209). It was named for the landowner and is located west of Pilot Mound near the northeastern margins of Rock Lake. The Avery site represents a multicomponent campsite with artifacts recovered dating from the McKean culture to the Selkirk phase (a Manitoba Late Precontact Period including both Plains and Prairie Side-Notched projectile points as well as Plains Triangular projectile points). The most comprehensive report on this site is a result of a 1970 Master of Arts thesis by Dennis C. Joyes, which included a synthesis of all previous excavations. The Besant occupation at the Avery site is evidenced by the presence of 28 Besant projectile points and high quantities of KRF as a raw material in toolstone manufacture (56%) (Joyes 1969). Vickers (1945:90) also remarked on the high proportions of chalcedony used in artifact manufacture at this site. Joyes (1970:213) also noted the presence of Laurel and Avery Corded ware found with the Besant artifacts at the site. Reeves (1970:165) remarked on the presence of bone uprights at the Avery site as being characteristic of Besant archaeological sites.

4.3.3 Snyder II (DgMg-15)

The Snyder II site (DgMg-15) has been classified as a village site and is located on a plain overlooking the Gainsborough Creek valley south of Melita, Manitoba near the Souris River.

Numerous explorers and researchers have visited the site over the years with the first possible recording of it by Professor Henry Youle Hind in 1858. Hind is said to have dug into a supposed collapsed earthlodge at the site as reported by his Métis escorts (Syms 1980:126). The site incorporates a number of burial mounds as well as a large U-shaped earthwork with more mounds in the immediate vicinity (Hamilton et al. 2006). Between 1907-1910, Dr. Henry Montgomery of the University of Toronto excavated a number of the mounds followed by surface collection by Chris Vickers in the 1960s and 1970s. Syms' work at the site began in the 1970s when he split it into two distinct archaeological sites; DgMg-15 included the northern and central part of the field, and DgMg-17 incorporated the southern mounds. Syms' original excavations took place to determine if an undisturbed depression feature was naturally occurring or man-made. Through the excavation of four units (each 80 x 180 cm), it was discovered to be a storage pit approximately 120 cm in diameter at the base and 123 cm in depth (Syms 1974:306-307). A number of additional features were uncovered during the course of the excavation, including six hearths. The artifact assemblage included the remains of eight pottery vessels, six retouched flakes, six flakes, six scrapers, three projectile points, one biface fragment, and one possible atlatl weight fragment with KRF and Swan River chert being the predominant lithic types. Also recovered were a bone scraper, a bone needle fragment, an undetermined bone tool worn from use and two small iron fragments (Syms 1974:308-311). Further work by Ronald J. Nash (1972, 1973) resulted in additional artifacts being recovered from across the site. Nash's collection was dominated by Swan River chert (44%) and KRF (32%) respectively (Syms 1980). Syms (1980) also noted that there was a large amount of debitage collected as well as cores and flakes. Forty-nine tools, including projectile points, scrapers, bifaces, choppers, worked flakes, utilized flakes and a perforator were also discovered in addition to numerous pottery sherds from at least one Blackduck vessel (Syms 1980:130). Of the 8 projectile points, 2 are classified as Besant/Sonota (Syms 1980:130). Thomson (1994) noted that some of the flakes identified as petrified wood or agate from this site are actually made from silicified lignite according to their geochemistry and were misidentified based on visual inspection alone.

4.3.4 Howden (EbLl-1)

The Howden Site (EbLl-1) was included in this analysis due to the presence of a particular variety of brown chalcedony known locally as St. Ambroise chalcedony (see section 5.2.5.1 for more information on the postulated geological origins of this material). The artifacts from this site were collected over a ten-year period between the shores of Lake Manitoba and Lake Francis. This collection numbers in the hundreds with over 100 projectile points collected dating to the Paleoindian through to the Late Woodland Period (Scaletta 1985). No associated radiocarbon dates exist for this site.

Chapter 5 –Provenance Studies of Chert and Chalcedony and Source Area Geology

In order to positively identify from where Besant/Sonota groups obtained brown chalcedony, an understanding of what constitutes a chert and/or a chalcedony is warranted. Additionally, an overview of the geological origins of each brown chalcedony sample area used in this research is presented in order to better understand the genesis and potential usage of material as toolstone in archaeological contexts.

5.1 Geological Overview of Cherts and Chalcedonies

Determining the formation of a lithic toolstone, whether from sedimentary, igneous, or metamorphic contexts, is necessary in establishing possible source areas. Two sedimentary rock types, chert and chalcedony, were of particular interest to Precontact Plains groups in western Canada and the adjacent United States based on their abundance in archaeological sites. For the purposes of clarification, sedimentary rocks are rocks that have "formed from (1) lithification of any type of sediment, (2) precipitation from solution, or (3) consolidation of the remains of plants or animals" under low temperature and low pressure (Plummer and McGeary 1996:527).

When looking at sedimentary rocks in regard to provenance studies, one is particularly concerned with the rock's chemical composition and its crystal structure. Chert and chalcedony are silica-rich (SiO_2) rocks composed of quartz crystals (Bates and Jackson 1984; Plummer and McGeary 1996). While both chert and chalcedony are considered to be of sedimentary origin and are siliceous in composition, they differ in how they are formed.

5.1.1 Chert

The word "chert" is an all-encompassing term that is used to describe a wide variety of lithic raw materials in the archaeological literature. Lithic artifacts that exhibit an opaque, smooth, cryptocrystalline (i.e., consisting of crystals that are only visible with microscopy) appearance and texture are often labeled as a variety of chert based on a quick visual inspection. Chert has been used to describe a wide range of sedimentary rocks including flint, chalcedony, agate, jasper, and, opal (Luedtke 1992). However, chert is not synonymous with these rocks and in fact can differ quite drastically based on its chemical composition. Chert and flint tend to be used interchangeably in some geological and archaeological literature. Luedtke (1992:5) notes that "flint" tends to be a historical usage of the term dating back to the eighth century, whereas "chert" does not appear in print until the 17th century. Flint is commonly used to describe sedimentary silica-rich, cryptocrystalline nodules found in chalk deposits in Europe.

In North America, chert is often used as an all-encompassing term that includes the different rock types listed above. Generally, chert is broken down into a number of different categories, usually based on colour. For example, "archaeologists generally call all red-, brown-, and mustard-colored cherts *jasper*" (Luedtke 1992:6). This is in no way a geological distinction, but one based only on visual inspection with little to no awareness of the geological context of the material.

Geologically, chert is "a hard, dense microcrystalline or cryptocrystalline sedimentary rock, consisting chiefly of interlocking crystals of quartz" (Bates and Jackson 1984:85). The quartz crystals within chert tend to be aligned equi-dimensionally (Rapp 2002:71). More specifically, chert is composed of various minerals, the most abundant being quartz (consisting of silicon dioxide, SiO_2) and including, in lesser quantities, other compounds such as aluminum oxides (Al_2O_3), iron oxides (Fe_2O_3), calcium oxides (CaO), magnesium oxides (MgO), sodium oxides (Na_2O) and potassium oxides (K_2O) in addition to other elements only found in trace amounts (Maxwell 1963). It is these different proportions and concentrations of minerals and elements that often aid in provenance studies.

Chert can occur as nodules or as layered deposits and is often formed as the result of inorganic precipitation or through the lithification and silica replacement of hard-shelled microscopic marine organisms or organic materials such as plant tissue and peat (Plummer and McGreary 1996). Formation of specific chert types is dependent on the area in which it is found. It is important to note that while understanding the chemical composition of chert samples is key to determining possible source locations, it is also vital to recognize that variability may exist in individual samples, source areas, and formations and not only on a geographical or regional scale. As such, an understanding of the formation or bed in which a chert sample is collected is critical in analysing lithic artifacts for provenance studies. Chert formation is not a simple, one step process, but rather one that can involve a number of stages including chemical alteration, replacement, and recrystallization; hence, variation may occur within one formation (Luedtke 1992).

Similar to other silica-rich sedimentary rocks, cherts come in a wide variety of colours, lustres and textures. Due to its crystalline structure, chert tends to fracture conchoidally, has a waxy lustre, is fine-grained to cryptocrystalline in texture and is rated as a 7 (hard) on the Mohs Hardness Scale, a scale typically used to describe rock properties in geology (Rapp 2002:71). Since cherts can be formed from inorganic precipitation and/or silicification of organic materials, the structural composition of the chert will influence all of its visual properties and it is possible for organic remains (plant materials and fossils) to be visible in some varieties. It is the high quality, cryptocrystalline cherts with a conchoidal fracture that were most desirable for stone tool formation and usage (Rapp 2002).

5.1.2 Chalcedony

Whereas chert is often identified in archaeological literature as a material type that exhibits a smooth, opaque and cryptocrystalline appearance, chalcedony is visually similar, but often identified on the basis of its translucency. Geologically, chalcedony is defined as "a cryptocrystalline variety of quartz. It is commonly microscopically fibrous, may be translucent or semitransparent, and has a nearly waxlike luster" (Bates and Jackson 1984:81). In some chalcedony, the quartz crystals tend to grow as "radiating fibers in bundles" which gives it a fibrous texture (Luedtke 1992:23). It is important to note that chalcedony can form pseudomorphs (a mineral or rock from which its original form or structure has been replaced by another mineral), such as petrified wood, with the silification of organic materials such as wood or peat. These pseudomorphs can complicate identification by showcasing structures, such as a fibrous texture, that is the result of silification processes and not true quartz crystal growth. Examples of these types of pseudomorphs can occur in peat bogs where plant tissue is preserved due to permineralization processes (see section 5.1.2.2). As such, understanding the geological origins of material is necessary in order to properly identify it.

When examining thin sections with a polarized light microscope, chalcedony can be divided into two different types: length-fast and length-slow. Length-fast chalcedony is more common than the length-slow variety. The major difference between the two is in how the quartz crystals within the fibers are oriented and as a result how quickly polarized light can pass through these fibers (Luedtke 1992:24). These different types of chalcedony may also indicate separate formation processes and environments (Luedtke 1992). Having two different forms of chalcedony that can also be found in some chert samples further complicates the understanding of how this material forms. Chert and chalcedony can tentatively be considered sister species of one another.

5.1.2.1 Moganite

Recently, research into quartz has revealed the presence of a new mineral that has implications for those studying both chert and chalcedony. Moganite is a controversial mineral that is still seeking recognition by the International Mineralogical Association (IMA), a group that seeks to promote the field of mineralogy and standardize mineral names (International Mineralogical Association 2009). First recognized in 1984, moganite (SiO_2) is a silica polymorph, a silicon dioxide mineral that can crystallize in more than one form (Pretola 2001) and is found in both chert and chalcedony (Heaney and Post 1992).

Heaney and Post (1992:442) believe that moganite is a rediscovery of a mineral first identified in 1892 by French mineralogists and called lutecite. It was subsequently abandoned when x-ray diffraction revealed only the presence of quartz in specimens previously believed to contain lutecite. The issue with moganite lies in the fact that in x-ray powder diffraction patterns, moganite overlies the major peaks of quartz making it virtually unrecognized. It is only with magnification of these diffraction patterns that moganite becomes visible (Heaney and Post 1992). As such it is thought that both chert and chalcedony are composed of quartz crystals as well as moganite in varying quantities. Heaney and Post (1992:443) note that some silica-rich materials do not contain any moganite, particularly weathered varieties. It is suspected that moganite has the ability to recrystallize to quartz or is water-soluble when exposed to surface weathering or hydrothermal fluids (Heaney and Post 1992:443). When it comes to provenance studies, the presence or absence of moganite may not indicate any relationships; however, it may be possible to compare ratios of moganite content in unweathered samples to source areas to determine possible affinities.

5.1.2.2 Petrified Wood

Petrified wood is considered a pseudomorph in that it is wood that is chemically replaced over time by another mineral such as chalcedony or opal. The original structure remains after silification, but it is not entirely composed of a different mineral. Petrified wood has also been referred to as silicified wood. The wood undergoes both permineralization (cellular material becomes entombed) and replacement of organic materials by minerals, according to Mustoe (2017:119). Larger specimens of petrified wood are more readily identifiable as such due to the visual appearance of a wood grain. However, in smaller samples (<2 cm), the wood grains may not be as readily apparent, and some material may be incorrectly classified as KRF.

5.1.2.3 Visually Similar Varieties of Brown Chalcedony

Knife River flint (KRF) is perhaps one of the most well-known lithic materials found in archaeological sites on the Northern Plains. It also appears to have been most desirable to Precontact Northern Plains people. Over the last few decades, developments in the oil, gas, and forestry industries have resulted in more archaeological assessments being undertaken within Canada and the United States. This has revealed the presence of lithic materials both within archaeological sites and in primary geological contexts that appear visually indistinguishable from KRF.

One particular type of lithic raw material that is visually identical to KRF is found in the Hand Hills area of east-central Alberta. Currently, little archaeological research has been undertaken to address this material type. Similar varieties of brown chalcedony are also reported to occur in the South Saskatchewan River valley, in the Souris gravels of Manitoba and from the White River Group outcrop of South Dakota (Ahler 1977; I. Dyck, personal communication 2009; Hlady 1965; Hoard et al. 1993; D. Meyer, personal communication 2008; E. Walker, personal communication 2008). Whether these materials represent primary or secondary sources of visually similar brown chalcedony needs to be determined. Primary sources represent areas where the geological material formed *in situ* whereas secondary sources are deposits of material that have been transported (e.g., via glacial, alluvial, fluvial, etc., actions) out of its primary context into regions where it would not naturally form. On the Northern Plains, previous glaciations and deglaciations as well as the Laramide orogeny have moved and redeposited large amounts of lithic materials across this region. As such, useable lithic material for stone tool manufacture can be found in secondary sources as isolated deposits as well as dispersed in the glacial drift that blankets much of the area.

For example, source areas of KRF-like materials occurring in Manitoba appear to be confined to the southwestern portion of the province along the Souris River (Hlady 1965). It is possible that the appearance of cobbles in this area is the result of pre-glacial drainage of the Knife River close to the Souris River channel (Gregg 1987; Leonoff 1970). However, Syms (1977:28) believes the Manitoba presence represents not KRF, but agatized wood (a type of chalcedony pseudomorph) and is unlikely to represent a primary source area. At best, it is a secondary deposit of materials from pre-glacial drainage northeast into Hudson Bay (Lemke et al. 1965).

While it appears that, visually, Hand Hills flint from east-central Alberta is an important candidate for use in comparative geochemical analyses with KRF, there exists other visually similar brown chalcedony materials from other regions of the northwestern and Canadian Plains as well. Visually similar brown chalcedony deposits from the Souris gravels of southwestern Manitoba, from areas along the South Saskatchewan River, from the White River Group outcrop of South Dakota and from eastern Montana, necessitate additional research into exactly what types of lithic materials exist in these areas. Due to the visual similarities of all of these materials to each other and to KRF, comprehensive geochemical analyses are necessary to elucidate any relationships that may exist.

Chalcedony is a complicated material that can make provenance studies difficult to undertake. With the acceptance of moganite as an accessory mineral found in both chert and chalcedony, questions concerning formation processes can be better answered with more research. Based on the complexity of chalcedony, a proper identification method including visual inspection and more in-depth petrographic and chemical techniques is necessary to distinguish it from other silica-rich rock types, including chert.

As was discussed, chert and chalcedonies are mainly composed of silicon dioxide (SiO_2) and impurities in the form of oxides along with trace elements. It is typically these trace elements numbering in the parts per million (ppm) or parts per billion (ppb) that help differentiate sources from one another. Trace elements found within chalcedonies and cherts indicate the depositional environment in which the rock formed and the original sediments that helped to form it (Luedtke 1979). Specifically, with chalcedonies, the analysis of rare earth elements (REEs) in the lanthanide series of the periodic table may help to separate out chalcedony source areas from one another (Luedtke 1979). Analysis of the elemental makeup of a source sample provides a clue into the variability both within and between source areas. There is no one element that appears to delineate source areas. Instead, it is a combination of elements and their relative abundances to each other that can help to identify source areas. As Luedtke (1979:747) notes, “a source is characterized not by a simple pattern, or ‘fingerprint’, but by a distribution of values for each element which must be described in terms of means, standard deviations, and other statistical characteristics”.

5.2 Geological Overview of Source Areas

Research into the geological origins for specific source locations in Saskatchewan and Manitoba have made evident the need for a brief discussion on buried valleys and preglacial drainage patterns on the prairies. Prior to the last glaciation, most river courses on the Northern Plains (e.g., Montana, North Dakota, Alberta, Saskatchewan and Manitoba) drained in a northeasterly direction rather than south into the Gulf of Mexico through the Mississippi River drainage (Cummings et al. 2012). Ancestral channels of large rivers such as the Yellowstone and Missouri Rivers, as well as smaller rivers such as the Knife River in North Dakota, once drained northeasterly into Manitoba. With the onset of glaciation, ice lobe advancement forced river courses to change to the south (Stalker 1961). With glacial retreat and melting, the large flows of glacial meltwater followed these new river courses southward into the Mississippi drainage system, further eroding them and establishing their modern course. Subsequently, the older and shallower preglacial river courses filled with sediment and became buried. However, one can differentiate these two types of river courses based on their morphologies. Preglacial river valleys tend to be very wide (3 to 16 km in width) and shallow, while postglacial river valleys are narrower and steep-sided as the meltwater flow cut into lower sedimentary layers eroding large quantities of material (Bluemle 1972; Stalker 1961). The identification of ancestral preglacial river courses through the mapping of buried valleys on the Northern Plains may help to explain the movement of some lithic material from its source area to secondary regions.

5.2.1 North Dakota – Knife River Flint

This stone was believed to have been widely traded over large distances into Canada and over large areas of the Plains region in the United States, especially as part of the Hopewell Interaction Sphere (Clark 1984). It is a product of the Knife River quarries found in the Dunn and Mercer counties of North Dakota, U.S.A. The first known reference to this quarry area appeared in a 1936 article in the *Minnesota Archaeologist* written by L.F. Crawford (Crawford

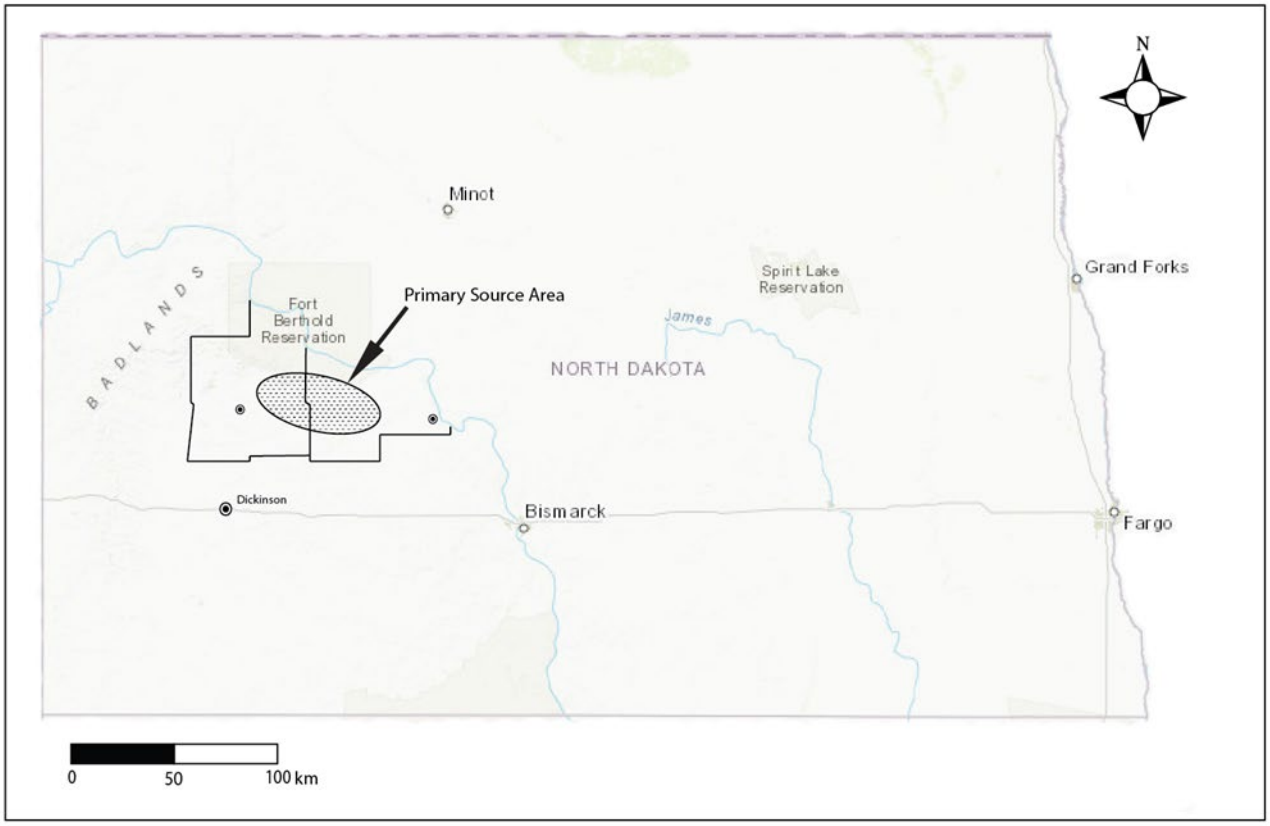

Figure 5.1 Kife River Primary Source Area in North Dakota as defined by Clayton et al. 1970

1936).

This source area was first defined on the basis of twenty-nine separate quarry sites in western North Dakota by L. Clayton, W.B. Bickley, Jr. and W.J. Stone in 1970 (Clark1984). Clayton and his associates (1970) were the first to comprehensively map and perform petrographic analyses on KRF. These sites cover an area approximately 70 km by 40 km near the Knife River in North Dakota (Figure 5.1). In his work within the region, Ahler (1986:5) noted that the term "primary" as used by Clayton et al. (1970)
denoted a region in which a large amount of KRF was quarried in the past but did not necessarily refer to the primary bedrock source of the lithic material.

The first historical record relating to the presence of KRF in North Dakota comes from the journals of William Clark. Clark (1805) noted the presence of "*black flint"* at the mouth of the Little Missouri River. Another reference to the material appeared in G.F. Will and H.J.

Spinden's (1906:164-165) archaeological, historical and linguistic study of the Mandans in regard to these people creating knives, "spearheads" and "arrowheads" out of "dark colored flints." The first published notice of the flint quarries in North Dakota occurred in a letter from Russell Reid, Acting Superintendent of the State Historical Society of North Dakota and Curator of the State Historical Society of North Dakota Museum, to Charles Brown, Director of the Wisconsin State Historical Museum (Murphy 2006:60-61). Reid notified Brown of the existence of quarries along the Knife River west of the town of Stanton, North Dakota based on information received from Lewis Crawford of the State Historical Society of North Dakota. In 1936, Crawford wrote that the quarries' existence and usage by First Nations groups had been known for an extended period of time. However, it was not until the mid-1920s that an actual quarry location was noted in the Knife River area and Crawford later identified another quarry feature north of Dodge, North Dakota (Crawford 1936; Murphy 2006: 61). Murphy (2006:60) noted that it was likely Lehmer in 1954 who was the first to use the term "Knife River flint" in a published article as he reported on areas slated to be flooded due to the construction of the Oahe Reservoir in South Dakota.

Stone found in the Knife River quarries of North Dakota, as determined by Clayton et al. (1970:284), occurs as varying sizes up to two feet in diameter in secondary deposits of slope-wash and gravels. It appears that KRF originated in the "hard siliceous (HS)" bed of the Eocene age, Golden Valley Formation (Clayton et al. 1970:285). In most of the quarry locations in North Dakota, erosional forces have removed much of the original bed. Since Clayton et al. (1970:287) could not find examples of KRF in its primary context, they also posited that it may come from an even older lignite bed in the Fort Union Group (Paleocene age). If so, it may occur naturally in areas outside of western North Dakota including eastern Montana, eastern Wyoming, northwestern South Dakota and southern Saskatchewan (Clayton et al. 1970).

Analysis of the "HS" bed has allowed researchers to conclude that it is made up of silicified lignite due to its "high carbon content associated plant cells, lack of detrital mineral grains, and associated unsilicified lignite" (Clayton et al. 1970:287; Hickey 1966:64-65). Lignite is a type of coal that is brownish-black in colour, it is transitional between peat and sub-bituminous coal and found in large quantities in western North Dakota (Bates and Jackson 1984:295; Bluemle 2000:112). Specimens of KRF are described as coffee-brown in colour, with a conchoidal fracture, translucent appearance and a dull to greasy lustre (Ahler 1986; Clayton et al. 1970; Rapp 2002). Luedtke (1992:49) performed some chemical analyses of KRF from the North Dakota quarries and found that it tends to be low in clay minerals, metals, and salts, is high in antimony, barium and uranium and has average quantities of rare earth elements such as lanthanum and cerium. A more recent study that included an analysis of KRF concluded that this material has a structure similar to silicified mudstone with quartz crystals organized as fibrous bundles as well as in a more equidimensional lattice (Pretola 2001:734). From the analyses, Pretola (2001) also found some moganite content within KRF. Root's (1992:25) research into the KRF quarries caused him to characterize the stone to being more like chert or flint than chalcedony due to the presence of equidimensional crystals in petrographic thin section.

Robert Christensen (1991a) set out to determine a method using instrumental neutron activation analysis (INAA) to separate samples of KRF from similar brown chalcedony varieties found within the Primary Source Area (PSA) and to discriminate between geographically distinct source areas within North Dakota. He too noted that there were similar varieties of brown chalcedony that macroscopically resembled KRF and felt that by identifying a method to distinguish between them, archaeologists could have a better understanding of settlement patterns and trade routes among Precontact populations. Samples of KRF were collected from five quarry sites (e.g., Medicine Butte, Crowley, Horse Nose Butte, Dodge and Dunn Center, a.k.a. the Lynch Quarries) within the PSA in North Dakota (Christensen 1991a). The samples were submitted to the University of Missouri Research Reactor Facility (MURR) for analysis and the data is available not only in Christensen's thesis, but as an Excel file on the MURR Archaeometry Laboratory Database website (Christensen 1991b). Through the analysis of 30 samples, Christensen found that 13 elements separate out the different source sample locations. The success of Christensen's research has prompted the need to geochemically explore other source areas of visually similar brown chalcedony across the Northern Plains.

Murphy (2014:1) has identified five major siliceous beds in western North Dakota: the Rhame Bed, Rainy Butte Chert, Taylor Bed, HS Bed, and Knife River flint. He also noted that KRF has never been found in primary context, but instead only in secondary deposits including gravels that range in age from the Eocene Period (40 million years old) to recent deposits. Geologists in the 1980s discovered large pieces of KRF on top of the Sentinel Butte Formation, north of the town of Killdeer, North Dakota. However, KRF was not present at the top of the Killdeer Mountains to the west. This suggests that the KRF was younger than the Sentinel Butte

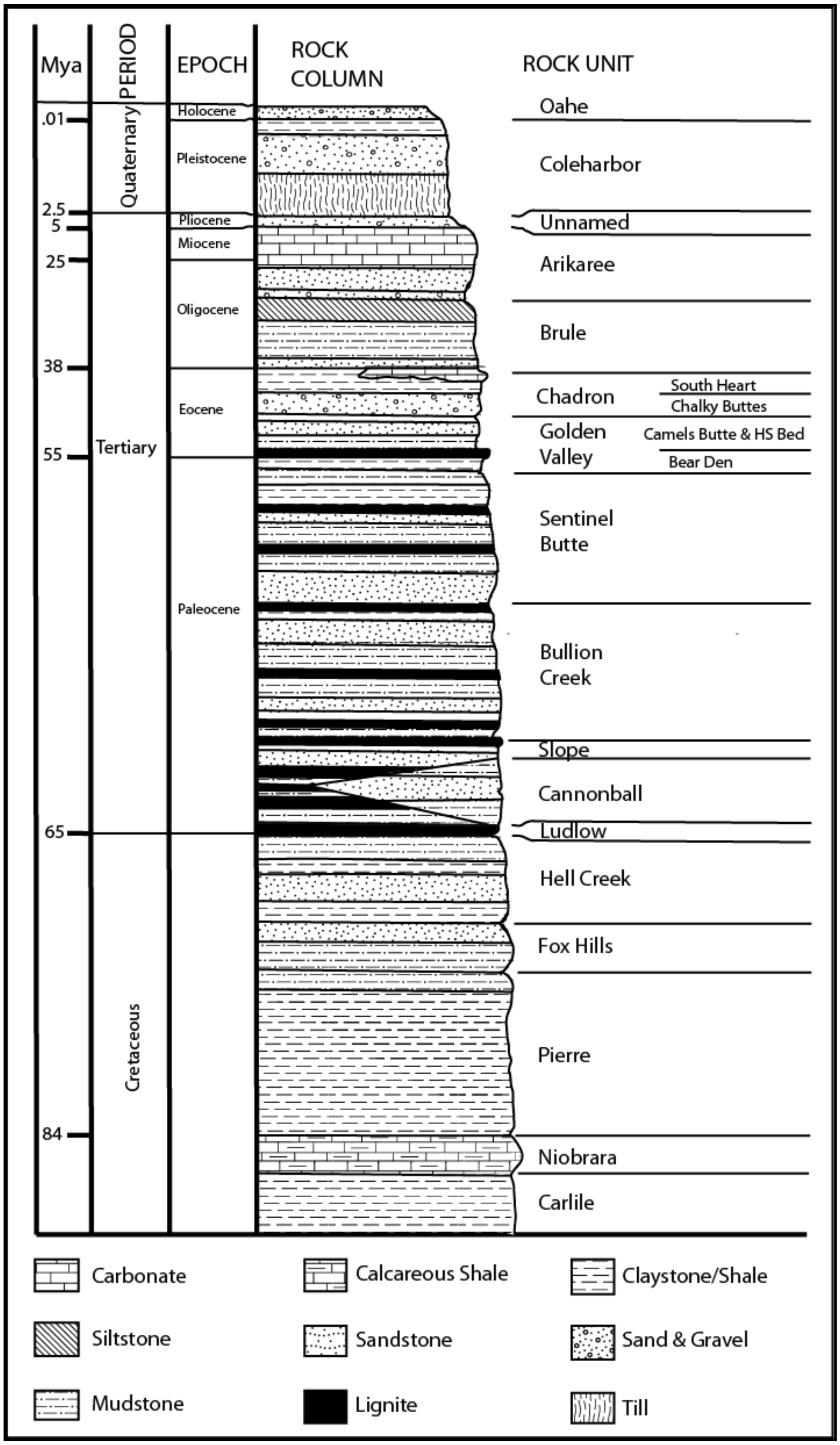

Figure 5.2: North Dakota Stratigraphic Column with Possible KRF-bearing Units

(*Adapted from Murphy 2014*)

Formation (Figure 5.2), but older or as old as the caprock of the Killdeer Mountains that is Miocene in age (Murphy 2014:4). Some quantities of KRF in the form of pebbles have also been found in the Chalky Buttes Member of the Chadron Formation (Figure 5.2), which limits the age of KRF to the Eocene Period. Murphy (2014:5) believed, based on this information that KRF comes from the Camel Butte Member of the Golden Valley Formation (Figure 5.2). This is stratigraphically equivalent to the "HS" Bed as suggested by Clayton et al. (1970). Murphy noted that it is possible that KRF formed both in the Killdeer Mountains as part of the Camel Butte Member and in the "HS" Bed. Since much of the Camel Butte Member is eroded, it is unlikely that this material will ever be found in primary context.

Despite the lack of primary context of KRF, numerous archaeological quarry locations have been recorded across the PSA. The area also includes artifacts indicative of quarrying practices such as anvil stones used to break open cobbles of raw material and numerous byproducts of stone tool manufacture such as flakes and shatter. Ahler (1986:7) noted that while the Lynch Quarries represents only approximately 2% of the total PSA, it was the most intensively exploited area for KRF extraction. Excavations in the 1970s at the site trenched across a 15-foot (4.6 m) span that bisected three quarry pits and provided information on the depth and distribution of KRF in the area (Loendorf et al. 1976). From this research, it was found that KRF cobbles tended to be located approximately 1 to 3 m below surface within an alluvial sand deposit (Loendorf et al. 1976:22-25).

The Lynch Quarries (32DU526) are located east of Dunn Center in Dunn County, North Dakota. This site was designated a National Historic Landmark in 2011 and is listed on the National Register of Historic Places. It encompasses approximately 690 acres (279 hectares) and includes a large number of quarrying pits. Thousands of quarrying pits are visible from air photos with more believed to have been filled in by sediment deposition over time (Figure 5.3).

The Crowley quarry group (32ME201) is located approximately 13 km south of Golden Valley, North Dakota. Records with the State Historical Society of North Dakota indicate that the site was originally recorded in 1946 with the Smithsonian Institution River Basin Surveys, but knowledge of its existence by local landowners predates this time (Atkinson 1933; Bauxar and Cooper 1946). The site is located on a ridge of hills near the Knife River and consists of pits with associated backfill mounds. Members of a 1946 United States Geological Survey noted that the KRF deposits found here were the residuals of an eroded lignite bed (Bauxar and Cooper

Figure 5.3: Examples of quarry pits at Lynch Quarries (32DU526), Dunn County, North Dakota *(Photo: K Steuber, 2010)*

1946). Weathered pieces of KRF can be found on the surface and unweathered samples are found *in situ* below ground. A 1981 report notes that a few bone fragments from the scapula of a large mammal were found in one of the backfill mounds. Site visits over the past 60 years have resulted in the collection of flakes, knives, scrapers, a drill, worked stone, and unmodified raw material samples for the State's collections (Neuman 1965; Bauxar and Cooper 1946).

The Medicine Butte quarry group (32DU1049) is located approximately 1.6 km east of Medicine Butte and is approximately 11 km south of the town of Zap, North Dakota. Similar to the other quarry groups, this quarry can be found in an upland area along the banks of a stream that feeds into nearby Coyote Creek (Christensen 1991a:20).

Horse Nose Butte is located approximately 5 km south and 7 km west of Halliday, North Dakota. The Horse Nose Butte quarry group (32DU325) consists of multiple quarry pits on the top and along the south slopes of the Butte as well as to the southeast in upland areas such as butte tops, slopes, and ridges (Christensen 1991a:20-21).

5.2.2 White River Group silicates

Research by Hoard et al. (1992, 1993), Huckell et al. (2011), and Nowak et al. (1985) has shown that there are visually similar examples of brown chalcedony within the White River Badlands of South Dakota. Examples of West Horse Creek chert (shortened to West Horse chert for the remainder of this study), Sentinel Butte chalcedony, Nelson Butte chalcedony, and Scenic chalcedony can look very similar to KRF from North Dakota.

The White River Group is Oligocene in age and can be found on the Central Plains of South Dakota, Colorado, Nebraska and Wyoming. Within this deposit cryptocrystalline materials are found that can be visually indistinguishable from brown chalcedony varieties found in North Dakota, Montana, Saskatchewan, Alberta and Manitoba. Hoard et al. (1993) analysed the geological origins of this material known as White River Group silicates (WRGS) and compared it to archaeological samples from the region. Similar to KRF, White River Group silicates are not localized to a single source area. This material can be found on Flattop Butte in northeastern Colorado, Table Mountain in east-central Wyoming and the White River Badlands of southwestern South Dakota (Hoard et al. 1993:698-699). Varieties that are visually similar to KRF are called Scenic chalcedony and typically found within the White River Badlands.

5.2.2.1. White River Badlands

The White River Badlands are located in southwestern South Dakota and extend into northwestern Nebraska and eastern Wyoming and Colorado and encompass the lands within the White River drainage basin (Benton et al. 2015). Within the Badlands are six major stratigraphic units including the Pierre Shale, the Fox Hills Formation, the Chamberlain Pass Formation, the Chadron Formation, the Brule Formation and the Sharps Formation. Of concern to this research is the lithic materials found within the Chadron and Brule Formations. Both of these formations occur as exposed outcrops in the Chalky Buttes, Little Badlands and Killdeer Mountains area of North Dakota (Hoganson et al. 2007).

The Chadron Formation dates to the late Eocene Period (34 to 37 million years ago) based on the presence of vertebrate fossils as well as paleomagnetic and radiometric dating

(Benton et al. 2015). It is fluvial in origin and is made up of claystone beds and some lenticular and sheet sandstones, conglomerates, and thin limestone sheets (Benton et al. 2015:20). Overtop of the Chadron Formation lies the Brule Formation of early Oligocene age (26 to 34 million years ago). This formation is also fluvial in origin and composed of mudstone, sandstone and siltstone interbedded with limestone sheets. Benton et al. (2015) note the presence of chalcedony veins in certain areas of the Badlands. These veins seem to be restricted to the upper Chadron Formation and in some areas, extending into the lower Scenic Member of the Brule Formation (Benton et al. 2015:64). The chalcedony veins are cemented between the pre-existing claystone and mudstone beds of both formations and their genesis remains a topic of research among geologists. Benton et al. (2015:66) stated that the chalcedony forms in an aqueous environment in a lower formation (likely the Cretaceous-aged Pierre Shale), due to the availability of dissolved silicon, calcium and sulfur needed to produce it, and migrates upwards into the upper Chadron and lower Brule formations. The presence of geothermal water in a nearby area may indicate that precipitation of minerals has occurred. At lower depths the oversaturation of dissolved solids in the water can cause precipitation of minerals to occur. It is hypothesized that mineralization with chalcedony occurs at these depths to form veins that later migrated upwards from the Pierre Shale into the Chadron and Brule Formation (Benton et al. 2015:66). When exposed at the surface, these chalcedony veins tend to be resistant to weathering, but occasionally spall naturally and cover the ground surface as lag deposits. Neutron activation analysis (NAA) by Hoard et al. (1992) on White River Group silicates (WRGS) show a distinct elemental separation from KRF as analysed by Christensen (1991a).

Hoard et al. (1993) analysed samples of West Horse chert and Scenic chalcedony from South Dakota in order to compare it to visually similar material found in an archaeological site in north-central Kansas. They used neutron activation analysis on samples from three quarry areas, including West Horse chert and Scenic chalcedony, to determine elemental signatures that could be used to separate the quarry areas from one another and allow for comparison with the artifacts found in two archaeological sites from the Central Plains. The raw elemental data from this study was accessible as an Excel file from the MURR Archaeometry Laboratory Database website and was included in the comparative analysis of source areas in this study. Altogether 120 samples were analysed by short-half-life and long-half-life neutron activation analysis (NAA). Using canonical discriminant analysis, Hoard et al. (1993:704) found that sources may be separated through the presence of fourteen elements.

Within the White River Badlands are two known quarry sources for WRGS: West Horse Creek quarry (39SH37) and the Nelson Butte quarry (39SH78) (Hoard et al. 1993). Both quarry areas were used in the past in order to remove Chadron Formation chalcedony to manufacture stone tools. These Chadron Formation exposures produce a number of different chalcedony varieties based on visual appearance, including Scenic chalcedony and West Horse chert. Of interest to this research is Scenic chalcedony, which can be visually identical to KRF whereas West Horse chert tends to be opaque and purplish-grey in colour (Hoard et al. 1992). Scenic chalcedony was initially described by J. S. Sigstad in 1972 as a "Knife River-type chalcedony" (Sigstad and Luoma 1972:7). Ahler (1975) also viewed the material and noted its translucency and visual similarity to KRF. Nowak et al. (1985:107) also describe Scenic chalcedony's similarities with KRF:

> "It is recognized as a non-porous silicate with a fairly uniform translucent dark-brown color and observable sedimentary structure consisting of irregular parallel layers and milky opaque lenses, probably opal formed of hydrated silica rather than detrital plant fragments as suggested for Knife River Flint. The material possesses excellent conchoidal fracturing."

At the West Horse Creek quarry, Scenic chalcedony is exposed in layers along the banks of West Horse Creek and is found in a number of workshops in the area as well (Hoard et al. 1993). The exposure of West Horse chert and Scenic chalcedony was first recorded by L. Adrien Hannus in 1982. Hannus was examining the nearby Clovis-age Lange/Ferguson site (39SH33), when he recovered a tertiary flake of what he believed to be KRF in association with butchered mammoth remains (Nowak et al. 1985). Investigations in the area revealed an outcrop of KRF-like material along the banks of West Horse Creek and the presence of lithic scatters and quarry workshops over two square miles of the outcrop (Nowak et al. 1985).

The Nelson Butte quarry is found in the vicinity of Battle Creek Canyon along the slope and top of Nelson Butte. Lueck and Butterbrodt (1984) identified artifacts such as mauls as well as depression features at the site. Scenic chalcedony from this location is a lighter caramel color with some yellow-red hues but maintains the same translucency as other Scenic chalcedony varieties (Nowak et al. 1985).

5.2.3 Montana Agates

Agate is another type of cryptocrystalline quartz made up of SiO_2 that is often considered a form of chalcedony (Schumann 1993). Similar to chalcedony, it can be found in a wide variety of colours including those that look visually similar to brown chalcedony. In terms of translucency, agate tends to be opaque but thin pieces do appear translucent. Agate is made up of length-fast chalcedony and is slightly porous while typically being formed as inclusions in volcanic rock (Frondel 1978; Flörke et al. 1991; Graetsch 1994; Monroe 1964; Schumann 1993). Within the Northern Plains region, agate is often found along the gravel bars of large river systems. One type, called Montana agate, is found in secondary deposits along the Yellowstone, Missouri, and Powder Rivers. This type of agate was likely formed in the Yellowstone basin within lava flow cavities whereby silica-rich solutions were deposited and later evaporated to form the rock. After the original rock formation, in which the agate formed, eroded away, this rock was later carried away and redeposited by ancestral and modern river courses (Dake et al. 1938; Thomson 1994). According to Thomson (1994:61-62) agates are found within Tertiary deposits on the Northern Plains including the Souris sand and gravel deposit (see section 5.2.6) and were likely formed as a result of volcanic activity in Montana.

5.2.4 Alberta – Hand Hills Flint

In 2005, a discussion held between the author and the principal archaeologist for Altamira Consulting Ltd. of Edmonton revealed that a large nodule of visually similar brown chalcedony had been collected from the Hand Hills area in east-central Alberta. Further conversations with some Alberta archaeologists corroborated the recognition that there was a local material that resembled KRF. However, no formal investigations into this possible source area have been undertaken prior to this work. All information that exists is found in isolated archaeological site forms of suspected quarry pits within the Hand Hills (D. Hanna, personal communication 2009). Currently, only one known study (Kirchmeir 2011) has been completed on identifying brown chalcedony materials found in archaeological sites in Alberta (see section 6.5.2.1).

The Hand Hills are located in east-central Alberta approximately 26 km west and 8 km south of the Town of Hanna. These two plateaus rise approximately 990 m above sea level (asl) with the western upland being approximately 70 m higher than the eastern upland and trend from northwest to southeast (Burns and Young 1988; Young 1991; Young et al. 1999). To the

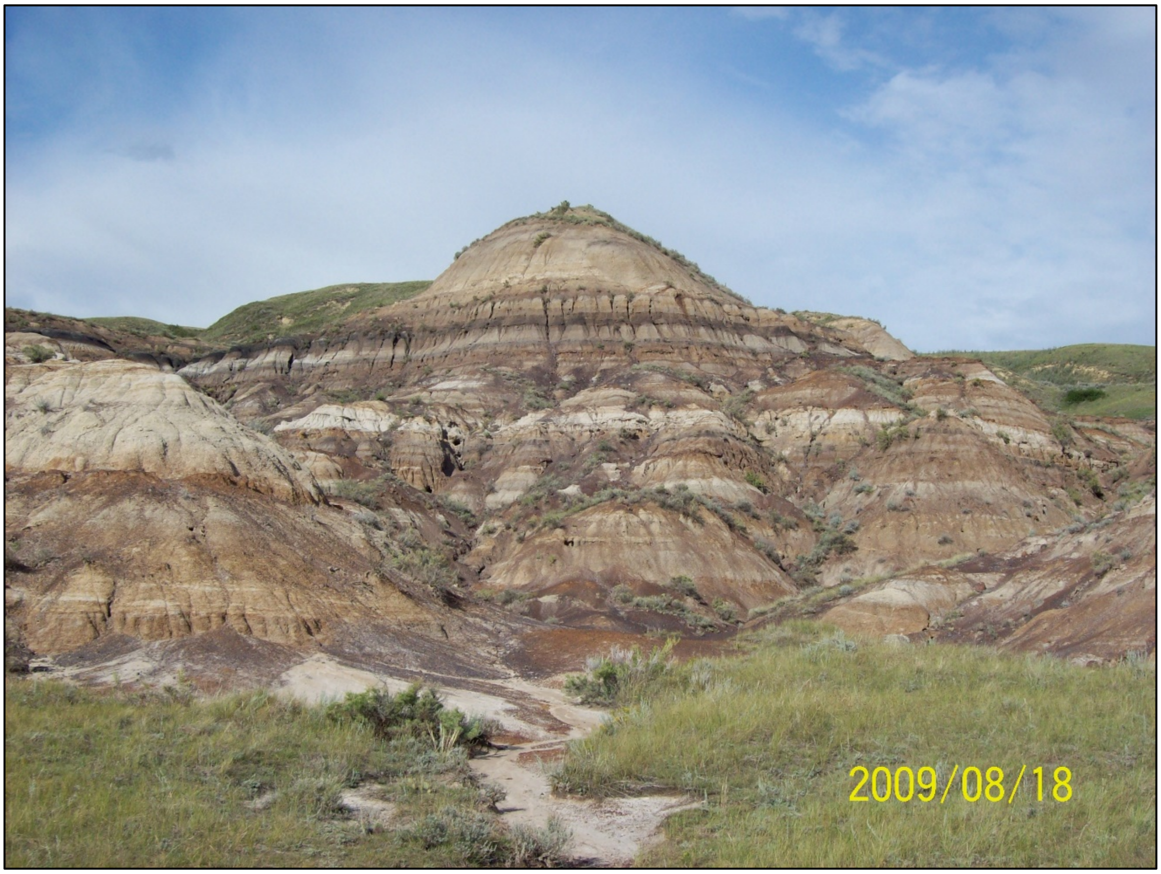

Figure 5.4: Stratigraphic layers exposed in the Hand Hills (*Photo: P. Steuber, 2009*)

southwest across the Red Deer River Valley another series of hills, known as the Wintering Hills, also dominate the topography of the local area and are similar in elevation and formation to the Hand Hills (Young 1991). Also, within the immediate area of the Hand Hills are Hand Hills Lake (found in a depression between the plateaus), Little Fish Lake (immediately to the south of the Hand Hills on the plain), and the Red Deer River to the west.

Today, the Hand Hills are predominantly vegetated with native prairie grasses yet, there are erosional exposures that display the bedrock geology of the area (Figure 5.4). Much research has been undertaken on the bedrock geology of this area of Alberta, due to the large amount of vertebrate deposits found within the Red Deer River valley, specifically, near the town of Drumheller. Tyrrell (1887) was the first to describe the area around Drumheller and the Hand Hills and along the Red Deer River valley. The oldest exposed rock in the area belongs to the Bearpaw Formation, formed during the Late Cretaceous Period, approximately 70 to 74.5 million years ago (Caldwell 1968; Cooper 2000) (Figure 5.5). This formation is mainly a marine

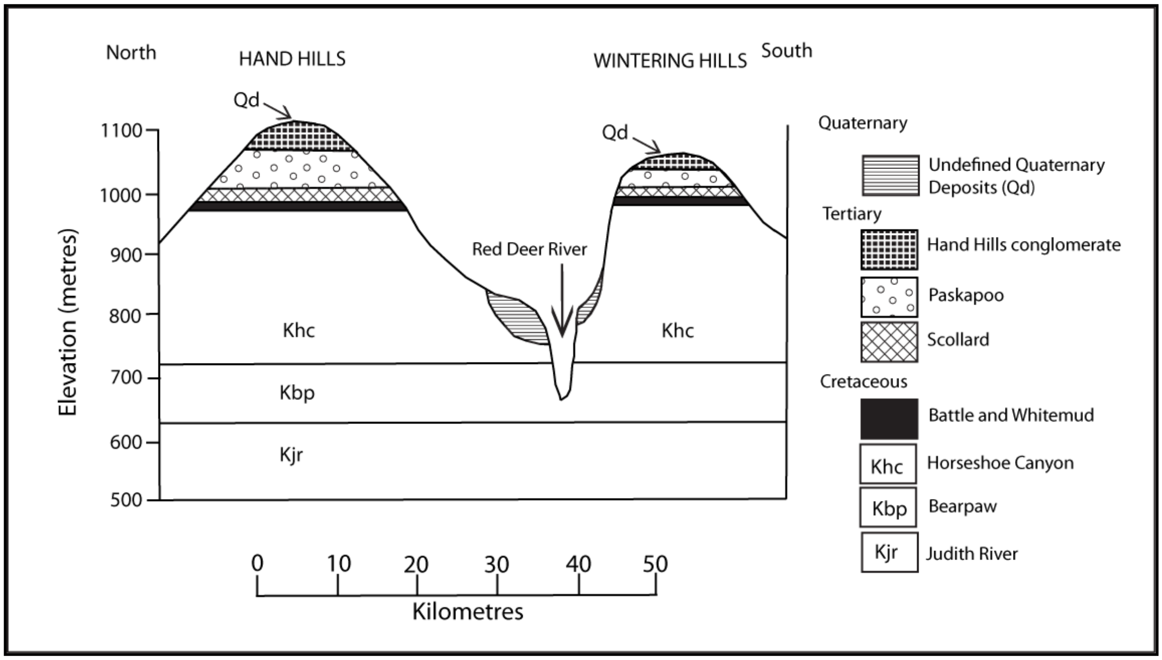

Figure 5.5: Geological Cross-Section of the Hand Hills Region

(*redrawn from Young 1991:8*)

sandstone and shale deposit. However, it also includes beds of iron nodules, bentonite and chert pebbles, and was the result of a prehistoric inland sea that blanketed the province (Wyatt et al. 1938). This bedrock is soft and as such is easily eroded and contorted by glacial action.

Overlying the Bearpaw Formation is the Edmonton Group, which consists of four formations: Horseshoe Canyon, Whitemud, Battle, and Scollard. Each of these formations are found within the bedrock stratigraphy of the Hand Hills and are of varying thicknesses. The Horseshoe Canyon Formation is also of Late Cretaceous Age and composed of sandstones, siltstones, claystones, shales and coals as well as volcanic ashes and represents a number of different environments including coastal margins, floodplains and estuarine channels impacted by periods of volcanic activity (Braman and Eberth 1988). The presence of a number of coal seams within this Formation has led to an increase in economic interest while the occurrence of fossilized vertebrate fauna (i.e., dinosaurs) has contributed to the overall scientific knowledge and tourism in the area (Braman and Eberth 1988).

The Whitemud Formation (Late Cretaceous) is also composed of sandstones, siltstones and claystones with a high bentonitic content. The environment represented by this formation is that of a delta plain with increasing deposition of volcanic ash (Braman and Eberth 1988:10).

The Battle Formation (Late Cretaceous) includes more bentonitic shale and also a large amount of volcanic ash. Braman and Eberth (1988:10) reported that deposition was likely to be in "standing bodies of water with a large amount of volcanic ash being contributed to the environment." The Scollard Formation is the final formation within the Edmonton Group and is comprised of sandstones, mudstones, coals and ironstones. This formation was deposited in an alluvial environment and it is noted that coals are abundant in the upper half of the deposit (Braman and Eberth 1988). At the base of the first coal seam in this formation is also found the Cretaceous-Tertiary (K-T) boundary that delimits the end of the Cretaceous Period and the beginning of the Tertiary. This point in time has been subject to considerable debate regarding the mass extinction of the dinosaurs and the appearance of an iridium anomaly, which is commonly thought to be evidence of an extraterrestrial impact event. The Paskapoo Formation (Tertiary Period) is of Paleocene age and can be found overlying the Edmonton Group. Included in this Formation are mudstones, shales, siltstones and sandstones suggestive of a depositional environment of shallow lakes and swamps (Young 1991; Fox 1988).

Capping the Hand Hills is a much-debated layer known as the Hand Hills Formation or Conglomerate. Warren (1954) regarded this layer as part of the Saskatchewan Gravels and Sands and due to a lack of material from glacial contacts in the east believed its source lies in the west. It can contain stones of quartzite and chert as well as arkose (Warren 1954). Vonhof (1969) and Stalker (1973) believe this layer is composed of gravels that are related to ancestral Bow River drainage also from the west. It is likely that this layer is related to mountain-derived sediments transported through fluvial action from the west, namely by way of the ancestral Bow River (Glen and Osborn 1986). This river at one point flowed much further to the east than its present-day course and would have deposited this sediment in the Hand Hills region. Russell (1958) was one of the first to describe this layer and called it a conglomerate. However, Storer (1976) referred to the sands and gravels in this layer as well as the glacial till as the Hand Hills Formation. Since this time both terms have been used interchangeably. This layer is assigned a Tertiary Age designation.

The Quaternary deposits on top of the Hand Hills are believed to date to the period of the Laurentide ice sheet; however, there is a lack of organic material suitable for radiocarbon dating. Additionally, any radiocarbon dates are believed to be unreliable due to contamination issues involving old carbon (Young 1991; Young et al. 1999). Shield clasts as well as Cordilleran cherts and quartzites are good indicators of Laurentide glaciation and its subsequent deposits (Burns and Young 1988). The presence of granite boulders and cobbles on the surfaces of the Hand Hills also indicates deposition by the Laurentide glaciation from their source areas in the Precambrian Shield to the north and northeast (Burns and Young 1988:7). Based on the constituents of the till and surface debris at the summits of the Hand Hills, it is likely that these deposits are a remnant of the last Wisconsinan glaciation.

It appears the Hand Hills and the nearby Wintering Hills were formed during the Laramide orogeny (75-35 million years ago), the last major uplift event of the Rocky Mountains (Burns and Young 1988; Gadd 2008). Sediments were carried to the east via fluvial transport and deposited over time eventually forming plateau areas (Russell 1957). Subsequent erosion (fluvial and glacial) over millions of years acted upon the area leaving the Hand Hills and Wintering Hills as upland areas on a large flat plain.

Unfortunately, a primary source area for brown chalcedony from the Hand Hills has not yet been located for the material and any samples collected have come from disturbed stratigraphic positions within gravel pits and erosional. Given the abundance of coal within formations in the Hand Hills, it is possible that a bed with silicified lignite also exists here with material similar to the KRF found in North Dakota. Unfortunately, little research has been undertaken to examine lithic materials from within the Hand Hills. Based on the bedrock geology of the Hand Hills, attention should be paid to formations such as Horseshoe Canyon and Scollard due to the presence of coal seams.

5.2.5 Saskatchewan – South Saskatchewan River Chalcedonies

Eldon Johnson (1998) examined nine major lithic materials found in archaeological sites in southern Saskatchewan. Based on his analyses, Johnson provided a comprehensive list of attributes that help to facilitate the identification of archaeological toolstones with particular source areas. Although Johnson examined many of the stone types found throughout the Plains region; others, including brown chalcedony, were not subject to the same sort of analyses, thus limiting the applicability of his study.

The possibility of additional sources of brown chalcedony in Saskatchewan was also explored. Local brown chalcedony in Saskatchewan is often termed “South Saskatchewan River Chalcedony” (Johnson 1998:32). This material appears to be a silicified peat, but the name is used interchangeably at times with silicified lignite and petrified wood. Johnson (1998:33) notes that this material is commonly found in archaeological sites along Lake Diefenbaker and has been found in sites in southern Saskatchewan as well. Visually similar samples of petrified wood were collected from the Lake Diefenbaker area as well and included in analysis to see how geochemically distinct petrified wood is from brown chalcedony. As some artifacts are very small in size (e.g., flakes), these small pieces may be misidentified as petrified wood instead of brown chalcedony and vice versa.

Archaeologists including Eldon Johnson (1998:33), Ian Dyck and Richard Morlan (Dyck and Morlan 1995) have noted the presence of large quantities of brown chalcedony in archaeological sites along the South Saskatchewan River and in southern Saskatchewan. Johnson (1998:34) attributed this concentration to local sources found in southern Saskatchewan and later transported along the South Saskatchewan River and in gravel deposits near Macrorie, Saskatchewan. The current understanding of the distribution of this material links it to preglacial drainage that moved chalcedonies, agates, silicified peats and quartzites out of Montana due to Rocky Mountain uplift during the Tertiary Period (Vonhof 1965b, 1969). These Tertiary gravels were transported northeastward from Montana into southern Saskatchewan and deposited. They now form the cap of the Cypress Hills and Wood Mountain Formations in the uplands of southwestern Saskatchewan (Vonhof 1965b, 1969). Due to the lack of battering and scarring on brown chalcedony nodules found in southwestern Saskatchewan, Johnson inferred that these materials did not undergo fluvial transport either during preglacial or postglacial times and as such may have formed *in situ* in the Wood Mountain uplands at some point (1998:34); however, he noted that more research into origins is warranted.

In her study of Souris gravels, Thomson (1994) provided a discussion of Tertiary erosion and deposition in Saskatchewan and Manitoba that may better explain the geological history of these regions. As stated previously, Rocky Mountain uplift during the Tertiary Period resulted in large quantities of lithic materials being transported eastward via preglacial drainage systems. Over time and through the geological process of erosion, the Tertiary materials deposited in Saskatchewan and Manitoba were removed leaving only small, distinct outcrops in upland areas or as part of buried valleys (Thomson 1994:29). Stalker (1968:156-157) noted that Tertiary deposits on the Plains can be found as part of three categories: (1) deposits on upland areas that form caps that prevent erosion, (2) deposits, usually gravels, that have been left behind due to mountain streams or as a result of some erosion of upland areas, and (3) deposits of material as a result of preglacial rivers. Two deposits that may explain the presence of brown chalcedony in southern and western Saskatchewan are the Cypress Hills and Wood Mountain Formations.

The Cypress Hills are an area that was left untouched by drainage from the ancestral Missouri and Yellowstone Rivers to the northeast and Montana rivers to the north as well as by the Wisconsinan glaciation (Vonhof 1965b, 1969). The Cypress Hills Formation caps the Cypress Hills of Alberta and Saskatchewan and consists of conglomerate and sandstone. This formation is typically made up of sandstone, silts, quartzite, argillite, arkose, chert, volcanic rock and fragments of fossilized wood and bone (Fraser et al. 1935; Leckie and Cheel 1990; Vonhof 1965a). The presence of non-marine vertebrate fossils within the Cypress Hills Formation indicate it is likely Oligocene in age and maybe the equivalent of the Chadron Formation in North and South Dakota (Russell 1950:54).

The Wood Mountain Formation is composed of gravels and sands located to the southeast of the Cypress Hills of Saskatchewan. This formation consists predominantly of quartzite and chert, and the vertebrate fossils indicate a Miocene age (Vonhof 1965b). During the Wisconsinan glaciation, the Wood Mountain uplands also remained unglaciated (Klassen 1993; Leckie et al. 2004). Gravels in this formation appear to derive from older material to the west that was transported northeasterly in preglacial times and are similar to those found in the Cypress Hills Formation (Vonhof 1969). Vonhof (1969:131) suggests that based on the similar gravel components within both formations they may be derived from the same source to the west. However, the Wood Mountain gravels tend to contain more chert, which likely indicates an origin in northwestern Montana, as does the presence of volcanic materials from this region (Leckie et al. 2004; Vonhof 1969). In terms of age, the Wood Mountain Formation likely dates to the late Miocene or early Pleistocene (Vonhof 1969). Like the Cypress Hills Formation, the Wood Mountain Formation has also undergone considerable erosion and its presence is limited today in southwestern Saskatchewan.

In terms of the material found in the gravels along the South Saskatchewan River, there are those that resemble patinated brown chalcedony, but when split open are more akin to fused shale. Petrified wood and chalcedonies do occur in the South Saskatchewan River gravels, but they are limited in their abundance and distribution. It is plausible that these pieces of petrified wood and brown chalcedony were transported from other locations during the last deglaciation and redeposited into glacial gravels found in southwestern and west-central Saskatchewan.

5.2.6 Manitoba – Souris Sand and Gravel

Gravel deposits in southwestern Manitoba are known to contain a variety of lithic materials including petrified wood, chert, agate, and silicified lignite. Sources of brown chalcedonies in Manitoba are typically linked to what is referred to as the Souris sand and gravel deposit.

The Souris sand and gravel deposit is composed of Tertiary gravels originating from the Rocky Mountains to the west and reworked Tertiary and glacial gravels (Thomson 1994; Toop 2010). They typically consist of quartzite, petrified wood, chert, agate, and jasper intermixed with silicified shale, granite clasts and carbonate of glacial origin (Toop 2010). The agates found within Souris sand and gravel deposits likely originate from the Yellowstone River to the southwest as this river is the only documented source of alluvial gravels containing agate (Toop 2010:2). Transport of these particular lithic materials is the result of preglacial valleys and drainage patterns in western Canada and the northwestern United States.

This deposit erodes out along the Souris riverbank in southwestern Manitoba. The earliest mention of gravels in this area can be attributed to Elson (1958). Elson (1958:63) noted the presence of "quartzose" gravel near the town of Souris, Manitoba and hypothesized that it dated to the Pleistocene Period due to the presence of glacial granitic material carried by rivers from the Rocky Mountain. Klassen (1969:2) applied the term, "Souris gravel and sand" to a deposit found in buried preglacial valleys in the region overlying bedrock. Further research by Wyder (1968) as well as Klassen and Wyder (1970) into buried preglacial valleys in southwestern Manitoba concluded that Souris sand and gravel deposits occurred in the Missouri buried valley (now Missouri-Yellowstone buried valley) near Frobisher, Saskatchewan and as such occurred in southwestern Manitoba likely as a result of the same buried valley system. Additional investigation by other geologists in the Brandon area determined that the Souris sand and gravel deposit was most likely of Tertiary or early Pleistocene age (Underwood McLellan and Associates 1977:79).

Research into geological origins of KRF and other brown chalcedony varieties from Manitoba archaeological sites is best known from Leslie M. Leonoff's 1970 Master of Arts thesis, *The Identification, Distribution and Sources of Lithic Raw Materials in Manitoba*

Archaeological Sites. Leonoff (1970) expanded on work originally undertaken by Walter Hlady in the 1960s into the origins of brown chalcedonies in Manitoba. Hlady (1965) suggested that a primary source of KRF found in southwestern Manitoba might be the Souris sand and gravel deposit near the town of Souris, Manitoba. Leonoff (1970:21) felt that the presence of this material was likely due to the preglacial drainage of the Knife River from North Dakota. Based on the large quantities of raw material found within the Dunn and Mercer Counties in North Dakota, Leonoff (1970:21) believed that KRF was transported northward into southwestern Manitoba by "river action". The course of the preglacial Knife River parallels that of the modern Souris River Channel (Leonoff 1970). Leonoff (1970:21) proposed that KRF was transported prior to Pleistocene glaciation from its primary geological origins in North Dakota to the Souris River Channel and deposited within the Souris sand and gravels where it can be found today as a result of glacial and fluvial erosion. Leonoff also felt that due to glacial and fluvial action, pieces of brown chalcedony found in the Souris sand and gravel deposit tend to be reduced in size from their North Dakota counterpoints, are less frequently observed, and tend to be of poorer knapping quality. Leonoff (1970:22) noted that in a 25-pound (11.34 kg) sample of Souris sand and gravel, there were only two stream-rounded pebbles of brown chalcedony each less than 1.25 inches (3.18 cm) in diameter.

In her thesis, Thomson (1994) analysed raw material samples from the Souris sand and gravel deposit and compared the results with archaeological collections from southwestern Manitoba in order to determine if macroscopic inspection is a sufficient lithic material identification tool. She (1994:137-138) concluded that some occurrences of KRF in southwestern Manitoba archaeological sites might actually be examples of silicified lignite from secondary deposits of Souris sand and gravel as well as other glacial and non-glacial gravel deposits.

Additionally, Thomson (1994:27) noted that very little research into the archaeological importance of the Souris sand and gravel deposit had been undertaken and instead, most studies had been focused on bedrock geology or ground water resources. Perhaps, the best-known analysis was undertaken by E. Leigh Syms and Harvey Young who collected samples from the Souris gravel pits in order to determine what lithic materials were present and their abundance in the deposit (Thomson 1994). When brown chalcedonies from the Souris sand and gravel deposit were compared to samples taken from the PSA in North Dakota, Thomson (1994:138) found that they too tended to be of poorer quality than the North Dakota samples and unlikely to be used as an “exclusive source of this material if other means of procurement were available, i.e., exchange from the south”.

5.2.6.1 St. Ambroise chalcedony

Examination of the lithic material types employed by the Manitoba Museum in their artifact classification system revealed another possible material type for study. Known as St. Ambroise chalcedony, this material is visually highly variable. It ranges in its raw form from glossy black and opaque in colour to “root beer brown” and patinated. Some samples resemble brown chalcedony and appear visually indistinguishable from KRF. For this reason, St. Ambroise chalcedony was included in this study. St. Ambroise chalcedony has been found as both unmodified raw material and fashioned into artifacts dating to Besant/Sonota groups. It appears, based on current known site locations, to be localized to the St. Ambroise area of Manitoba. St. Ambroise is located on the southern tip of Lake Manitoba, approximately 90 km northwest of Winnipeg. Geological origins of this material are currently unknown due to its localized occurrence in the St. Ambroise area. The bedrock geology of the area indicates surface or near surface formations dating to the Jurassic and Silurian age boundary (201.3-145 million years and 443.8-419.2 million years respectively). The Silurian bedrock is composed of the Interlake Group (Davies et al. 1962). Lithology for this group includes dolomite and limestone in the upper portions. The Jurassic-aged bedrock is composed of four formations including from oldest to youngest: the Amaranth, Reston, Melita, and Waskada formations (Davies et al. 1962). Geological maps indicate that the Amaranth Formation can be found in the St. Ambroise area. This formation contains large quantities of dolomitic shale, anhydrite, gypsum, dolomite and shale. This area was also within Glacial Lake Agassiz and, as such, large quantities of silt and lacustrine sediment blanket the region.

Further investigation is required in order to fully understand the origins of St. Ambroise chalcedony. It is of note that the Assiniboine River approximately 3,000 to 7,000 years ago flowed north from Portage La Prairie and emptied into Lake Manitoba in the St. Ambroise region (Corkery 1996). It is possible that this river may have undercut buried sediments that included the chalcedony in question, causing it to erode out and allowing for its use in archaeological contexts.

5.3 Summary of Geological Overviews

Due to the wide geographical area in which lithic raw materials were moved by people in Precontact times, proper knowledge and determination of source areas is necessary. The large variety of visually similar material that exists across the Northern Plains can cause confusion when it comes to creating any hypotheses about trade and settlement patterns of Precontact groups. Visual identification is no longer a sufficient means to identify lithic material and the advent of numerous geochemical techniques allows archaeologists to better understand where lithic raw material originated. However, without a proper understanding of the geological processes that occurred over millions of years in North America, even determining a potential source of brown chalcedony can be fraught with challenges. While the geological history of some of the potential source areas may indicate a secondary deposition of brown chalcedony (e.g., Souris sand and gravels, Hand Hills flint, and Wood Mountain Formation material) and not a true "primary source area", determining how these materials relate to one another and to their archaeological counterparts is vital.

Chapter 6 – Literature Review of Analytical Techniques

When undertaking lithic analysis in archaeology, including provenance studies, it is important to identify each of the lithic materials that were used. This includes preliminary techniques such as a visual inspection, recordings of colour, lustre, texture, etc., that can lead to an identification of the specific rock type. This study commenced with a review of the relevant archaeological and geological literature in order to properly identify possible source areas of brown chalcedony on the Canadian Plains. In addition, consultations with archaeologists knowledgeable about poorly known Canadian brown chalcedony sources were conducted, along with firsthand visits to these potential source areas in order to collect samples.

6.1 Petrographic Methodology

While macroscopic examination can often separate a lithic artifact into sedimentary, igneous or metamorphic classification, further analysis is needed before a proper and full identification can be determined. Too often archaeologists rely on a casual visual inspection to "lump" classify a rock (e.g., chert, chalcedony, obsidian, jasper, quartz, quartzite) when additional questions should be asked as to the toolstone origins. Many archaeologists feel that a visual examination is good enough to determine a specific lithic type and consequently its origins. The problem lies in that visual identification is never sufficient to conclusively determine source areas of lithic raw materials. For this reason, further analyses are absolutely necessary, starting with basic petrographic analysis followed by geochemical analyses to better elucidate elemental structure and makeup.

6.2 Basic Petrographic Analysis

Basic petrographic tests including colour, lustre, hardness and texture primarily classify rocks according to their basic material and can also be useful in determining clastic (composed of fragments from pre-existing rocks or minerals), evaporate (formed from precipitation of an aqueous solution and concentrated by evaporation), or carbonate (formed from carbonates of magnesium, calcium, and/or iron) sedimentary rocks (Bates and Jackson 1984; Garrison 2016). These tests are inexpensive and require no special equipment other than a 10x hand-lens and a scratch plate. After a basic analysis, typically the next step in proper rock identification is the use of petrographic thin sections via either a low-power binocular or a high-powered optical-resolution petrographic microscope (Garrison 2016).

6.2.1 Colour

Colour is typically the first physical property to determine and perhaps the easiest. Johnson (1998) notes that while a striking feature of rocks, colour is not always a reliable method of identification. Since rocks can show a great deal of colour variation within a sample as well as a source area and other factors such as heat treatment may result in a colour change, basic visual identification based on colour is limited in its actual utility. The Munsell Rock Color Guide (Munsell Color 2012) is used to assess colour based on hue, value, and chroma. The three are combined to form a standardized colour designation that is remains consistent throughout the Munsell system. Rather than randomly picking one colour (e.g., brown, black, white, red) to describe a rock sample, the Munsell System allows for a replicable colour determination.

6.2.2 Lustre

Typically, the next step in visual lithic identification is the determination of a sample's lustre or reflectivity to light. Lustre can be classified with terms such as metallic, translucent, pearly, earthy, or vitreous (glassy). Similar to colour determination, processes such as heat treatment can change the lustre of a sample from waxy to vitreous in the case of some chalcedonies (Johnson 1998:25).

6.2.3 Hardness

Hardness is a measure of how easily scratched an object can be and is based on the Mohs Scale of Hardness. This Scale was created by the German mineralogist Freidrich Mohs in 1812. The scale ranges from 1 to 10 with increasing hardness throughout. The softest material can be scratched by a piece of talc, the mid-range material is apatite and a diamond is considered to be in the tenth space. This scale can be helpful in distinguishing different minerals as well as rock types. Most chalcedonies fall within the 6.5 to 7 range of the scale.

6.2.4 Texture

Texture refers to the size, shape and arrangement of any grains found in a rock sample or its microstructure. This can give clues as to the rocks' origins. Grain sizes range from crypto- and micro-crystalline, crystalline, clay-sized, silt-sized, sand-sized, and gravel-sized. Grain shapes are classified as well-rounded to angular.

6.2.5 Translucency & Patination

The translucency of a rock is similar to its lustre in regard to how a specimen absorbs or reflects light. Samples can be classified as translucent, transparent or opaque. If a rock absorbs or reflects light, it is opaque; if light passes through the rock, it is said to be transparent. Translucency means that rocks partially absorb light, so it tends to be between transparency and opaqueness.

Patination refers to a thin layer that forms on the surface (cortex) of a rock and is typically the result of weathering. Patination is very common on rocks classified as Knife River flint and other brown chalcedonies and has often been used as a basis of identification of KRF materials. Brown chalcedonies tend to have a characteristic white weathering rind on the exterior surface of a nodule and/or artifact. This patina can be the result of the processes of cortication or desilification. Shepherd (1972:114-124) gives an overview of how these processes act on flint. Cortication is a microporous cortex that forms when flint is dehydrated whereas desilification occurs when silica in the flint is dissolved due to an aqueous environment (VanNest 1985:326). The two processes can work in conjunction with one another to create a white outer layer or patina. VanNest (1985) undertook a study of the patination on KRF artifacts from the Lynch Quarries in North Dakota. She found that the white to grey patination commonly found on samples from this site was formed through desilification and that temperature and pH changes in a laboratory setting can contribute to the rate of silica dissolution (1985:336).

Weathering is also a concern when it comes to connecting samples to source areas. Chemical alteration can occur as a result of weathering processes over time that may alter the concentrations of key elements used to source particular samples. This is why provenance studies often deal with elemental concentration ranges and standard deviations to account for possible weathering effects (Luedtke 1979).

6.2.6 Petrographic Thin Sections

Typically following the basic visual petrographic analyses, the use of petrographic microscopy is employed. Thin sections of rocks and minerals are examined using a petrographic microscope, which uses polarized light to determine mineralogical features in translucent samples (Raith et al. 2012). Past research into KRF (Root 1992) using petrographic thin sections has not shown any key identifiable characteristics at this level of analysis to help classify different source areas of this material. However, advancements in microfossil analysis in petrographic thin sections using scanning electron microscopy may prove useful in future studies.

The possible occurrence of plant remains, if identifiable, may also aid in provenance studies. Quinn (2008) attempted to trace artifact origins through provenance studies by looking at microfossils, the remains of organic material, found within inorganic materials like stones, pottery, and building material. By using a scanning electron microscope (SEM), the silicified plant remains that occur in some chalcedony specimens may be identified and compared with plant remains found in lithic samples from known source areas. This would also help in distinguishing visually similar brown chalcedonies such as Hand Hills flint, White River Group silicates, etc. While not the focus of this research, the potential exists that this method could be adopted in subsequent studies on brown chalcedonies. For this study, more comprehensive and in-depth procedures to determine elemental composition for each source area was necessary through geochemical analysis. Additionally, the source samples that underwent geochemical analysis were modified to not contain any inclusions in case their presence skewed the elemental concentrations and the archaeological samples were ablated in areas were no inclusions were present for the same reason.

6.3 Geochemical Examination Techniques

Given that the chert, chalcedony and flint materials listed above are visually similar to one other, more sophisticated techniques are required in order to determine source areas and to compare the material. The use of petrographic analysis is important in determining some properties of each of the sedimentary samples, such as the presence or absence of particular minerals, orientation of the crystal structure, etc. However, in order to more conclusively determine how these samples, relate to each other, other chemical techniques are required.

Chemical techniques commonly used in provenance studies include, but are not limited to, various forms of x-ray diffraction, x-ray fluorescence, neutron activation analysis, proton- or particle-induced x-ray emission spectroscopy, and inductively-coupled plasma mass spectrometry. All of these techniques have been used on rocks as part of provenance studies, although not all of them have been used on chert and chalcedony materials.

6.3.1 Inductively-Coupled Plasma Mass Spectrometry

Inductively-coupled plasma mass spectrometry (ICP-MS) is used to determine elemental concentrations within samples. In this technique, a sample is ionized in plasma. The ions are sorted and separated through electric and magnetic fields based on the mass-to-charge ratio of the ions. A detector measures the amount of each ion as it passes through an analyzer. Chemical elements are determined based on their atomic mass through mass to charge ratios (m/z) of each element (Pollard et al. 2007:160-161). The advantages of the ICP-MS technique are that it can detect all elements at once, which makes for rapid processing of samples, and that it is more precise than other techniques as it can detect concentrations in parts per billion (ppb) (Pollard et al. 2007:195). This technique can be further enhanced by the addition of different detector configurations including multicollectors and sample introduction techniques, such as laser ablation. Major disadvantages to using inductively-coupled plasma mass spectrometry are the cost associated with running samples and access to the equipment. However, the technique is becoming more popular among archaeologists dealing with provenance studies (Evans et al. 2007; Gratuze 1999; Gratuze et al. 2001; Hess 1996; Roll et al. 2005; Speer 2014).

Evans et al. (2007) looked at sourcing black chert deposits in northern England using three variations of inductively-coupled plasma mass spectrometry (ICP-MS, laser ablation-ICP-MS and ICP-atomic emission spectroscopy) and comparing the results generated by the three techniques. Hess (1996) also used ICP-MS coupled with neutron activation analysis to analyse chert artifacts found in an archaeological site within close proximity to a chert source area. The goal of this research was also to compare results produced by the two techniques. Overall, Hess (1996:76) felt that ICP-MS was superior to neutron activation analysis due to its reliability as a technique, sensitivity, and overall cost.

Speer (2014) used LA-ICP-MS to analyse trace element data on Clovis projectile points from the Gault site in with geochemical data from source areas across the Edwards Plateau in

Texas and one geological sample from the Knife River area of North Dakota. He was able to determine group memberships of the projectile points on a spatial level from macro-regional, regional, and local scale. By using the laser ablation technique, the projectile points were only minimally damaged, and Speer was able to determine how they related to the source areas sample in Texas and North Dakota. The majority (21 out of 33) projectile points shared affinities with the Edwards Plateau sources. As the level of spatial analysis decreased (i.e., from more than 500 km, down to scales of 30 and 500 km, and 1 and 30 km) it became more difficult to distinguish between specific source areas. However, Speer (2014) did determine that sources from outcrops belonging to different formations have distinct geochemical signatures that can be distinguished from one another. Speer's (2014) study showed that the usage of this geochemical technique is helpful in differentiating between local and non-local toolstone resources particularly with regards to Clovis projectile points from the Gault site.

Particularly of interest to this research is the study undertaken by Roll et al. (2005) on Montana cherts using laser-ablation inductively-coupled plasma mass spectrometry. Once again, the goal of the study was to determine elemental composition of samples from source areas and to detect any affinities between sample locations. The technique was able to accomplish this goal; however, more information and research regarding source areas in Montana are needed to refine the results. The authors also used laser-ablation-ICP-MS to look at different colour combinations within single samples in order to determine if there were any chemical differences. The use of ICP-MS again was able to show that differences were present in some samples (Roll et al. 2005:69).

Proponents of ICP-MS note that certain configurations, namely laser ablation, is only minimally destructive, leaving only microscopic traces of damage on a sample surface (Speakman et al. 2007:275). Overall, ICP-MS appears to be a technique comparable to neutron activation analysis without the added expense and radiation and has been shown to be applicable to studies involving cherts and chalcedonies.

6.4 Potential Issues that Arise with Geochemical Analyses

Deciding on which analytical technique to use in lithic provenance studies is only one step to determining connections between artifacts and source areas. Other considerations need to be acknowledged and corrected for. Most geochemical techniques (e.g., LA-ICP-MS, whole sample

X-Ray Fluorescence, etc.) work best on freshly broken, smooth surfaces that are unweathered, have not been subject to chemical alteration and are not subject to large variations in surface topography. Provided a clean and smooth surface is available, the analytical techniques may proceed. However, since many provenance studies involve linking artifacts to source areas, there exists the possibility that the governing body in charge of the artifact after excavation may not appreciate researchers crushing the tool or breaking off pieces for samples. Many studies that have been carried out using chemical analytical techniques have encountered this problem and, in some cases, tried to correct for it by analysing the weathered outer cortex of raw materials or by trying to refine techniques so that the equipment can penetrate the weathered area (Clark and Purdy 1979; Tang et al. 2001). Weathering may deplete or increase various elements and minerals on the outer cortex of a sample (Cackler et al. 1999; Clark and Purdy 1979; Luedtke 1992). If this is the case, this may obscure results and limit the possibility of linking artifacts to source areas. The best approach is likely to undertake analysis on weathered areas in addition to interior surfaces and compare the results.

Another concern involves the likelihood of variation within individual samples as well as within source area formations. Variation may also obscure results generated from chemical analyses based on where the samples were procured within a source area and which portion of the artifact was analysed. Roll et al. (2005) overcame this problem by sampling more than one area on an individual sample that displays variations in colour. By taking into account potential issues such as weathering and sample variation, researchers can overcome errors that may result in their analyses. It is important to know the material that is being studied and to be able to account for possible problems before spurious results are obtained.

6.5 Rational Behind Selected Geochemical Analyses

While Johnson's (1998) examination of visually identifiable features is a necessary first step in distinguishing lithic materials, further analysis is absolutely necessary to determine conclusively where source areas of specific materials are located and to better understand the variation between visually similar lithic materials at a microstructural and chemical level. The use of analytical techniques in lithic provenance studies is a vital addition to fully understanding settlement patterns as well as trade and exchange relationships among Precontact groups on the Northern Plains. Trace element analysis of chalcedonic materials using techniques such as total acid digestion inductively-coupled plasma mass spectrometry and laser-ablation-inductively-coupled plasma mass spectrometry (LA-ICP-MS) will prove helpful in linking archaeological toolstones to source areas. With this in mind, this study explores the applicability of these techniques to brown chalcedonies in subsequent chapters.

6.5.1 Limitations of the Geochemical Techniques Used in this Study

It is imperative to create an inclusive dataset from source area samples against which to compare the results of the archaeological analysis. This dataset will help to explain inter- and intra-site variability and provide a baseline from which future research can be undertaken. Error issues can be kept to a minimum by preparing samples in a clean laboratory environment, using homogeneous material, and removing any forms of weathering. Taking all of these factors into account will provide an elemental dataset that is accurate and comprehensive.

However, one of the biggest limitations to this type of geochemical research is cost. Using the ICP-MS is costly in terms of time as running a sample can take varying amounts of time depending on how the sample is prepared. Most geological samples are standardized in their size and easily fit into laboratory equipment. In fact, the equipment is ultimately designed for standardized sample sizes. This is not an issue when it comes to source samples as they can be destroyed (powdered, acid digested, etc.); yet, archaeological samples are best suited for minimally or non-destructive techniques. Sample preparation can take time especially in order to standardize the sample size for the equipment as well as prepare the sample for destruction. Once all samples were prepared, the actual sample run times for the destroyed source samples was relatively quick. In regard to the archaeological samples, non-uniform sizes of artifacts required more time and more preparation (i.e., mounting in the sample holder) before any analysis could be run. As such, far fewer archaeological samples can be analysed in the same time period as the source samples. However, the accuracy and precision of this technique can make up for the costs of time.

Geochemical equipment (specifically LA-ICP-MS) is not available to all universities and research institutions. At present there are only three machines in western Canada, of which two are in working order. Coupled with the availability of the equipment is whether or not the laboratory has the proper sample holders in which to undertake archaeological research. This criterion brought the total number of available LA-ICP-MS machines down to one in western

Canada. As geochemical laboratory equipment is not used solely for archaeological research, but throughout the social sciences and natural sciences, availability of equipment is also constrained. Access to equipment and laboratory schedules are limited due to demand. Therefore, the window of opportunity to undertake research projects is extremely narrow.

Monetary cost is another large limitation of this type of research. Geochemical sourcing of archaeological materials to possible quarry locations requires adequate samples sizes to comprehensively explain and solve the questions asked. Geochemical analyses can cost thousands of dollars overall depending on the type of equipment used. Newer techniques, such as LA-ICP-MS, tend to be more expensive due to their cutting-edge technology. However, the cost is balanced by the sensitivity and accuracy of these new techniques. Specifically, regarding LA-ICP-MS, the technique is very precise, can give elemental concentrations in the parts per billion (ppb) range, and is minimally destructive in that the archaeological material does not have to be destroyed. The resulting data gathered from using LA-ICP-MS is worth the cost of the analysis. As such, a balance must be reached between sample sizes, availability of equipment, and overall cost. For the purposes of this research, it was felt that having a larger dataset of source samples as compared to archaeological samples was necessary to best quantify the elemental makeup of source areas and account for variability within source areas and between them. A smaller archaeological sample was selected for analysis due to cost and availability of equipment. Despite the small archaeological sample size, the results from this analysis are accurate and provide insight into cultural processes at work in procuring lithic raw material by Besant/Sonota groups.

6.5.2 Field Identification Techniques

While not part of the goal of this research, in the future it is hoped that a method of identification can be determined to allow for an expedient and inexpensive identification of brown chalcedony specimens without the need to resort to time-consuming and expensive geochemical analyses. This would provide archaeologists working with recently collected material the ability to determine a likely source area for the material they have encountered.

6.5.2.1 Ultraviolet Light Analysis

Peter Kirchmeir (2011) used ultraviolet (UV) light to identify brown chalcedony samples from the PSA of North Dakota and from within the Royal Alberta Museum collections, including Hand Hills flint. He also used the same method to compare archaeological samples from 15 Late Precontact Period sites in Alberta in order to determine proper lithic characterizations beyond visual inspection. Kirchmeir determined that visual identification of artifacts from Alberta archaeological sites are only correctly identified as KRF 50% of the time. When combined with microscopic and UV inspections, he felt a correct identification of KRF material increased to 69% and 95% respectively (Kirchmeir 2011:89). Unfortunately, some brown chalcedony samples including Hand Hills flint fluoresced very similarly to KRF samples and as such it is difficult to correctly identify local brown chalcedonies from KRF using UV analysis alone.

As seen with Kirchmeir's (2011) study in Alberta, the application of ultraviolet light has been used to identify silica-rich lithic materials in a number of cases in the United States as well (Hofman et al. 1991; Lyons et al. 2003). This technique analyzes the colours fluoresced by lithic material under both shortwave and longwave ultraviolet light and compares it against a comparative sample of known sources. A study has been undertaken primarily dealing with Edwards chert from Texas, but also includes a consideration of the fluorescent properties of KRF using this technique (Hofman et al. 1991:301). In order for this technique to be applicable to this and future studies of brown chalcedonies on the Canadian Plains, more source areas will need to be identified and verified. If successful in this study, this technique will provide an expedient, inexpensive and non-destructive approach to lithic identification.

Laura Evilsizer (2016) used Kirchmeir's (2011) methodology with ultraviolet light to examine KRF in archaeological sites throughout Montana. She looked at the relative abundance of KRF in Montana archaeological sites throughout the Precontact Period, noting that usage of this material varied widely depending on the geographic location of sites as well as the time period in which they were inhabited. Using UV light, Evilsizer (2016) compared KRF to a number of visually similar rocks including Flaxville Gravels and Fort Union Formation chert and found that they do not fluoresce in the same way as KRF, leading her to accept the applicability of this technique as a means of lithic identification. When comparing 22 archaeological assemblages from Montana she found that KRF is under-identified in the majority (54%) of the sites studied and suggests that archaeologists should not be as cautious in their lithic identifications as well as adopt the usage of UV light as an identification tool (Evilsizer 2016:109-110). Caution must be stated before using Evilsizer's (2016) suggestions. Kirchmeir (2011) had shown in his research that some brown chalcedony varieties, such as Hand Hills flint, did fluoresce in a similar fashion to KRF. While Evilsizer (2016) found that the materials she analysed did not have this same outcome, it is very possible that other visually similar brown chalcedonies not analysed or even as yet unknown could also fluoresce the same as KRF.

6.5.2.2 Portable X-Ray Fluorescence

X-ray fluorescence (XRF) involves x-rays striking a sample. Electrons of an element are excited by the x-ray energy and move to different orbital levels. Electrons in higher orbitals fall back down into lower orbits to fill voids left by excited electrons and as they emit photon energy in the form of the wavelength which is characteristic of the element they are from (Pollard et al. 2007:101). Based on the intensity of the secondary radiation emitted by the x-ray beam on the sample, lighter elements in a sample may not be detected (Pollard et al. 2007). In order to counter this problem, a vacuum must be maintained in the sample chamber when using the laboratory form of this technique. As with all geochemical techniques, sample preparation is an important element for this technique to produce correct results.

A mobile version of XRF has become more popular in the last few years as a field technique for determining elemental concentrations in rock samples. Portable XRF (pXRF) has become a handy tool for researchers in museum and field settings to quickly analyse materials for their elemental composition without the necessity of a lab setting. Some archaeologists have begun to adopt this technology to use as a "in field" analytical technique to source lithic materials. While the technology has been used in the past for mining and other geological research in seeking bulk elemental results, its applicability to archaeology is still to be taken with some caution. pXRF instruments have been criticized for a lack of calibration and the inability to detect certain elements (Garrison 2016; Liritzis and Zacharias 2011; Shackley 2011) thereby limiting their applicability as an "in field" archaeological sourcing tool. Issues can also arise with the possibility of contamination on whole samples due to weathering and matrix effects when clean interior samples are not used. Despite these issues, archaeologists are increasingly using this technology to attempt to source lithic artifacts whether comprehensive elemental datasets for specific source areas exist or not. For these reasons, any results or conclusions based solely on the use of pXRF instruments in archaeology should be taken with extreme caution until these results can be replicated under traditional laboratory conditions.

The use of pXRF in archaeology also has advantages towards field identification of lithic artifacts in archaeology sites on the Plains. The ability to take pre-existing artifact collections and quickly, and accurately determine their elemental concentrations for comparison with known source areas is a burgeoning avenue of research. However, full characterization of source areas is again necessary and issues regarding the errors inherent with using pXRF (contamination, weathering, and matrix effects) must be resolved. Future equipment and advances in the science behind pXRF as well as UV light analysis may provide those expedient means of identification.

6.5.2.3 Summary

As discussed above, in the past decade there has been an increase in the usage of techniques such as UV fluorescence and pXRF to assist in providing source area determination for archaeological lithic materials. The inconsistencies in results shown in the most recent studies (Evilsizer 2016; Kirchmeir 2011) on UV fluorescence as a method of determining KRF indicates that this method of analysis is not a reliable way of distinguishing between visually similar varieties of brown chalcedony and as such was excluded as an analytical technique for this study.

While the usage of pXRF is a popular and more accessible method of sourcing lithic material, it too was not used as an analytical technique in this study. pXRF appears to show a greater degree of accuracy in lithic sourcing studies than other methods (e.g., UV fluorescence), save for the full geochemical characterization of visually similar brown chalcedony sources across the northern Plains. Before this technique can be used with confidence more research into characterizing source areas is necessary.

6.6 Multivariate Statistical Analyses

When dealing with complex and large datasets, determining which relationships are related and which are irrelevant are important. Multivariate statistical analysis has long been used in the social sciences including archaeological datasets. Chemometrics is the use of mathematical and statistical methods to “design or select optimal measurement procedures and experiments and provide maximum chemical information by analysing chemical data” (Meglen 1992:219). The total acid digestion ICP-MS analysis of the 98 brown chalcedony source samples used in this dissertation resulted in thousands of data points of chemical data with over 40 elements analysed in each sample; far too many to analyse on a case-by-case basis. As is discussed in section 7.3 not all the data points or variables are significant, and it is important to determine which ones are useful or relevant for source analysis and determining affinities or differences between particular source locations. Even after discarding elements and oxides that fell below detection limits for some of the analysed samples, there remained a large dataset to process. The goal is also to determine which elements or combination of elements help to characterize a particular source area. Univariate statistical analyses can only examine one variable at a time, which is insufficient for this dataset where multiple variables can have causal relationships with each other in determining the total elemental makeup of any brown chalcedony sample. For this reason, multivariate statistical analyses are crucial in order to understand the information generated.

Multivariate statistical analyses can determine how variables are related to one another and how both dependent and independent variables interact. Specifically, for the purposes of this research, the goal is to determine which elements co-vary with others to separate out distinct source locations. To do this, we need to reduce the variables that are acting independently via dimensional scaling: "the variation in multiple dimensions (variables) is reduced to a smaller number of independent variables that control the remainder of the variation" (VanPool and Leonard 2011:286). Analyses such as factor analysis and principal component analysis (PCA) are two useful techniques that are commonly employed in the manipulation of geochemical statistical data in order to clarify relationships between variables. Other techniques such as discriminant analysis have been used by a number of archaeologists for archaeological source analysis as well (e.g., Christensen 1991a; Hoard et al. 1993; Luedtke 1978, 1979; Quigg et al. 2011). In order to determine which is the best statistical method for this study, an overview of the various techniques is warranted.

6.6.1 Factor Analysis

Factor analysis determines linear relationships between patterns, reduces data to a manageable level and reduces dimensionality (Bartholomew et al. 2011; Yong and Pearce 2013). This is an exploratory data analysis that models shared variation among variables. It ranks variables on how closely related to one another they are as "factors". A factor is a set of observed variables that are related to one another. Exploratory factor analysis explores the dataset in order to uncover patterns and test predictions (Child 2006). In exploratory factor analysis, factors are ranked based on loadings. Loadings can indicate the weight of variables in that they indicate the strength of the variables in a single factor. The loadings can vary from -1 to 1; if the loadings approach 0, it indicates that the variables do not have any effect.

Factor analysis is a complex mathematical procedure that is made more accessible through such statistical software as Statistical Package for the Social Sciences (SPSS) and Palaeontological Statistics (PAST). Factor analysis must undergo two forms of rotation: orthogonal (including varimax and quartimax) and oblique (direct oblimin and promax), in order to better understand the results. The purpose of rotation is to have each of the variables that are being analysed load on as few factors as possible (Yong and Pearce 2013). Unrotated matrices, such as oblique rotation, show general patterns of relationships while the rotated matrices show distinct clusters of relationships if they exist (Rummell 1992). These rotated matrices are referred to as orthogonal, varimax, or quartimax. Here the factors are rotated 90° from each other. This rotation is designed to create a simple structure where each factor defines clusters of interrelated variables that can more easily be interpreted (Cattell 1973). Factors can be extracted by a number of methods, including principal component analysis. In fact, there are some that see exploratory factor analysis as a slightly more complex form of principal component analysis (Cattell 1952, 1978; Child 2006; McDonald 1985). Another issue with factor analysis is that it is a classificatory technique, not an identification technique, and that it tests "geological realities" instead of identifying source areas for artifacts (Luedtke 1979:747). For the above reasons and because the dataset analysis resulted in one major error issue that was extremely difficult to resolve (see section 7.5.1), factor analysis was discarded as a statistical technique for this research.

6.6.2 Cluster Analysis

Cluster analysis is very similar to factor analysis in that it separates variables in groups or "clusters" that are similar to one another and separates those variables that are different from others. It differs from factor analysis in that the groupings are based on distance or proximity versus variation or correlation. Cluster analysis is another classification technique according to Luedtke (1979) that has been used in past archaeological sourcing research. Luedtke feels that this type of analysis ignores the structure inherent in the dataset by overlooking the fact that some samples came from a single source and it presumes that all elements are weighted equally in term of importance, which may not be the case (1979:747). Due to these issues raised by Luedtke (1979), unsuccessful attempts at using this type of analysis with the dataset, and that it is very similar to factor analysis, cluster analysis was discarded as an analytical method.

6.6.3 Principal Component Analysis (PCA)

Principal component analysis (PCA) takes cluster analysis one-step further by separating clusters or groups from one another into principal components by using linear algebra. Each of these principal components helps to explain the total variability with samples and helps to determine which variables are significant and how they are related to one another. The first principal component showcases the greatest amount of variability. PCA can also show which variables are not related to one another and whether a principal component is important to the overall structure of a sample or just noise. Again, this is a useful technique for data reduction and deciphering patterns in large datasets (Wold et al. 1987; Farnham et al. 2003). Like factor and cluster analysis, principal component analysis looks at shared variation and models it. By summarizing the data in a dataset, one can better understand the data and create models for which variables are more significant than others; such as those elements that characterize specific source areas. The main difference between PCA and factor analysis is error and variation. While factor analysis ignores variation, assuming all the variation is held in common across the various factors, principal component analysis includes it with all of the components reflecting all of the variation across all the variables. However, this assumption of variance can be helpful by allowing analysts the ability to determine which variables are dependent or independent of one another. Both factor analysis and principal component analysis can present the data output as axes in a scatterplot. The first two axes count for the most variation in the dataset and from these, clusters can be seen in a bivariate plot that shows the relationship between variables. The closer the variables are to each other, the stronger the correlation between them. However, PCA can have its limitations in that it relies on linear assumptions. In order to find correlations between variables in a dataset, PCA sets out to find orthogonal projections with the highest variances. If the dataset is not linear correlated, PCA may inadvertently force variables into principal components where they may not belong (Farnham et al. 2003; Shlens 2014).

6.6.4 Discriminant Analysis (DA)

Discriminate analysis (DA) assumes that a dataset can be distinguished, based on its variables, into groups. It differs from both factor and principal component analyses by statistically removing variables that are believed to have no "discriminant value" (Garrison 2016:288; Klecka 1975). This type of analysis works best on pre-defined groups such as source areas. The distance between variables in groups is compared by "pair-wise generalized squared distance function, D^2" or also known as the Mahalanobis distance (Garrison 2016:288). Distances between groups and variables can be statistically calculated and variables separated into distinct groups or clusters.

This type of analysis is common in archaeological settings when trying to connect source areas to artifacts (Hoard et al. 1993; Luedtke 1978, 1979; Quigg et al. 2011; Sieveking et al. 1972). The applicability of this technique as an identification tool and its ability to help distinguish between multiple source areas makes it a logical starting point in this research. In fact, both Luedtke (1979) and Reidy et al. (2013) recommend using DA as the best mean of quantifying elemental data in geochemical studies as it can separate out groups, predict which variables belong to a particular group and can distinguish a group's elemental makeup.

Chapter 7 – Research Methodology

Analytical research into methods used to determine differences between brown chalcedony varieties from source areas across the Northern Plains commenced with basic petrographic analyses followed by geochemical analysis. The methods used in Johnson's (1998) thesis involving hardness, colour, lustre, texture, etc. were employed in the identification of the tool stone specimens prior to any chemical analysis. For the chemical analyses, total acid digestion inductively-coupled-plasma mass spectrometry (ICP-MS) was completed on the potential source area samples prior to the archaeological comparative samples in order to establish a range of source area variability both between and within individual sample locations and provide an elemental dataset on which all samples could be compared. Archaeological samples from Besant/Sonota sites in Alberta, Saskatchewan and Manitoba were then chemically analysed using laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS) in order to determine their elemental make-up and how they relate to particular source areas.

7.1 Source Area Locations

Source area samples of brown chalcedony were collected from a number of locations across the United States Northern Plains and the Canadian Plains (Figure 7.1, Table A.1).

7.1.1 North Dakota Sample Areas

Samples were collected from a number of locations within the Primary Source Area (PSA) of the Knife River flint quarries (see section 5.2.1). Sampling locations for this study were based on primary quarry groups as identified originally by Clayton et al.

- (1970) and later by Christensen (1991a). They were taken near known archaeological quarrying sites. They are: Lynch Quarries (7 locations)
- Crowley quarry group (2 locations)
- Medicine Butte quarry group (2 locations)
- Horse Nose Butte quarry group (5 locations)

At each sampling location, samples of KRF were collected from multiple distinct areas (see Figure B.7 and Table A.1). More samples were collected than was needed for the analyses used in this study. Samples that underwent petrographic and geochemical analyses were selected on

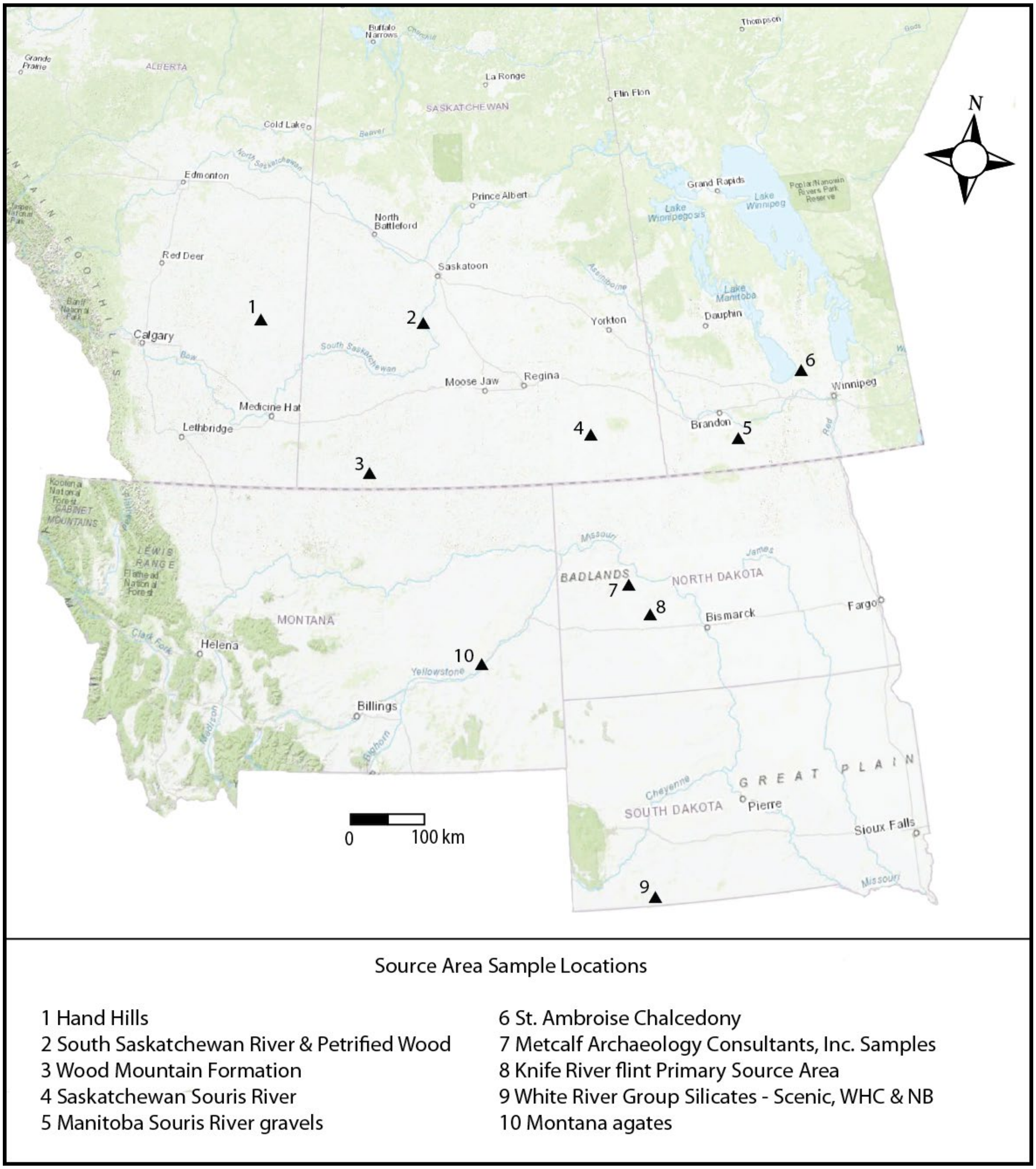

Figure 7.1: Source Area Sample Locations

the basis of their internal homogeneity after any weathered cortex or patina was removed. The samples were broken down into small pieces free of any patination or inclusions for use in the laboratory analysis. For this study, multiple samples from the Lynch Quarries were taken from seven separate locations at erosional scarps in the sides of pit walls.

Though the Crowley quarry group is owned by the State of North Dakota, there is no easement to the site, which requires the crossing of private lands. Inability to gain access to the quarry and the lack of erosional exposures at the site necessitated the collection of samples from the State. Three samples were obtained from the collections of the State Historical Society of North Dakota for chemical analyses. These samples are provenienced to the Crowley Quarry group.

From the Medicine Butte quarry group (32DU1049) two sample locations were selected nearby the quarry site for the collection of material. Five locations in the Horse Nose Butte quarry group area were selected for unmodified samples of KRF. At the Medicine Butte and Horse Nose Butte locations, samples were removed from erosional exposures and consisted of non-culturally modified material. All PSA locations provided nodule-sized (10-20 cm in diameter) samples for this analysis.

7.1.1.1 Samples from Metcalf Archaeology Consultants, Inc. (Dunn County, North Dakota)

Discussions with a local archaeologist also resulted in another sample being collected from outside the Primary Source Area (J. Harty, personal communication 2015). A sample from 32DU2216 was collected from within Dunn County, North Dakota, but outside the defined boundaries of the PSA (Figure 7.1). Site 32DU2216 is located north of Jim Creek. It was excavated by archaeologists from Metcalf Archaeology Consultants, Inc. in November 2015 as part of National Register of Historical Places (NRHP) eligibility testing. This site is described as having multiple occupation zones, including habitation and quarrying, though some areas have been impacted by agricultural practices (Harty 2015). Harty (2015:2) reports that the site consists of "thousands of artifacts … representing all stages of reduction and tool manufacture". All artifacts as well as unmodified cobbles of KRF were collected during the testing process. Two of these unmodified samples were sent to the author for inclusion in this research study. The samples (F.20 and XU57) from 32DU2216 were added to the study in order to determine if they share any affinities with the PSA samples and could possibility provide further insight into the geographic distribution of KRF in North Dakota (see Figure B.8 and Table A.1).

7.1.2 South Dakota Sample Areas – White River Group Silicates

Samples from the White River Badlands of South Dakota including Scenic chalcedony, Nelson Butte chalcedony, and West Horse chert were obtained from Robert Hoard of the Kansas State Historical Society and Adrien L. Hannus of the Archaeology Laboratory at Augustana University in South Dakota (see Figure B.9 & B.10 and Table A.1 & A.2). Unlike the nodules collected from the other source areas used in this study, the White River Group silicates samples had already been reduced to small (<2 cm in diameter) flakes due to their parent material being used in previous studies by Hoard et al. (1993).

7.1.3 Montana Sample Area

Three large nodules of Montana agate were selected from the lithic collection of the Saskatchewan Archaeological Society in Saskatoon. These samples had been collected by the former Executive Director, Tim Jones, from alluvial deposits along the Yellowstone River near Glendive, Montana (Figure 7.1). From the original nodules, smaller pieces were flaked off to be used in this study's source area analysis.

7.1.4 Alberta Sample Areas

Sampling locations from the Hand Hills (Figure 7.1) were chosen after consultation with local rock collectors and landowners in the area. Based on the advice of Walter Alksne of Hanna, Alberta, samples of Hand Hills flint were collected from an eroding creek bed within the western portion of the Hills. As this location is found within the Hand Hills, the samples collected from the erosional exposure are felt to be representative of the chalcedony material found by other archaeologists and rock collectors in the immediate area (see Figure B.1 and Table A.1). Other locations suggested by local informants were explored, yet no suitable samples of flint were found.

7.1.5 Saskatchewan Sample Areas

Numerous pedestrian surveys along the shores of Lake Diefenbaker were undertaken in 2009, 2010, 2013 and 2015 in order to collect samples of brown chalcedony. Only four samples of material were collected, and they were substandard in terms of visual similarity. Brent Kevinsen, an archaeologist and flintknapper, was able to procure nodules of brown chalcedony from the

South Saskatchewan River valley that were visually similar to Knife River flint for this research (see Figure B.2). These samples were obtained from gravel pits along the east bank of the South Saskatchewan River approximately 10 km north of the Lake Diefenbaker Dam (Figure 7.1).

Discussions with a local geologist (F. McDougall, personal communication 2015) have led to the acquisition of samples of brown chalcedony out of the Wood Mountain Formation near Eastend, Saskatchewan. Again, these samples are visually similar to KRF (see Figure B.1). A final sample of brown chalcedony was obtained from Jeff Coleclough, a flintknapper, who collected it out of a gravel pit near Riceton, Saskatchewan (see Figure B.4). Due to its location as part of the Saskatchewan Souris Watershed, it is believed that this sample may be similar to samples collected from the Souris River in Manitoba (Figure 7.1).

Six samples of petrified wood were also collected from the shores of Lake Diefenbaker during sample collection for brown chalcedony materials. These were included in this study's geochemical analysis to see how petrified wood compares to brown chalcedonies (see Figure B.3 and Tables A.1 & A.2). Small artifacts or debitage of petrified wood can sometimes be mistaken for KRF. As such, including petrified wood in the study will further demonstrate how it relates to visually similar brown chalcedonies on an elemental level.

7.1.6 Manitoba Sample Areas

To determine if brown chalcedony found in the Souris sand and gravel deposit is indeed chemically identical to KRF or is of a different geological origin, two locations along the Souris River near Souris, Manitoba were visited for the collection of samples to use in this current analysis (Figure 7.1). These samples were removed as smaller nodules (<10 cm in diameter) and reduced to small flakes for analysis (see Figure B.5 and Table A.1 & A.2).

Discussions with Manitoba archaeologists (Kevin Brownlee, personal communication 2015) had brought to light the presence of another brown chalcedony variety known locally as St. Ambroise chalcedony. St. Ambroise chalcedony has been observed at the south end of Lake Manitoba near the small community of St. Ambroise, north of Portage la Prairie (see section 5.2.5.1). It has been found in unmodified raw material form as well as being shaped into archaeological artifacts (see Figure F.6 and Table 7.1 & E.1). A shortage of unmodified raw material in the Museum's collections resulted in only archaeological artifacts of this material being included in the geochemical analysis. A discussion of the results of the St. Ambroise chalcedony artifacts can be found in section 8.7.4.

7.1.7 Summary

Samples from the PSA in North Dakota, the Hand Hills of Alberta, the South Saskatchewan River valley near Lake Diefenbaker, and the Souris Gravels of Manitoba were collected in person by the author. Archaeologists in the United States who have analysed and published on White River Group silicates were consulted for their expertise on the material and how to obtain it. Additional samples from the Montana, Lake Diefenbaker, Wood Mountain, Riceton, and Dunn County areas were obtained for this research by knowledgeable individuals such as flintknappers, professional archaeologists and a retired geologist.

These samples were procured under the assumption that they were representative of the local material available to groups in the past. Each piece of material was selected based on homogeneity of the rock as well as variability between and within selected quarry locations. For this reason, numerous specimens from potential source areas were gathered in order to document the range of variability that can be found within a single outcrop or exposure. This included everything from brown chalcedony samples that were fractured and poor in knapping quality to those of high knapping quality. Individual exposures, outcrops, and quarry pits were photographed, and their locations recorded via a Global Positioning System Receiver (GPSr). For the purposes of the subsequent analysis, the sample selection was refined to include samples that were free of any patina, weathering and inclusions so as not to introduce any potential error. These samples underwent basic petrographic analysis, as seen in Table A.2 and section 7.3 below, prior to geochemical characterization.

7.2 Petrographic Methodology

For the purposes of consistency, a Munsell Rock Color Guide was used throughout all analyses to standardize the colour determinations of both source and artifact samples. A high-resolution flatbed scanner (Microtek ScanMaker *i*900) was then used to photograph each source sample in order to produce high-resolution images that could be magnified to get a better visual inspection of the sample structure than a hand lens could provide (Appendix B). All digital scanning was undertaken at the Saskatchewan Archaeological Society office in Saskatoon by mining geologist

Frank McDougall on behalf of the author. All basic petrographic analyses (including colour, lustre, hardness and texture) were completed by the author (see Appendix A, Table A.1 and A.2). Prior to petrographic and geochemical analyses, the patina and outer cortex of each of the samples was removed. For the archaeological samples, those lacking patina or with minimal patina present were chosen for analysis.

Each source sample was examined under direct sunlight at the same time as all other samples to provide consistency and not allow any error to be introduced into the visual analysis as a result of shadow or differing light sources. Under this direct light colour was determined using the Munsell Rock Color Guide as was the samples' lustre and translucency. Hardness was determined by attempting to scratch each sample against a number of objects including a glass plate and a steel nail and then using those same objects to scratch each sample. Texture was determined based on the presence or absence of visible grains as well as their size, shape, relationship, and orientation to other grains using a 10× magnification hand lens. Patination was assessed by its presence or absence on each sample and then later removed from the source samples for chemical analysis so as not to introduce any error. Appendix A lists the results of the petrographic analyses on each source sample.

7.3 Geochemical Analyses Used in this Study

In order to obtain elemental data by which to distinguish between specific source areas of brown chalcedony, a number of geochemical analyses where undertaken. Since the source samples were of little archaeological significance as they were unmodified, it was felt that destruction via acid digestion was the quickest and most economical technique in which to gather elemental data. The inability to access LA-ICP-MS equipment due to repairs also necessitated the need for acid digestion ICP-MS of the source samples to take place prior to analysis of the archaeological materials. All samples collected for this research study from Alberta, Saskatchewan, Manitoba, North Dakota, and South Dakota underwent total acid digestion inductively-coupled plasma mass spectrometry. Robert Hoard of the Kansas State Historical Society and Adrien L. Hannus of the Archaeology Laboratory at Augustana University in South Dakota provided physical samples of West Horse chert, Nelson Butte chalcedony, and Scenic chalcedony for this analysis. Elemental data from Christensen's 1991 instrumental neutron activation analysis of the Primary

Source Area in North Dakota and Hoard's et al. 1993 neutron activation analysis of White River Group Silicates including West Horse chert and Scenic chalcedony are discussed in section 8.4.

7.3.1 Source Sample Preparation

Samples collected from the source areas across the Northern Plains were washed in distilled water before any visual or chemical analyses were carried out. The outer cortex and patina on each sample was removed via flintknapping in order to provide an unaltered surface from which analyses could take place. Samples were broken down into smaller pieces to facilitate the acid digestion procedure via laboratory standards (see section 7.3.1.1) and to ensure that no inclusions (e.g., silicified plant matter) were added to the geochemical analysis. Samples were again washed in distilled water to remove any external contaminants that might have occurred during the cortex removal and reduction processes. They were separated by source area and assigned a sample number to keep track of elemental data (see appendices A and G).

7.3.1.1 Inductively-Coupled Plasma Mass Spectrometry (ICP-MS) Total Digestions

Each source area produced a number of individual samples that underwent total acid digestion in order to detect any homogeneity or heterogeneity within a source location. Acid total digestion converts samples from a solid state to a liquid state in order to determine bulk elemental analysis. All 98 samples were processed in a clean laboratory free from contaminants at the Saskatchewan Research Council Geoanalytical Laboratory in Saskatoon, Saskatchewan. Source samples were powdered and dried before undergoing total dissolution so as not to leave any solid material that could potentially obstruct the ICP-MS nebulizer. Using a mixture of ultra-pure concentrated acids ($HF:HNO_3:HClO_4$), an aliquot of each sample was digested to dryness in a hot block digesting system. This aliquot was then dissolved, and deionized water was added to make up the volume necessary prior to analysis (Robert Miller, personal communication 2018).

NIST 612 standard samples were also analysed and used throughout the source sample analysis to calibrate the machine and ensure proper elemental detection limits were achieved. NIST 612 is a standard certified by the National Institute of Science and Technology that can be used to both calibrate and validate microanalytical techniques (Hinton 1999). In silica-rich materials, such as cherts and chalcedonies, the NIST 600 series of glasses (which includes both NIST 612 and 614) contain 61 elements of known concentrations that can be used as a measurement standard during geoanalytical techniques (Hinton 1999; International Association of Geoanalysts 2018). These samples are found as circular wafers that are loaded into the sample chamber during analysis. Typically, the NIST wafers are tested after every few sample runs to provide an ongoing validation of the data being produced.

The dissolved samples were loaded into the sample chamber of a Perkin Elmer Optima 5300 DV mass spectrometer, which was then sealed and put under vacuum pressure to maintain a steady plasma beam and keep the resultant sample ions from scattering. Argon gas was added to the sample chamber and the samples were introduced into the plasma as a solution. Each sample entered the instrument nebulizer via a peristaltic pump and a thin tube. Once in the nebulizer a small amount of solution, as a mist, was expelled by the instrument nebulizer. The plasma was heated to 6000°C and kept at this temperature in order to ionize the molecules into positive ions. These positive ions in the plasma were injected into a quadrapole mass selector. From here, the positive ions were identified along with their relative abundances.

7.3.2 Archaeological Sample Preparation

Archaeological samples were chosen based on inferred function and style from the ten sites described in chapter four. Besant and Sonota-aged sites were the only ones included as part of this research. The individual artifacts for each of the sites analysed were chosen based on their function, type, and lack of visible patina. As with the source samples, each artifact was scanned in by volunteer, Frank McDougall, or the author at the Saskatchewan Archaeological Society office in Saskatoon using their high-resolution scanner (Microtek ScanMaker *i*900). Again, this process was undertaken so that the high-resolution images could be magnified to get a better visual inspection of the artifact than a hand lens could provide. This helped to identify areas of homogeneity on each sample for the geochemical analysis. Photos of all the artifacts that underwent LA-ICP-MS analysis can be found in Appendix F. Each artifact was weighed and measured, and these measurements are included in Table 7.1 as well. Many of the artifacts had been previously identified as being made from KRF as part of their catalogue and original analysis. The only artifacts not catalogued as KRF were those from the Howden Site (EbLi-1) in Manitoba. These two artifacts were labeled as St. Ambroise Chalcedony, another visually similar brown chalcedony to KRF, from the Lake Manitoba region (see chapter 5.2.5.1 for a discussion on this material type). The archaeological samples were coded according to their Borden

Table 7.1: Artifacts Used as Part of LA-ICP-MS Analysis

#	Site	Borden	Catalogue #	Type	Condition	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Alberta									
1	Fincastle	DlOx-5	843	Projectile Point	Broken, 1 ear remains	1	1.1	0.75	0.3
2			900	Flake, Secondary	Broken	1.6	1.9	0.35	1.3
3			13970	Projectile Point	Broken, missing tip	2.1	1.68	0.6	2.4
4	Muhlbach	FbPf-1	28	Biface/Sidescraper	Broken; missing tip and lateral edge	4.39	2.5	0.6	7.4
5			30	Projectile Point	Complete	3.68	2.05	0.55	4.4
6			264	Projectile Point	Complete	3	2.1	0.52	3.4
7	Smith-Swainson	FeOw-1,2,3	H.72.7.799	Projectile Point	Broken, missing tip	3.82	2	0.49	3
8			H.72.7.800	Projectile Point	Broken	2.09	1.73	0.45	1.9
9			H.72.7.837	Flake, Secondary	Complete	2.7	1.7	0.3	1.7
Saskatchewan									
10	Crane	DiMv-93	8584	Endscraper, Thumbnail	Complete	2.4	2.5	0.6	5.1
11			9083	Projectile Point	Broken, missing tip	2.3	2.3	0.5	3.2
12			9211	Projectile Point	Broken, base only	1	2.2	0.4	1.1
13	Fitzgerald	ElNp-8	346	Flake, Utilized	Complete	2.1	1.9	0.5	2
14			16350	Flake, Secondary	Broken	2.3	3.1	0.3	2
15			No Cat #	Projectile Point	Broken, base only, Meyer 91 Coll.	1.3	2.1	0.5	1.7
16	Melhagen	EgNn-1	674	Projectile Point	Complete	4	2.1	0.6	5.3
17			4841	Projectile Point	Broken, missing tip	2.1	1.85	0.4	2

Table 7.1: Artifacts Used as Part of LA-ICP-MS Analysis Continued

#	Site	Borden	Catalogue #	Type	Condition	Length (cm)	Width (cm)	Thickness (cm)	Weight (g)
Saskatchewan									
18	Melhagen	EgNn-1	7205	Projectile Point/Knife	Broken, midshaft	3.85	2.8	0.5	5.8
Manitoba									
19	Avery	DhLs-2	M9	Projectile Point	Broken; missing ear and tip	3.55	2.05	0.55	4.6
20	Howden	EbLi-1	M402	Flake Projectile Point	Complete	2.7	1.75	0.35	1.7
21			M405	Projectile Point	Complete	2.55	1.95	0.65	3.3
22	Richards Kill	DhLw-2	M71	Projectile Point	Broken; missing tip and shoulder	3.75	2.15	0.65	5.8
23			M122	Projectile Point	Broken; missing one shoulder and ear	3.7	2.2	0.6	5
24	Snyder II	DgMg-15	M491	Projectile Point	Broken; missing portion of tip	2.7	2.15	0.6	4
25			M1412	Projectile Point	Broken; missing portion of tip	3.1	1.85	0.5	3.8

Figure 7.2: Sample Holder for LA-ICP-MS with Artifacts Mounted

designation and catalogue number (see Appendix E, Table E.1). Where there were too many numbers in the name, the sample number was shortened to the Borden number and an identifying letter (e.g., ElNp8A, ElNp8B, ElNp8C, etc.) for the actual analysis in order to make it easier to keep track of multiple samples during each analysis run.

7.3.2.1 LA-ICP-MS Sample Preparation Process

Archaeological samples were mounted on a specially designed sample holder with Parafilm “M” Laboratory film to help stabilize each mount (Figure 7.2). One of the issues with archaeological samples in high-end geochemical machinery is the angularity and irregularity of the samples themselves. Most samples submitted for laser ablation analysis are either mounted in an epoxy disc of uniform size or are polished thin sections. Since the desired outcome of using this

Figure 7.3: Close-up of Artifact with Ablation Points Being Defined

technique in archaeological samples is minimal destruction to the specimen, creative mounting (including the use of double-sided tape) of each artifact into the sample holder was undertaken. Three artifacts at a time were securely mounted in the sample holder with the Parafilm "M" Laboratory film and double-sided tape along with the standards disks (NIST 612 and 614). The artifacts were further secured using the included sample holder supports and care was given to ensure that all samples were located at approximately the same height in order to fit into the sample chamber and not cause the laser beam to become unfocused. The sample holder was

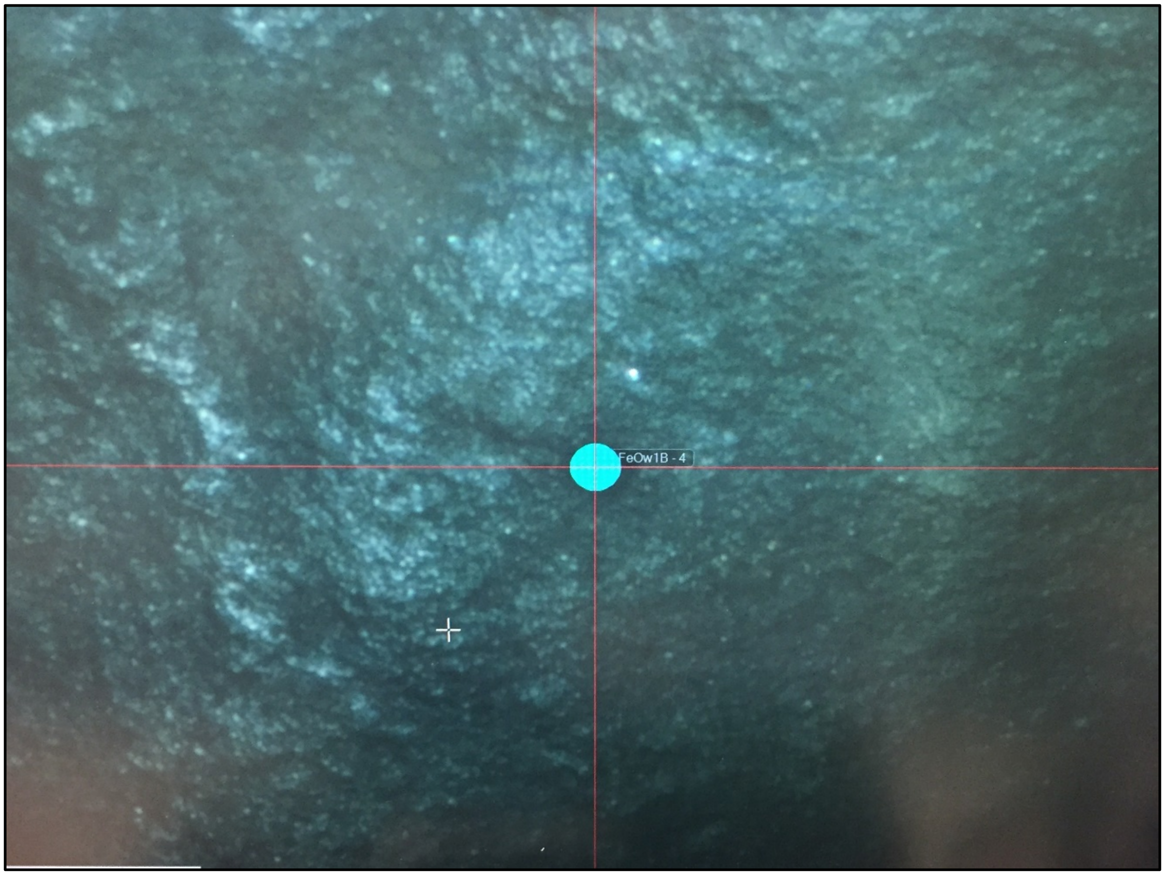

Figure 7.4: Close-up of Artifact Surface Showing Material Homogeneity

scanned on an Epson flatbed scanner (Epson Perfection v500 Photo 6400 dpi) to import into the software program, *GeoStar*. *GeoStar* is the control software for the laser ablation system from which ablation points on samples are defined and controlled.

The sample holder was then placed inside the sample chamber of the LA-ICP-MSand sealed in. A vacuum was created in the sample chamber to prevent any contamination from outside elements, regulate the plasma beam and prevent sample ions from scattering. In *GeoStar*, control points were added to orient the sample holder image to the laser ablation assembly. Once control points were obtained and the image was photo rectified, sample points were added (Figure 7.3). Due to the irregularity of the artifact surface, it was recommended to ablate points across the artifact rather than using a continuous ablation line. Using a continuous line would cause the laser to go into and out of focus, which would skew elemental data collection. On each artifact five sample points were selected for the laser to ablate. The points were placed in areas of homogeneity on the artifact (e.g., not in large macrofossil inclusions, near any patina, or_in contact with catalogue numbers, etc.) as to not introduce any additional error into the analysis (Figure 7.4). To focus the laser beam, each sample surface was ablated a number of times, which also removed any surface contamination. Analyses of archaeological materials made from glass have found that alteration layers can typically be approximately 10 µm in thickness (Panighello et al. 2015). By ablating the surface beyond this thickness, the possibility of weathering effects from the surface becomes significantly decreased. Using artifacts with no visible patination and ensuring ablation depths for this analysis were in the range of 30 – 50 µm mitigated the issue of surface contamination in the elemental analysis. NIST 612 and 614 standards were used throughout the analysis to calibrate the machine and ensure proper detection limits were achieved as well as to guard against any matrix effects (see section 7.3.2.3). The spot size for the artifact samples, and the NIST 612 and NIST 614 standards, were 130 µm over the more commonly used spot size of 90 µm. A larger spot size was chosen for the archaeological samples to be sure that we were collecting as much elemental data as possible. Each sample run took between 50 and 90 minutes to complete. The NIST 614 standard was introduced within each sample run as a control check for the analysis as was standard practice in this geoanalytical laboratory. This standard was treated as an "unknown" and elemental quantities were collected for it. The output data on NIST 614 was compared to the Geological and Environmental Reference Materials (GeoReM 2017) website from which the preferred values for NIST 614 were consulted (Jochum et al. 2005). All values from the LA-ICP-MS analysis correlated with those listed by GeoReM. (Appendix E, Table E.2) indicating that the machine process was in acceptable working order and no matrix effects were taking place.

Each archaeological sample received elemental analysis on 4-5 points per sample. If one or more of the 5 points was discarded, it was likely due to the sample having moved during the vacuum process and the laser being unable to focus correctly on a single spot. For example, two samples from the Crane site (DiMv-93D and E) were reanalyzed in a second sample run because they had moved during the original run and no elemental data was collected. Cherts and chalcedonies are considered silicates, meaning that they are predominantly made up of silicon (^{29}Si). As such, looking at the SiO_2 values on the GeoRem website and comparing it to the results from the NIST 614 standard with the rest of the artifact elemental dataset will indicate whether the machine is operating within normal range and if the artifacts are being properly analysed. Preferred SiO_2 values for this analysis and the NIST 614 standard should be in the range of 72.1 ± 0.9 %m/m, which was taken as a normal baseline for the overall procedure. By looking at the SiO_2 values, certain points were removed from analysis under the assumption that there was a possibility that not enough material was collected for mass spectrometry analysis and in order to reduce possible error.

7.3.2.2 Instrumental Parameters

A *Resonetics RESOlution* laser ablation system for LA-ICP-MS coupled with a Thermo Scientific Element XR High Resolution-ICP-MS unit in the Arctic Resources Mass Spectrometry Facility in the Department of Earth and Atmospheric Sciences at the University of Alberta in Edmonton was used to process the archaeological samples in single point analysis mode. Again, in order to mitigate any surface contamination from being introduced into analysis and to eliminate any signal transience, each analysis spot was pre-ablated for 250 ms. The sample was ablated by a Nd:YAG COMPexPro Excimer laser with a diameter of 130 µm and operated at 26% of the transmitted energy of 120.7 mJ (i.e., 31.4 mJ) at a repetition rate of 10 Hz for 70,000 ms. The resultant material is transported via a helium-argon gas carrier into the mass spectrometer where the individual atoms are ionized via argon plasma at 10,000 K and separated by their mass-to-charge ratio and analysed by a quadrapole mass selector. After the ablation process, the inductively-coupled plasma mass spectrometry follows the same procedure as described in section 7.3.1.1.

Data from the mass spectrometer analysis was processed via the *iolite* software package, a program designed to process mass spectrometry data, under the direction of Dr. Yan Luo, the laboratory's Laser Ablation Technical Specialist. Raw elemental data from each of the archaeological samples was imported into Microsoft *Excel* as a Comma-Separated Values (.csv) file from *iolite*, a data processing software package for mass spectrometry results. From here the data was studied and analysed by the statistical software package, Palaeontological Statistics (PAST).

7.3.2.3 Issues with Fractionation and Matrix Effect

Fractionation is a problem that sometimes results with mass spectrometry analyses. It is when the sample undergoing analysis separates into a number of smaller samples or fractions. These fractions may have different compositions or elemental makeups from one another and may cause error to be introduced into sample analysis as well as unclear elemental data results. In an ideal situation, all of the sample would be ionized and collected before being analysed in the mass spectrometer; however, the likelihood of this happening is rare in laboratory settings. Suffice it to say, fractionation is an issue which almost all mass spectrometry deals with. Awareness of the issue is necessary and steps to mitigate the issue are mandatory (Agatemor and Beauchemin 2011b; Neff 2012). Proper equipment for the laser ablation setup is vital. One of the advantages of using the *Resonetics RESOlution* Laser Ablation System is its ablation cell design, which minimizes the amount of fractionation that takes place. It is believed that if any fractionation took place during the course of this analysis, it was minimized and due to proper equipment maintenance and the type of ablation cell used did not introduce any spurious results.

Matrix effects are the appearance of an over- or an under-abundance of a particular analyte or element that can skew the elemental concentrations in an analysis in a number of geoanalytical techniques, including LA-ICP-MS (Agatemor and Beauchemin 2011a, 2011b; Yuan et al. 2011). It is impossible to completely eliminate matrix effect, but it can be reduced by calibration methods. In silicate materials, such as chert and chalcedony, using external and internal standards such as NIST 612 and 614 as well as awareness of the concentration of a major element, such as ^{29}Si, is necessary to counter matrix effect and fractionation. Proper sample preparation and the removal of the weathered exterior cortex to expose interior homogenous surfaces also reduced the likelihood of the matrix effect in this analysis. The usage of five ablation points across each artifact has also mitigated any resultant matrix effects during the analysis. By choosing more than one sample area (or ablation point) one can compare how homogenous a single artifact is. The results from this analysis (see Appendix H) show a trend towards consistency in elemental concentrations in each of the artifacts analysed across their respective ablation points indicating the homogeneity of each sample.

7.4 Statistical Analyses

Concentrations of each analyte varied from source to source and while some elements appear to separate out sources, one must be careful to focus solely on a single or a few elements. For this reason, it was important to undertake multivariate statistical analysis in order to fully characterize what a source area looks like geochemically by analysing the entire elemental makeup of samples (see section 6.6).

The elemental dataset was separated by each source sample location and analysed using the statistical software, Palaeontological Statistics (PAST) Version 3.16 (Hammer et al. 2001). This software package is free and readily available for download for both Apple OS and Windows platforms and has undergone numerous version updates with the most recent in July 2017. This software package was chosen over the more commonly used Statistical Package for the Social Sciences (SPSS) based on ease of use. SPSS is hosted online unless a commercial or private license of the software is purchased and can be prone to lagging and crashing. For these reasons, PAST was chosen for its ease of use and desktop application.

The individual ablation points for each archaeological sample was averaged for each element in order to properly compare the results from both the archaeological and source samples as the source samples provided bulk elemental results. In order to determine how the source area samples related to one another, the data was put into the PAST software and initially factor analysis was chosen as the statistical method. Unfortunately, numerous attempts to process the data resulted in an error occurring for this type of statistical analysis.

7.4.1 Not Positive Definite Matrices Issue

When the source sample dataset was entered into SPSS and PAST and factor analysis chosen as the multivariate statistical technique, the software programs worked as expected to with the production of eight different factors of various loadings. It was only when checks on the results were undertaken that a hidden error appeared that brought the results into question.

When undertaking a check on the data results, buried within the output from SPSS was an error: "Not Positive Definite Matrices". This error message indicates that the matrix contains zero or negative Eigenvalues. This error can be caused by a number of issues including linear dependency in which two or more variables are perfectly correlated or dependent on each other, software problems when reading the data, a typing error, syntax errors, etc. (Wothke 1993). The data was rechecked and rerun with the same error message resulting, indicating that the likely issue was with linear dependency among the variables. Further experimentation and troubleshooting with the dataset into determining which variables were causing the issue was unsuccessful. Additional research into factor analysis and its uses along with the being unable to solve the issue indicated that it was not the best statistical analysis for the data used in this study.

7.4.2 Principle Component and Discriminant Analyses

The source sample elemental dataset underwent both principal component and discriminant analyses via PAST. Both statistical techniques were used as a check to ensure that the results from each technique were sound and that no variables were accidently sorted into principal components in which they did not belong (see section 6.6.3). Both types of statistical analysis resulted in comparable results and as such both were deemed valid methods of analysing the elemental data in this study. Once the source sample data was analysed to determine distinction between specific source areas, it was then compared to the results of both Christensen (1991b) and Hoard et al. (1993) for KRF and White River Group silicates respectively. By undertaking this type of comparison, the validity of this study's results can be confirmed and help to prove conclusions about the use of locally available sources of brown chalcedony. The analysis of this comparison is discussed in section 8.4. The elemental data from the archaeological samples was then compared to the source sample results using discriminant analysis in order to ascertain what toolstone was procured for select archaeological artifacts from Besant/Sonota sites. From this, a number of conclusions were formulated and a discussion on the archaeological implications of the results can be found in chapter nine.

Chapter 8 – Results of the Petrographic and Geochemical Analyses

8.1 Petrographic Results

Petrographic analysis, following the description in section 7.3, provided little in terms of differentiation between samples of brown chalcedony from different source areas. In terms of colour, the Saskatchewan source samples range in browns from dusky, yellowish, grayish, to moderate to brownish gray. The Alberta source samples vary from light to moderate brown and grayish brown while the Manitoba samples tend from moderate to dusky brown as well as grayish brown and dark yellowish brown. The North Dakota, Nebraska and Montana samples are similar to those found in the Canadian provinces with the addition of a pale yellowish brown and a pale brown. Overall, two Munsell colours dominate the entire sample in terms of overall numbers; 5 YR 2/2 (dusky brown) and 10 YR 2/2 (dusky yellowish brown). For lustre, all samples in this study displayed a waxy lustre. In terms of hardness, the samples used in this study fall within the 6.5 to 7 range of the Mohs Scale of Hardness. For texture, all source samples in this study can be classified as cryptocrystalline with no visible grain structure. The source samples can all be classified as translucent in that they are both partially transparent and opaque. Finally, raw material samples from all the source locations studied showed various stages of patina development from minimal (partly cloudy) to full patination (white and opaque). Patina alone was not enough to visually distinguish between source location as patina formation occurs at all locations.

8.2 Source Sample Acid Digestion ICP-MS Results

Mass spectrometer analysis resulted in the identification of 53 elements from the source samples. Of these, nine elements and their oxides (e.g., Cd, Cs, Ga, Hf, MnO, P_2O_5, Ta, TiO_2, and W) were discarded from the analysis as they were below detection limits in over 50% of the samples. This left 44 elements including oxides and rare earth elements (REEs) that were used to analyse the source areas. The mean and standard deviation were calculated for each element and are presented in Table 8.1. Comparison of elements within each source area showed some general trends for each area on the basis of 15 analytes. Key elements that are present in Saskatchewan source areas include barium (Ba), strontium (Sr), and zirconium (Zr) for South Saskatchewan River samples; barium (Ba), chromium (Cr), copper (Cu), molybdenum (Mo), uranium (U),

Table 8.1: Mean Elemental Concentrations and their Standard Deviations for Each Source Area

**All values in ppm unless otherwise stated.*

Elements & Oxides	Saskatchewan				Alberta	Manitoba	North Dakota		South Dakota			Montana
	South Sask River	**Wood Mountain**	**Souris River**	**Petrified Wood**	**Hand Hills**	**Souris River**	**Primary Source Area**	**Metcalf Archaeology Samples**	**West Horse Chert**	**Scenic Chalcedony**	**Nelson Butte**	**Agate**
	n=13	*n=6*	*n=1*	*n=6*	*n=8*	*n=20*	*n=5*	*n=9*	*n=19*	*n=7*	*n=1*	*n=3*
Li	2.42 ± 3.61	0.2	2	0.72 ± 0.77	2.13 ± 0.35	1.2 ± 0.41	2.40 ± 1.14	0.72 ± 0.96	6.37 ± 2.93	11.71 ± 1.70	0.1	2.33 ± 0.58
Be	0.12 ± 0.09	0.32 ± 0.15	0.7	0.07 ± 0.08	0.53 ± 0.10	0.35 ± 0.10	0.20 ± 0.15	0.30 ± 0.26	0.07 ± 0.08	1.23 ± 0.17	0.1	0.17 ± 0.06
Na_2O	0.009 ± 0.009	0.01 ± 0.01	0.04	0.002 ± 0.004	0.03 ± 0.01	0.02 ± 0.01	0.02 ± 0.004	0.01 ± 0.01	0.04 ± 0.01	0.09 ± 0.10	0.05	0.03 ± 0.01
MgO	0.004 ± 0.004	0.01 ± 0.01	0.01	0.01 ± 0.004	0.01 ± 0.001	0.004 ± 0.001	0.01 ± 0.004	0.002 ± 0.002	0.004 ± 0.003	0.001 ± 0.001	0.01	0.004
Al_2O_3	0.03 ± 0.02	0.03 ± 0.01	0.08	0.05 ± 0.01	0.10 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.04 ± 0.03	0.11 ± 0.04	0.21 ± 0.02	0.13	0.09 ± 0.01
K2O	0.01 ± 0.004	0.01 ± 0.002	0.02	0.01 ± 0.004	0.03 ± 0.003	0.02 ± 0.002	0.03 ± 0.01	0.02 ± 0.01	0.04 ± 0.01	0.03 ± 0.003	0.03	0.03 ± 0.01
CaO	0.02 ± 0.01	0.02 ± 0.01	0.02	0.02 ± 0.01	0.02 ± 0.01	0.02 ± 0.02	0.07 ± 0.07	0.01 ± 0.004	0.15 ± 0.12	0.23 ± 0.17	0.08	0.02
Sc	0.33 ± 0.11	1.07 ± 0.51	0.2	1.02 ± 0.71	0.16 ± 0.08	0.26 ± 0.09	0.28 ± 0.30	0.08 ± 0.06	0.11 ± 0.09	0.30 ± 0.12	0.01	0.13 ± 0.06
V	0.73 ± 1.42	16.28 ± 16.19	0.7	5.15 ± 5.39	0.69 ± 0.29	1.27 ± 0.75	1.00 ± 0.29	0.99 ± 1.24	12.73 ± 7.56	1.19 ± 0.40	20	0.57 ± 0.15
Cr	2.70 ± 1.96	5.67 ± 1.97	25	9.83 ± 15.46	3.83 ± 1.94	4.85 ± 7.56	30.20 ± 5.45	2.22 ± 1.86	6.53 ± 19.27	2.86 ± 2.27	24	1.33 ± 0.58
Fe_2O_3	0.05 ± 0.04	0.85 ± 0.97	0.04	0.33 ± 0.38	0.04 ± 0.02	0.05± 0.04	0.06 ± 0.02	0.03 ± 0.03	0.05 ± 0.04	0.01 ± 0.01	0.05	0.02 ± 0.02
Co	0.14 ± 0.08	1.04 ± 1.32	0.08	0.67 ± 0.70	0.10 ± 0.05	0.10 ± 0.09	0.10 ± 0.03	0.17 ± 0.22	0.11 ± 0.23	0.11 ± 0.04	0.1	0.05 ± 0.02

Table 8.1: Mean Elemental Concentrations and their Standard Deviations for Each Source Area Continued

Elements & Oxides	Saskatchewan				Alberta	Manitoba	North Dakota		South Dakota			Montana
	South Sask River	**Wood Mountain**	**Souris River**	**Petrified Wood**	**Hand Hills**	**Souris River**	**Primary Source Area**	**Metcalf Archaeology Samples**	**West Horse Chert**	**Scenic Chalcedony**	**Nelson Butte**	**Agate**
	n=13	*n=6*	*n=1*	*n=6*	*n=8*	*n=20*	*n=5*	*n=9*	*n=19*	*n=7*	*n=1*	*n=3*
Ni	1.32 ± 0.77	3.23 ± 3.29	1.2	3.33 ± 3.22	1.68 ± 0.91	2.35 ± 4.11	0.74 ± 0.18	0.82 ± 0.62	3.04 ± 10.31	1.21 ± 1.19	0.7	0.70 ± 0.26
Cu	1.29 ± 0.80	5.98 ± 4.34	3.4	2.20 ± 0.96	2.89 ± 0.91	1.16 ± 0.82	1.52 ± 0.61	1.21 ± 0.64	2.43 ± 1.77	5.79 ± 3.18	0.9	1.57 ± 0.45
Zn	1.72 ± 3.73	8.52 ± 8.39	0.1	3.22 ± 3.55	29.4 ± 49.81	2.40 ± 0.89	0.46 ± 0.49	0.1	1.11 ± 1.87	4.34 ± 7.64	1	0.1
Rb	0.16 ± 0.10	0.17 ± 0.05	0.3	0.35 ± 0.15	0.29 ± 0.04	0.26 ± 0.06	0.34 ± 0.11	0.20 ± 0.14	0.81 ± 0.32	0.83 ± 0.10	0.6	0.2
Sr	7.00 ± 7.49	2.83 ± 1.17	1	6.67 ± 7.81	2.63 ± 0.74	4.95 ± 4.54	3.80 ± 1.64	1.36 ± 0.97	4.11 ± 3.33	33.86 ± 55.33	6	3.33 ± 0.58
Y	1.19 ± 0.84	3.95 ± 3.35	1.9	1.00 ± 0.57	1.43 ± 0.61	0.25 ± 0.08	6.44 ± 9.86	6.08 ± 6.07	0.69 ± 0.45	19.51 ± 15.97	5.6	0.67 ± 0.29
Zr	17.31 ± 16.02	3.83 ± 6.01	16	5.17 ± 2.48	22.75 ± 49.41	1.90 ± 1.49	24.20 ± 24.94	0.94 ± 1.32	3.96 ± 3.01	2.14 ± 0.38	12	2.33 ± 0.58
Nb	0.35 ± 0.28	0.01	0.3	0.11 ± 0.12	0.15 ± 0.05	0.13 ± 0.07	1.02 ± 1.78	0.03 ± 0.04	0.18 ± 0.12	0.24 ± 0.08	2.1	0.01
Mo	0.12 ± 0.11	7.23 ± 8.44	0.16	0.53 ± 0.98	0.09 ± 0.06	0.10 ± 0.11	0.12 ± 0.03	0.12 ± 0.10	0.15 ± 0.24	0.14 ± 0.04	0.09	0.06 ± 0.04
Ag	0.05 ± 0.02	0.19 ± 0.07	0.03	0.02 ± 0.04	0.10 ± 0.04	0.08 ± 0.10	0.07 ± 0.03	0.02 ± 0.02	0.09 ± 0.08	0.04 ± 0.09	0.05	0.03 ± 0.01
Sn	0.06 ± 0.08	0.01 ± 0.01	0.04	0.02 ± 0.02	0.14 ± 0.22	0.07 ± 0.06	0.06 ± 0.03	0.02 ± 0.03	0.04 ± 0.05	0.07 ± 0.06	0.04	0.04 ± 0.03
Ba	149.23 ± 166.14	53.00 ± 29.76	43	226.50 ± 320.88	15.63 ± 4.66	52.00 ± 55.33	51.40 ± 18.16	9.56 ± 4.42	6.42 ± 8.46	344.86 ± 631.45	40	12.67 ± 5.03
Pb204	0.01 ± 0.003	0.09 ± 0.16	0.01	0.02 ± 0.02	0.01 ± 0.01	0.01 ± 0.01	0.01 ± 0.004	0.01 ± 0.01	0.03 ± 0.01	0.03 ± 0.02	0.01	0.01 ± 0.002
Pb206	0.15 ± 0.06	1.51 ± 2.31	0.11	0.32 ± 0.31	0.24 ± 0.16	0.15 ± 0.16	0.19 ± 0.07	0.15 ± 0.11	0.42 ± 0.29	0.58 ± 0.25	0.29	0.14 ± 0.02

Table 8.1: Mean Elemental Concentrations and their Standard Deviations for Each Source Area Continued

Elements & Oxides	Saskatchewan				Alberta	Manitoba	North Dakota		South Dakota			Montana
	South Sask River	**Wood Mountain**	**Souris River**	**Petrified Wood**	**Hand Hills**	**Souris River**	**Primary Source Area**	**Metcalf Archaeology Samples**	**West Horse Chert**	**Scenic Chalcedony**	**Nelson Butte**	**Agate**
	n=13	*n=6*	*n=1*	*n=6*	*n=8*	*n=20*	*n=5*	*n=9*	*n=19*	*n=7*	*n=1*	*n=3*
Pb207	0.11 ± 0.05	1.31 ± 2.20	0.07	0.26 ± 0.27	0.17 ± 0.10	0.11 ± 0.12	0.13 ± 0.06	0.12 ± 0.09	0.32 ± 0.25	0.48 ± 0.21	0.15	0.11 ± 0.02
Pb208	0.29 ± 0.12	3.11 ± 5.20	0.18	0.66 ± 0.68	0.42 ± 0.24	0.270 ± 0.28	0.35 ± 0.15	0.29 ± 0.23	0.78 ± 0.61	1.19 ± 0.52	0.38	0.26 ± 0.05
PbSUM	0.56 ± 0.22	6.02 ± 9.87	0.37	1.26 ± 1.27	0.84 ± 0.50	0.54 ± 0.56	0.69 ± 0.29	0.57 ± 0.43	1.55 ± 1.17	2.28 ± 0.99	0.83	0.51 ± 0.10
Bi	0.1	0.17 ± 0.08	0.1	0.13 ± 0.08	0.3 ± 0.14	0.16 ± 0.14	0.12 ± 0.04	0.1	0.22 ± 0.14	0.24 ± 0.11	0.1	0.13 ± 0.06
La	1.55 ± 1.31	0.87 ± 0.71	2	1.38 ± 2.30	1.86 ± 1.07	*b.d.l*	4.02 ± 7.27	1.80 ± 2.15	0.38 ± 0.43	8.71 ± 7.20	3	0.40 ± 0.52
Ce	2.62 ± 2.09	2.18 ± 1.92	4	2.37 ± 3.36	3.75 ± 2.44	*b.d.l*	9.60 ± 15.32	12.67 ± 17.77	0.84 ± 0.81	16.00 ± 11.94	7	1.33 ± 0.58
Pr	0.32 ± 0.22	0.38 ± 0.25	0.4	0.33 ± 0.30	0.53 ± 0.23	0.1	1.10 ± 1.68	1.82 ± 2.19	0.10 ± 0.09	1.74 ± 1.24	0.9	0.20 ± 0.10
Nd	1.18 ± 0.79	1.67 ± 1.10	1.3	1.12 ± 0.78	2.28 ± 1.08	0.36 ± 0.14	4.00 ± 5.93	8.12 ± 9.70	0.41 ± 0.29	6.91 ± 5.06	3.4	1.00 ± 0.53
Sm	0.19 ± 0.17	0.38 ± 0.29	0.2	0.22 ± 0.08	0.53 ± 0.29	0.11 ± 0.03	0.84 ± 1.15	1.87 ± 2.17	0.06 ± 0.07	1.37 ± 0.99	0.8	0.23 ± 0.15
Eu	0.07 ± 0.05	0.13 ± 0.10	0.03	0.09 ± 0.08	0.13 ± 0.07	0.04 ± 0.02	0.15 ± 0.17	0.38 ± 0.43	0.01 ± 0.01	0.39 ± 0.36	0.13	0.06 ± 0.03
Gd	0.19 ± 01.5	0.50 ± 0.39	0.2	0.18 ± 0.08	0.58 ± 0.30	0.1	0.78 ± 1.13	1.64 ± 1.81	0.07 ± 0.08	1.89 ± 1.46	0.7	0.20 ± 0.10
Tb	0.03 ± 0.02	0.09 ± 0.07	0.03	0.03 ± 0.01	0.08 ± 0.04	0.02	0.14 ± 0.20	0.24 ± 0.24	0.01 ± 0.01	0.31 ± 0.24	0.17	0.03 ± 0.02
Dy	0.22 ± 0.14	0.63 ± 0.52	0.21	0.19 ± 0.07	0.48 ± 0.23	0.08 ± 0.02	0.98 ± 1.41	1.44 ± 1.40	0.11 ± 0.08	2.23 ± 1.74	1.25	0.23 ± 0.11
Ho	0.04 ± 0.03	0.14 ± 0.11	0.06	0.03 ± 0.02	0.09 ± 0.04	0.02	0.23 ± 0.33	0.27 ± 0.25	0.02 ± 0.02	0.47 ± 0.37	0.27	0.05 ± 0.02
Er	0.15 ± 0.10	0.42 ± 0.37	0.2	0.11 ± 0.06	0.23 ± 0.13	0.04 ± 0.01	0.76 ± 1.09	0.75 ± 0.68	0.08 ± 0.06	1.36 ± 1.06	0.91	0.15 ± 0.06

Table 8.1: Mean Elemental Concentrations and their Standard Deviations for Each Source Area Continued

Elements & Oxides	Saskatchewan				Alberta	Manitoba	North Dakota		South Dakota			Montana
	South Sask River	Wood Mountain	Souris River	Petrified Wood	Hand Hills	Souris River	Primary Source Area	Metcalf Archaeology Samples	West Horse Chert	Scenic Chalcedony	Nelson Butte	Agate
	n=13	*n=6*	*n=1*	*n=6*	*n=8*	*n=20*	*n=5*	*n=9*	*n=19*	*n=7*	*n=1*	*n=3*
Yb	0.12 ± 0.09	0.45 ± 0.37	0.27	0.12 ± 0.07	0.21 ± 0.12	0.03 ± 0.01	0.79 ± 1.03	0.70 ± 0.58	0.09 ± 0.07	1.16 ± 0.86	0.88	0.15 ± 0.07
Th	0.21 ± 0.17	0.05 ± 0.02	0.27	2.56 ± 2.63	4.02 ± 2.37	0.18 ± 0.07	1.05 ± 1.55	0.08 ± 0.03	0.12 ± 0.05	0.27 ± 0.07	0.75	0.16 ± 0.05
U	1.41 ± 0.49	21.50 ± 2.42	2.86	1.52 ± 1.35	4.18 ± 0.92	3.08 ± 0.70	3.09 ± 0.78	3.28 ± 1.01	14.75 ± 9.54	11.45 ± 1.97	23.4	2.44 ± 0.31

Oxides (wt %)   Rare Earth Elements

b.d.l = below detection limits

vanadium (V), and zinc (Zn) for Wood Mountain samples; barium (Ba), chromium (Cr), and zirconium (Zr) for the sample from the Souris River near Riceton; and barium (Ba), chromium (Cr), strontium (Sr), vanadium (V), and zirconium (Zr) for samples of petrified wood. In Alberta, elements that characterize the Hand Hills samples include barium (Ba), thorium (Th), zinc (Zn), and zirconium (Zr) while Manitoba Souris River samples contain high amounts of barium (Ba), chromium (Cr), and strontium (Sr). In North Dakota, the PSA is characterized by barium (Ba), cerium (Ce), chromium (Cr), neodymium (Nd), yttrium (Y), and zirconium (Zr) while the samples from Metcalf Archaeological Consultants, Inc in North Dakota contain high amounts of barium (Ba), cerium (Ce), neodymium (Nd), and yttrium (Y). From South Dakota, West Horse chert contains barium (Ba), chromium (Cr), lithium (Li), uranium (U), and vanadium (V); Scenic chalcedony contains barium (Ba), cerium (Ce), copper (Cu), lanthanum (La), lithium (Li), neodymium (Nd), strontium (Sr), uranium (U), and yttrium (Y); the Nelson Butte sample contains barium (Ba), cerium (Ce), chromium (Cr), strontium (Sr), uranium (U), vanadium (V), yttrium (Y), and zirconium (Zr). Finally, the samples of agate from Montana are characterized by barium (Ba), strontium (Sr), uranium (U), and zirconium (Zr). No one element distinguishes a specific source area from another. Rather, one must look at the relative abundances of key elements to determine where a sample fits geochemically within a source area (Table 8.2).

Figure 8.1 shows a discriminant analysis of the 12 source areas in which samples were collected, with 95% ellipses surrounding each grouping. Geochemically all the samples share similarities with one another, but there is enough distinction to separate out different source areas from one another especially near the graph centroid (Figure 8.2).

The White River Badlands samples (West Horse chert, Scenic chalcedony and Nelson Butte) are very distinct from the rest of the groupings while there is a clustering of the Petrified Wood, Wood Mountain, South Saskatchewan River, Manitoba Souris River, Hand Hills and North Dakota samples. This is not surprising considering the geological origin of brown chalcedony in these overlapping sources areas. If the chalcedonies found in the Wood Mountain area, South Saskatchewan River, Manitoba Souris River and even the Hand Hills and non-primary source area samples from North Dakota are the result of preglacial drainage of sediments from Montana during the Rocky Mountain uplift of the Tertiary Period than one would expect all these materials to be very closely related to one another.

Table 8.2: Abundances of Elements Shared Between Source Areas

**ppm* = parts per million

Elements (*ppm*)	**Saskatchewan**				**Alberta**	**Manitoba**	**North Dakota**		**South Dakota**			**Montana**
	South Sask River	**Wood Mountain**	**Souris River**	**Petrified Wood**	**Hand Hills**	**Souris River**	**Primary Source Area**	**Metcalf Archaeology Samples**	**West Horse Chert**	**Scenic Chalcedony**	**Nelson Butte**	**Agate**
Graph Labels	Sask River	Sask Wd Mtn	Sask Souris	Sask Pet Wd	HH	MB Souris	ND PSA	ND	SD WRB/WHC	SD WRB/Scenic	SD WRB/NB	MT Agate
Lithium (Li)	2.42	0.1	2	0.72	2.13	1.2	2.4	0.72	6.37	11.71	0.1	2.33
Vanadium (V)	0.73	16.28	0.7	5.15	0.69	1.27	1	0.99	12.73	1.19	20	0.57
Chromium (Cr)	2.7	5.67	25	9.83	2.9	4.85	30.2	2.22	6.53	2.86	24	1.33
Copper (Cu)	1.29	5.98	3.4	0.67	2.89	1.16	1.52	1.21	2.43	5.79	0.9	1.57
Strontium (Sr)	7	2.83	1	6.67	2.63	4.95	3.8	1.36	4.11	33.86	6	3.33
Yttrium (Y)	1.19	3.95	1.9	1	1.43	0.25	6.44	6.08	0.69	19.51	5.6	0.67
Zinc (Zn)	1.73	8.52	0.1	3.22	18.41	0.68	0.46	0.1	1.11	4.34	1	0.1
Zirconium (Zr)	17.31	3.83	16	5.17	22.75	1.81	24.2	0.94	3.96	2.14	12	2.33
Molybdenum (Mo)	0.12	7.23	0.16	0.53	0.09	0.1	0.12	0.12	0.15	0.14	0.09	0.06
Barium (Ba)	149.23	53	43	226.5	15.63	52	51.4	9.56	6.42	344.86	40	12.67
Lanthanum (La)	1.55	0.87	2	1.38	1.64	0.1	4.02	1.8	0.38	8.71	3	0.4
Cerium (Ce)	2.62	2.18	4	2.37	3.75	0.1	9.6	12.67	0.84	16	7	1.33
Neodymium (Nd)	1.18	1.67	1.3	1.12	2.28	0.36	4	8.12	0.41	6.91	3.4	1
Thorium (Th)	0.21	0.05	0.27	2.56	4.02	0.18	1.05	0.08	0.12	0.27	0.75	0.16
Uranium (U)	1.41	21.5	2.86	1.52	4.18	3.08	3.09	3.28	14.75	11.45	23.4	2.44

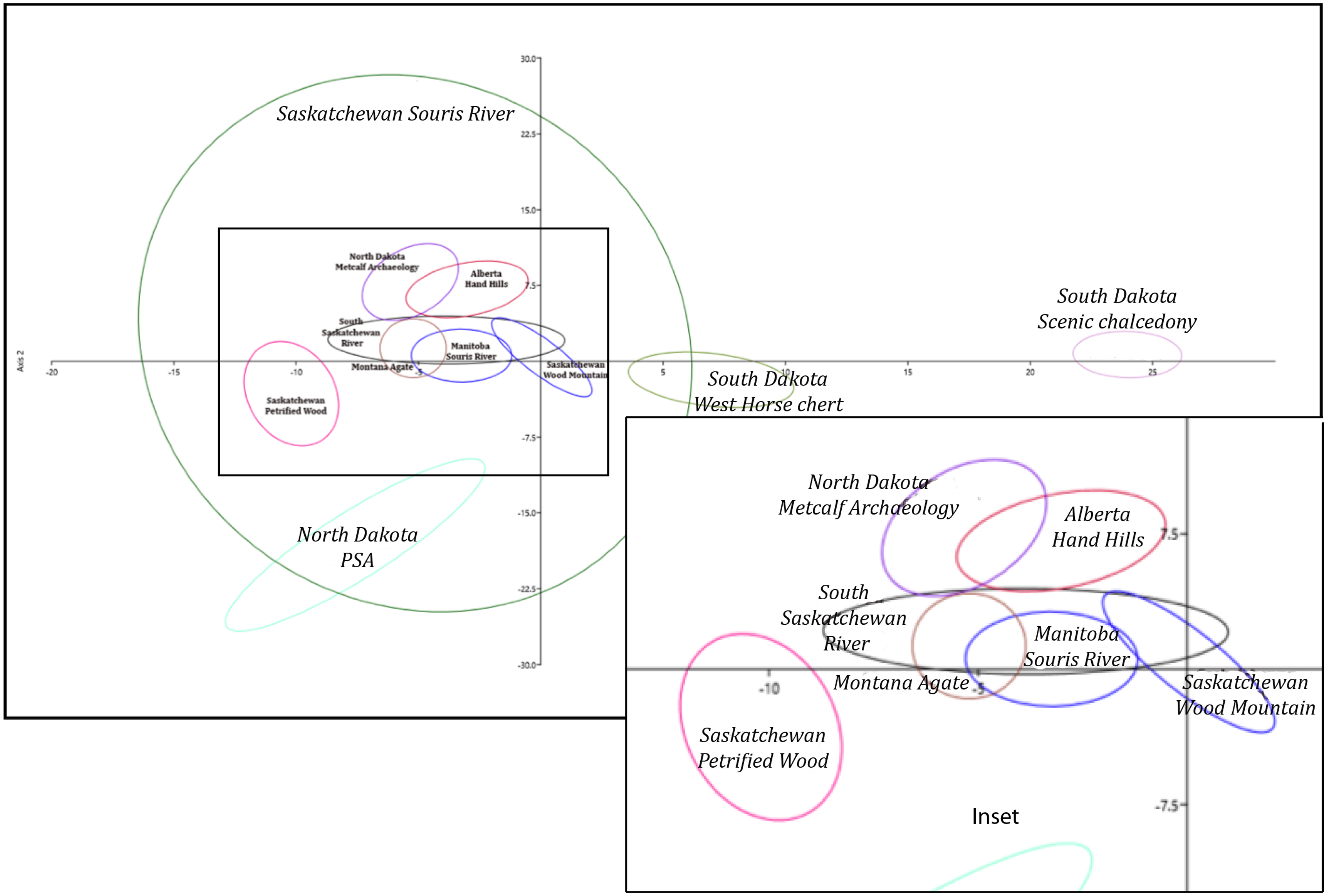

Figure 8.1: Discriminant Analysis of Source Samples (95% Confidence Intervals)

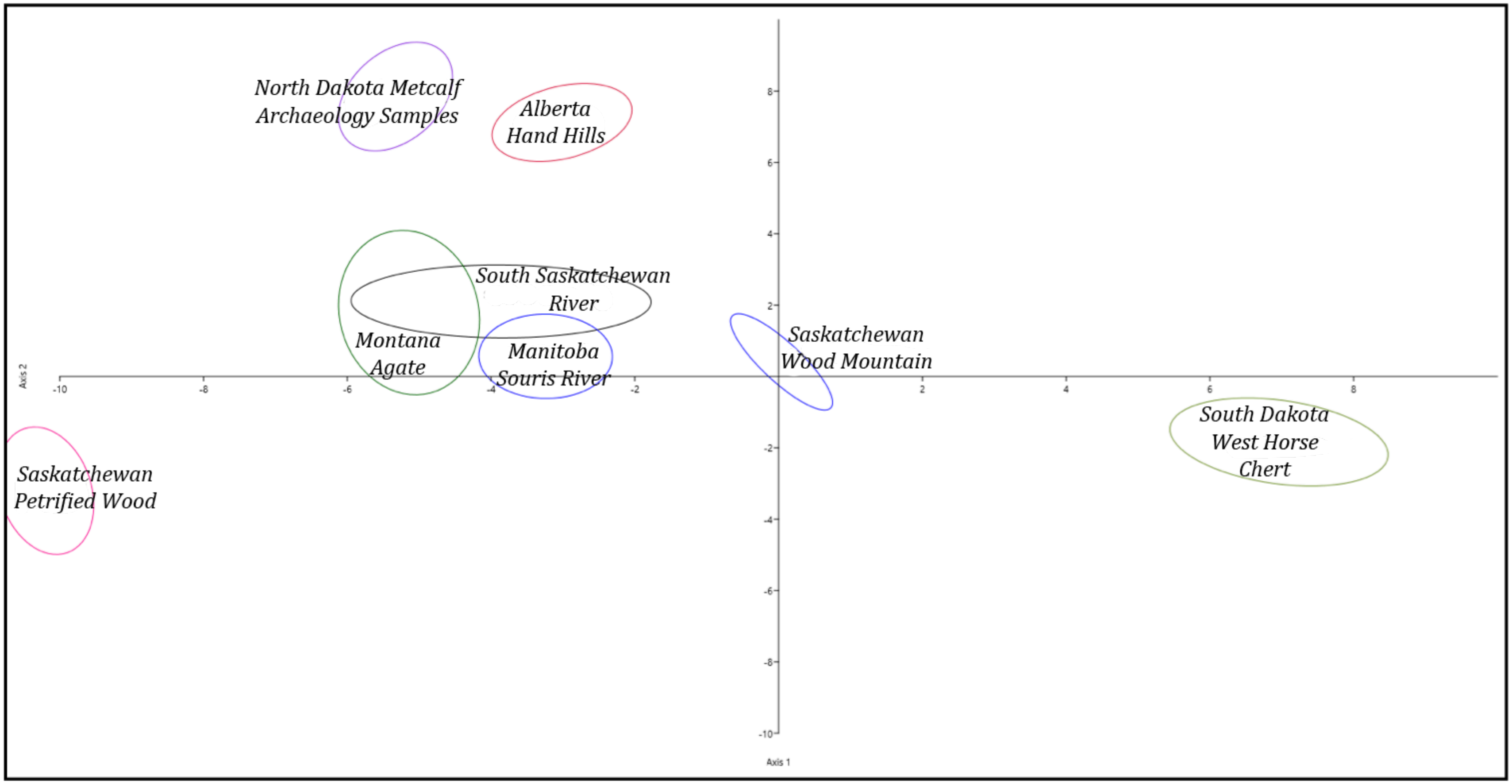

Figure 8.2: DA Centroid Source Areas at 50% Confidence Intervals for Ellipses

The PSA samples from North Dakota, while in a separate and distinct grouping, share affinities with the Souris River sample from Saskatchewan. It is of note that the other North Dakota samples are removed from the ones from the PSA, indicating that those lithic resources in the PSA are distinctive enough to separate out from visually similar brown chalcedonies. This may suggest that the material in the KRF Primary Source Area had a much different formation environment than other brown chalcedonies in the state that are related more to preglacial drainage from Montana. In fact, the brown chalcedonies found within the PSA may have been formed separately in situ in North Dakota as part of the Camel Butte Member or the "HS" Bed. When compared, the samples from the different quarry locations within the PSA are similar to one another in their elemental makeup (see Table 8.3). However, there are those elements, which appear to characterize particular source locations. Very low amounts of zirconium (9 ppm) are found within materials from the Lynch Quarries as compared to Crowley (68 ppm), Horse Nose Butte (18 ppm) and Medicine Butte (17 ppm). Additionally, the amount of barium is doubled in the Lynch Quarries and Horse Nose Butte samples over what is found in Medicine Butte and Crowley. The high amounts of rare earth elements (e.g., Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, and Yb) and thorium could be used to geochemically characterize the Crowley quarry from the other three used in this analysis. When a biplot (Figure 8.3) of the groupings is constructed, elements such as barium, cerium, chromium, strontium, thorium, uranium, vanadium, zinc, and zirconium are significant to help to separate out the distinct source area groupings. These elements are felt to be the ones that best represent distinct areas.

Principal component analysis (PCA) of the entirety of the source sample datasets results in 44 principal components although 97% of the variance can be found in the first PC and 99% of the variance in the first ten principal components (Tables 8.4 and 8.5). This high degree of variance in the first 10 principal components also indicates that the data is sound in that it does not contain much noise. If noise were present, many principal components would be needed to explain less than 50% of the data. Variance is important because it indicates how influential one variable is against another. The higher the variance, the more influential that variable is. In the above case since 97% of the variance can be found in the first principal component and the highest weighted elements are barium and strontium, this means that these two elements are highly correlated with one another and influence the other variables to a high degree thus helping to characterize source areas.

Table 8.3: Elemental Concentrations for Quarry Sample Locations Within the PSA

PSA Sources		Elements and Oxides													
		Li	Be	Na_2O	MgO	Al_2O_3	K_2O	CaO	Sc	V	Cr	Fe_2O_3	Co	Ni	Cu
Crowley	n=1	3	0.4	0.03	0.007	0.09	0.025	0.05	0.2	0.7	38	0.08	0.11	0.8	2.2
Horse Nose Butte	n=1	1	0.01	0.02	0.013	0.07	0.017	0.06	0.2	0.9	29	0.04	0.12	0.7	0.8
Lynch Quarries	n=2	2	0.15	0.02	0.0065	0.095	0.0285	0.1	0.105	1	25.5	0.055	0.1	0.75	1.65
Medicine Butte	n=1	4	0.3	0.02	0.004	0.1	0.026	0.02	0.8	1.4	33	0.05	0.09	0.7	1.3

PSA Sources		Elements and Oxides													
		Zn	Rb	Sr	Y	Zr	Nb	Mo	Ag	Sn	Ba	Pb204	Pb206	Pb207	Pb208
Crowley	n=1	1	0.5	3	24	68	4.2	0.13	0.11	0.1	28	0.004	0.2	0.075	0.319
Horse Nose Butte	n=1	0.1	0.2	6	1.8	18	0.3	0.12	0.04	0.05	69	0.006	0.127	0.094	0.228
Lynch Quarries	n=2	0.55	0.35	4	1.4	9	0.2	0.115	0.08	0.04	61	0.0095	0.181	0.127	0.316
Medicine Butte	n=1	0.1	0.3	2	3.6	17	0.2	0.12	0.04	0.05	38	0.014	0.28	0.228	0.593

Table 8.3: Elemental Concentrations for Quarry Sample Locations Within the PSA Continued

		Elements and Oxides														
PSA Sources		PbSUM	Bi	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Yb
Crowley	n=1	0.599	0.1	17	37	4.1	14.6	2.9	0.44	2.8	0.49	3.49	0.82	2.7	2.6
Horse Nose Butte	n=1	0.455	0.1	1	3	0.4	1.5	0.3	0.06	0.2	0.05	0.29	0.06	0.22	0.25
Lynch Quarries	n=2	0.634	0.15	0.55	2.5	0.3	1.2	0.3	0.065	0.25	0.04	0.26	0.055	0.185	0.22
Medicine Butte	n=1	1.12	0.1	1	3	0.4	1.5	0.4	0.1	0.4	0.08	0.62	0.15	0.5	0.68

		Elements and Oxides	
PSA Sources		Th	U
Crowley	n=1	3.82	3.12
Horse Nose Butte	n=1	0.36	2.78
Lynch Quarries	n=2	0.355	3.545
Medicine Butte	n=1	0.38	2.47

= Oxides (wt %)   = Rare Earth Elements

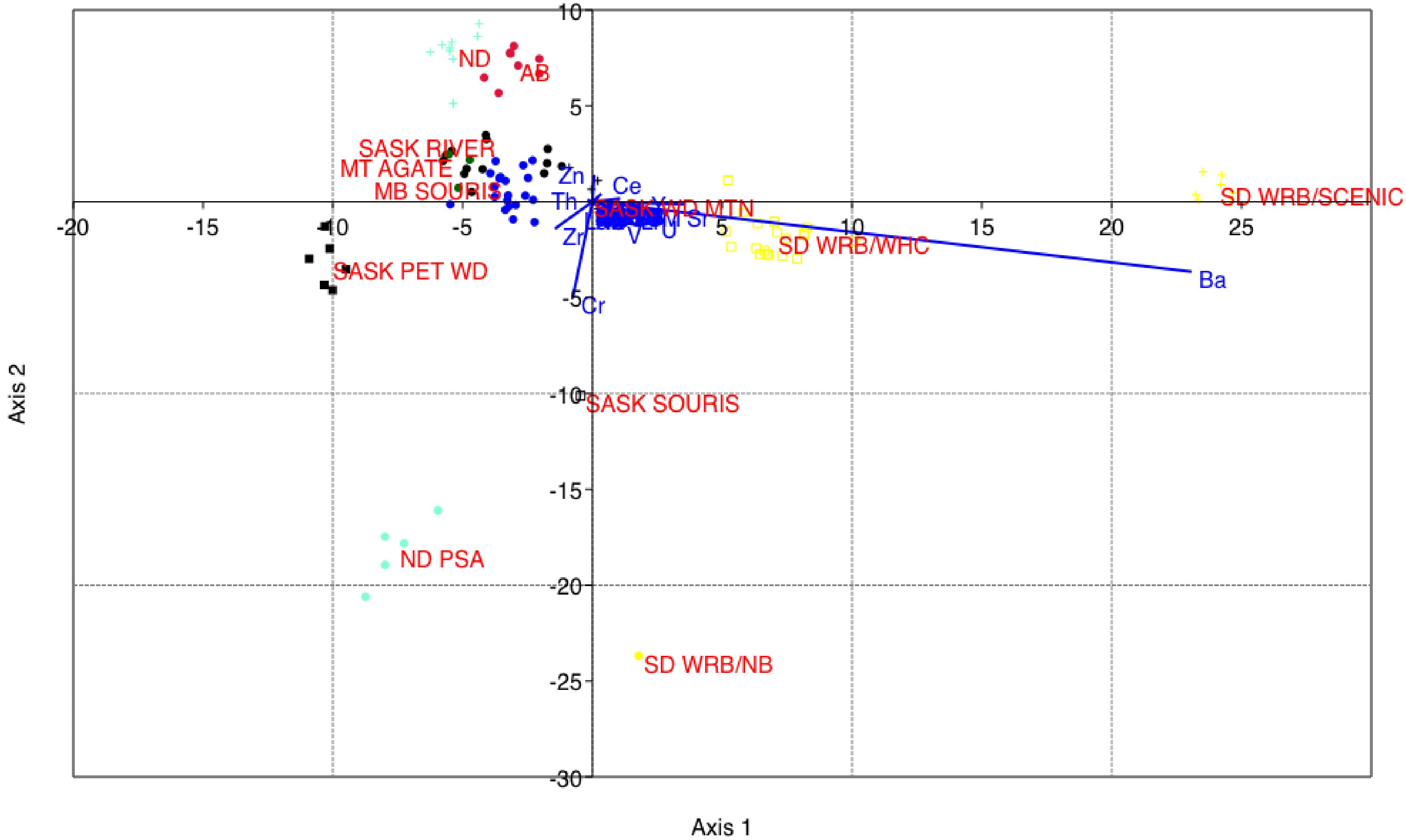

Figure 8.3: DA Biplot of Source Area Samples

Table 8.4: Principal Component Analysis of Source Area Samples

PC	1	2	3	4	5	6	7	8	9	10
Eigenvalue	106731	792.137	402.521	336.528	273.895	247.575	84.964	39.6737	28.6461	19.4884
% variance	97.913	0.72669	0.36926	0.30872	0.25127	0.22712	0.077944	0.036396	0.026279	0.017878

Elements & Oxides	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
Li	-42.69	0.081412	9.4234	4.6927	7.847	3.6326	14.69	7.6242	28.445	10.217
Be	-58.893	-8.6996	-8.1222	0.47946	-2.4611	-4.4113	0.51789	0.41685	-0.2226	1.3079
Na_2O	-60.61	-9.5435	-9.2668	0.66303	-3.2107	-5.9185	0.065242	0.0083791	-1.1345	1.3196
MgO	-60.72	-9.6135	-9.4051	0.65893	-3.3099	-6.0123	-0.056582	-0.040425	-1.2665	1.2655
Al_2O_3	-60.362	-9.3258	-8.9786	0.71017	-3.0692	-5.7877	0.19229	0.1282	-0.92874	1.3996
K2O	-60.663	-9.5368	-9.305	0.67348	-3.252	-5.9764	-0.0021055	0.0019109	-1.1967	1.2928
CaO	-60.224	-9.4968	-9.0165	0.80008	-2.891	-5.7505	0.3112	-0.074345	-1.033	1.3571
Sc	-59.468	-8.1758	-7.9143	0.54027	-2.3874	-6.3268	-0.50073	0.26349	-1.09	0.86075
V	-46.195	7.1126	44.323	-3.2317	48.062	-30.856	-23.525	-23.024	4.3059	3.0182
Cr	-43.598	54.273	73.004	60.616	-52.713	-0.52973	2.2011	-1.5442	-6.5722	7.1345
Fe_2O_3	-59.994	-9.1695	-8.0593	0.27281	-2.6167	-6.8133	-1.5811	-0.88328	-1.1079	0.46488
Co	-59.344	-8.7057	-7.004	0.65843	-3.0552	-7.0288	-2.066	-0.81728	-0.79878	-0.031787
Ni	-52.162	5.2716	22.437	18.486	-22.649	-13.013	-0.89535	0.97876	12.044	-22.167
Cu	-50.214	1.5102	8.6395	-1.345	3.4394	-3.7813	0.72002	2.2959	8.7606	-2.246
Zn	-47.387	2.4581	54.17	-101.17	-34.472	9.3912	4.1422	-0.58259	-1.1839	0.52151
Rb	-59.1	-8.1659	-6.8171	1.0926	-1.5102	-5.4701	0.89461	0.7505	0.45714	1.9315
Sr	100.18	-16.365	2.3506	8.2455	16.665	24.737	44.966	-19.014	-4.9617	-4.6093

Table 8.4: Principal Component Analysis of Source Area Samples Continued

Elements & Oxides	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
Y	-14.684	-0.28017	2.4807	6.8467	13.445	44.813	0.54274	-6.14	3.2369	-1.4696
Zr	-27.855	170.44	-43.294	-17.238	7.4959	-6.3682	4.0854	-1.9557	0.21112	-1.1934
Nb	-59.828	-7.0718	-8.3621	1.3935	-3.0698	-4.3904	-0.46413	-0.11213	-1.7	2.8073
Mo	-58.757	-7.0101	1.3044	-2.1077	2.9707	-9.6762	-8.1505	-9.7809	-0.86044	-7.1246
Ag	-60.596	-9.2573	-8.9544	0.65932	-3.1363	-6.0544	0.0033811	0.11177	-1.1082	1.1554
Sn	-60.554	-8.9282	-9.3996	0.53465	-3.3132	-5.9842	0.12797	0.031624	-1.0692	1.1748
Ba	2135.9	-2.0197	-1.3803	-0.60657	-2.1084	-3.9604	-2.9608	1.3433	0.1278	0.34894
Pb204	-60.634	-9.5756	-9.3027	0.6554	-3.2123	-6.0164	-0.028142	0.1471	-1.2921	1.1469
Pb206	-58.921	-8.3111	-7.1244	0.50067	-1.5235	-6.0546	0.314	2.9622	-1.6332	-0.57047
Pb207	-59.229	-8.7216	-7.5982	0.54218	-1.91	-6.0801	0.26654	2.6931	-1.6308	-0.44422
Pb208	-57.001	-7.3005	-4.9786	0.42063	0.045444	-6.0817	0.631	6.4633	-2.04	-2.775
PbSUM	-53.576	-4.9888	-0.68943	0.13501	3.3663	-6.2198	1.3271	12.393	-2.7934	-6.4344
Bi	-60.142	-8.7085	-8.481	0.55324	-2.9602	-5.9461	0.32168	0.38379	-0.73445	1.1261
La	-39.369	-0.80073	-3.3359	2.5756	0.71519	18.287	0.77927	-1.6789	-0.23985	4.4814
Ce	-22.013	11.563	5.182	5.9026	9.2937	69.102	-21.788	2.8865	-0.20107	-1.2441
Pr	-56.268	-6.9713	-7.6451	1.2046	-1.6639	2.7775	-3.2418	0.57076	-1.0944	0.72779
Nd	-42.826	0.14765	-1.9159	2.4027	4.0623	30.626	-13.984	2.7469	-0.34137	-2.646
Sm	-57.207	-7.6778	-7.7589	0.88416	-1.7878	1.926	-3.3168	0.58972	-1.1396	0.24325
Eu	-59.421	-9.3033	-9.048	0.6352	-2.95	-4.4208	-0.649	0.05051	-1.2158	0.94985
Gd	-56.067	-7.9762	-7.6667	0.838	-1.4099	1.9576	-2.252	0.15482	-0.93773	0.20798
Tb	-59.965	-9.3538	-9.1355	0.71028	-3.0189	-4.7965	-0.34016	-0.052103	-1.2175	1.1384

Table 8.4: Principal Component Analysis of Source Area Samples Continued

Elements & Oxides	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
Dy	-55.214	-7.6616	-7.3135	1.131	-1.1052	1.729	-1.4943	-0.3383	-0.9233	0.61881
Ho	-59.596	-9.2044	-9.0011	0.79976	-2.8696	-4.4328	-0.2978	-0.13631	-1.202	1.1814
Er	-57.413	-8.1814	-8.0694	1.1654	-1.9947	-1.5027	-0.80848	-0.43468	-1.1391	1.1421
Yb	-57.971	-8.1043	-8.0461	1.2046	-2.1018	-2.0851	-0.84664	-0.37369	-1.1877	1.3139
Th	-59.487	-4.4159	-5.714	-6.138	-5.5242	-2.6896	1.3129	0.64406	-1.283	2.2531
U	-39.877	15.763	54.789	1.5515	65.849	-8.543	10.838	20.342	-9.1076	-1.1521

= significant elements as determined by DA

= PCA significant elements

= Strong elemental loadings

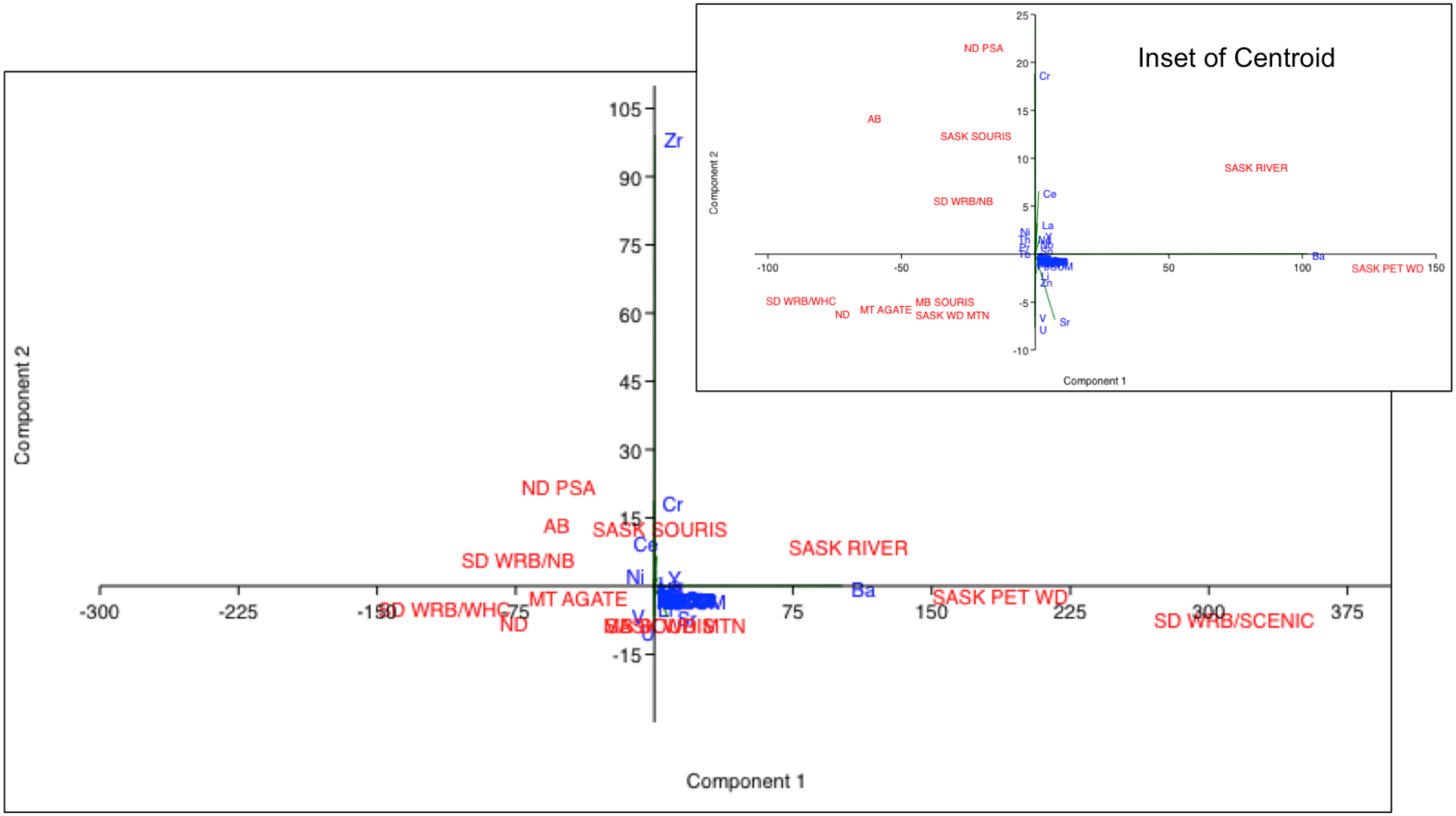

Figure 8.4: PCA Biplot of Source Area Samples

Table 8.5: Cumulated Variance of the First 10 Principal Components

PC	Eigenvalue	% Variance	% Cumulated Variance
1	12986.2	97.345	97.345
2	175.236	1.3136	98.6586
3	89.5741	0.67145	99.33005
4	47.3426	0.35488	99.68493
5	21.0242	0.1576	99.84253
6	10.3609	0.077665	99.920195
7	5.14973	0.038603	99.958798
8	3.15233	0.02363	99.982428
9	1.84677	0.013843	99.996271
10	0.433072	0.0032463	99.9995173

Eigenvalues are mathematically determined measures that indicate the amounts of variation in each principal component and are equivalent to loadings as discussed in factor analysis. The larger the eigenvalue, the more significant or important that principal component is. The closer to zero the eigenvalue is, the less effect that principal component has on the overall dataset. We can see by the PCA (Figure 8.4 and Table 8.4) that the elements as selected by the discriminant analysis are present as are some additional ones in the lower principal components including lanthanum, lithium, copper, neodymium, nickel, and yttrium. This is consistent with the mean elemental concentrations determined in Table 8.2, which presents the relative abundances of elements as compared to source areas. All together this indicates that those 15 elements (Ba, Ce, Cr, Cu, La, Li, Nd, Ni, Sr, Th, U, V, Y, Zn and Zr) are the ones that are most likely to characterize distinct source areas of brown chalcedony.

8.3 Comparative Analysis of Source Sample Data with Hoard et al. (1993) and Christensen (1991a and 1991b) Elemental Datasets

The elemental dataset from the West Horse chert samples that was gathered and originally analysed by Hoard et al. (1993) underwent PCA to see if similar elements characterize the 1993 samples as compared to the dataset used in this dissertation. The West Horse chert source areas separate into nine principal components that account for 84.186% of the overall variance in the dataset. Distinctive elements include aluminum (Al), arsenic (As), barium (Ba), calcium (Ca), iron (Fe), potassium (K), lanthanum (La), manganese (Mn), sodium (Na), strontium (Sr), uranium (U), and vanadium (V) (see Figure C.1 and Table C.2 in Appendix C). Not all the same elements were included as were analysed in this study's source sample dataset. However, certain elements such as barium, lanthanum, strontium, uranium and vanadium feature as characterizing elements in both analyses and datasets.

When comparing the two datasets (i.e., 1993 and 2018) the values of the selected elements should be similar. For the Hoard et al. (1993) dataset, the published table of elemental values only lists 22 samples as opposed to the available Excel file which lists 25. For the purposes of this analysis, the published table of elemental values was used. A PCA biplot of the datasets show that the selected elements are comparable with a few exceptions (Figure 8.5). Elements such as chromium (Cr) and nickel (Ni) become outliers that appear to show the differences in the two datasets. Other elements that show divergence from the main cluster near the centroid include barium (Ba), vanadium (V), and uranium (U). This is likely because Hoard et al. (1993) did not separate out the West Horse chert from the Scenic chalcedony as this study has done.

Of interest to note are the concentration values of elements from the Hoard et al. (1993) data. Both dataset's element values are in parts per million (ppm) except where noted in Appendix C, Table C.3. The analysis from 1993 shows very low elemental values for each element with some not even registering a value, indicating they are below detection limits (e.g., nickel (Ni) and thallium (Tl)) (Appendix C, Table C.3). In the case of nickel (Ni), the value in this study was in the range of 3.04 ppm for the West Horse chert samples, an increase of three-times over the 1993 study. The lack of values for nickel in the Hoard et al. (1993) data explains why the statistical analysis separated it as an outlier. The majority of the other elements (e.g., aluminum (Al), calcium (Ca), cobalt (Co), cerium (Ce), dysprosium (Dy), europium (Eu), iron (Fe), hafnium (Hf), lanthanum (La), neodymium (Nd), rubidium (Rb), samarium (Sm), strontium (Sr), thorium (Th), titanium (Ti), ytterbium (Yb), and zinc (Zn)) are relatively similar overall between both datasets.

Similar observations can be made in regard to the elemental data from the KRF Primary Source Area as analysed by Christensen (1991a). Elements such as aluminum (Al), barium (Ba), cerium (Ce), iron (Fe), potassium (K), and lanthanum (La), manganese (Mn), neodymium (Nd),

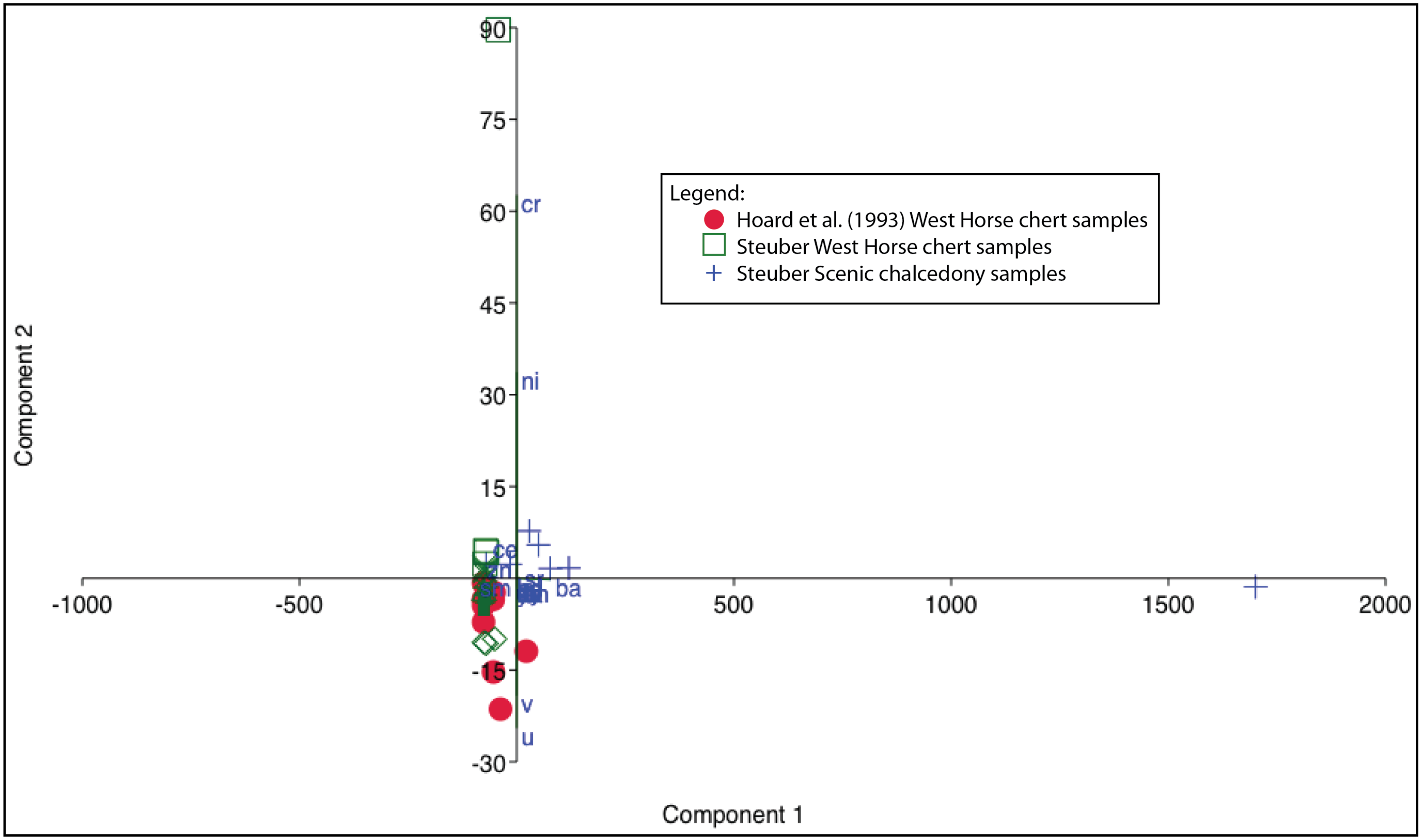

Figure 8.5: PCA Biplot of Hoard et al. (1993) and 2017 West Horse Chert Samples Selected Elements

sodium (Na), strontium (Sr), and uranium (U) characterize the various quarry sources located within the PSA (see Appendix D, Figure D.1 and Table D.2). The source areas can be characterized through nine principal components that account for 99.999% of the overall variance in the dataset. When compared to this study's source area elemental dataset, again elements such as barium (Ba), cerium (Ce), lanthanum (La), neodymium (Nd), strontium (Sr), and uranium (U) figure prominently as those that characterize the KRF source areas. When comparing relative elemental amounts of similarly analysed elements the majority of the elements show similar values between the 1991 and this study's datasets (see Appendix D, Table D.3). Major outliers include aluminum (Al), chromium (Cr), iron (Fe), nickel (Ni), potassium (K), sodium (Na), and vanadium (V). A possible explanation for some of these outliers is the presence of oxides (measured in % weight) versus elemental concentrations (measured in ppm) in the two different datasets. This study's dataset did not measure individual concentrations for elements such as aluminum, iron, potassium, and sodium and instead recorded these elements as oxides (e.g., Al_2O_3, Fe_2O_3, K_2O, and Na_2O). Thus, it is difficult to compare the concentrations as they are not exactly the same and are represented in different units. The same is true for those elements found in the Hoard et al. (1993) dataset (see Appendix D, Table D.4). However, both nickel (Ni) and vanadium (V) registered as below detection limits in Christensen's (1991b) dataset. When a PCA biplot of the datasets was constructed, all three (i.e., Hoard et al. 2013, Christensen 1991b, this study) show comparable results (Figure 8.6). The majority of the selected elements (i.e., 19) can be found together near the centroid for all three datasets with elements such as iron (Fe), sodium (Na), potassium (K), aluminum (Al), and ytterbium (Yb) showing the variability between the datasets and indicating that these elements are too highly variable to be used as distinguishing elements when it comes to differentiating source areas.

8.4 Discussion

Visually distinguishing between samples of brown chalcedony from different source locations indicate that there is too much similarity between samples to confidently make a correct source determination. In order to properly label a sample of brown chalcedony as being from a specific area such as the PSA within North Dakota or elsewhere, geochemical analyses are mandatory. The availability of geochemical techniques is more widely accessible than it has been in the past and elemental detection limits have increased in sensitivity since these techniques were first

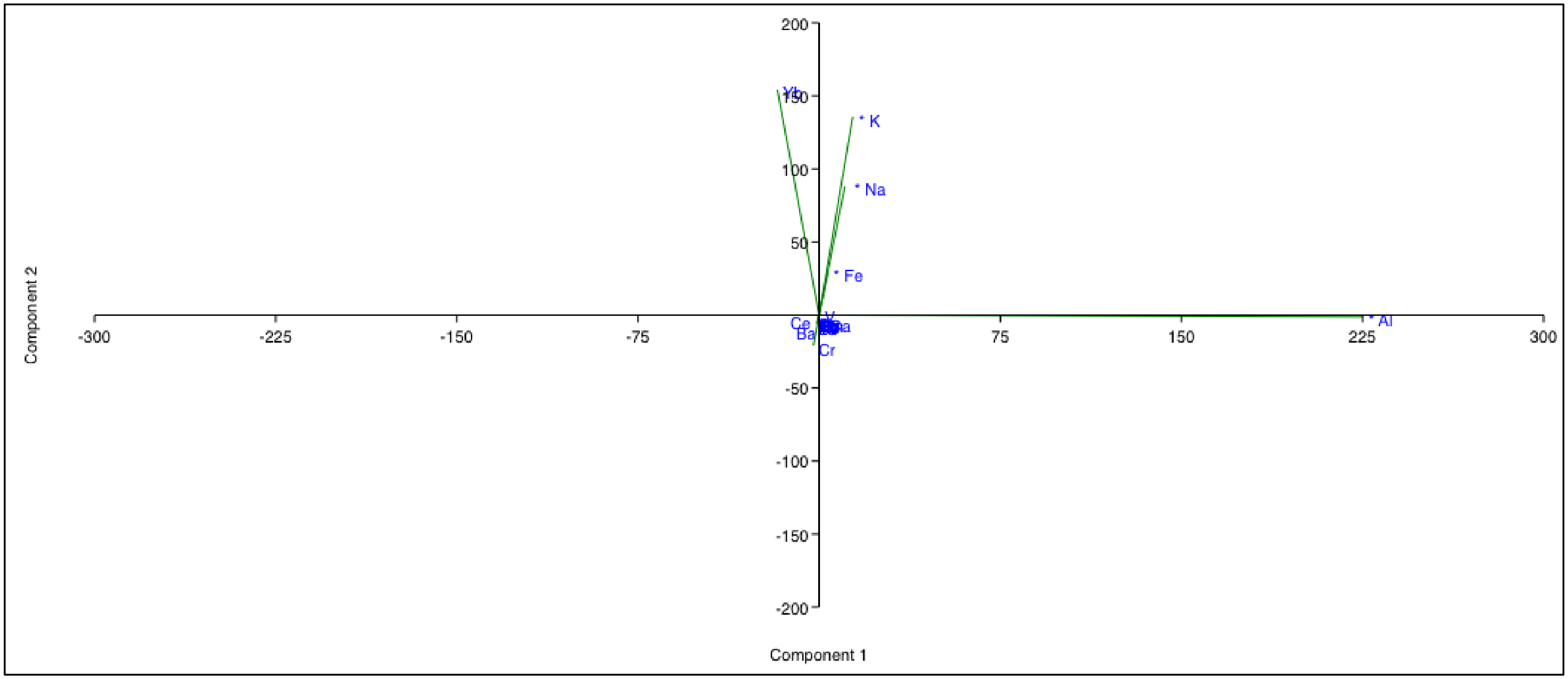

Figure 8.6: PCA Biplot of Knife River Flint Samples from Hoard et al. (1993), Christensen (1991b) and This Study

introduced. Total destruction of source samples is warranted and applicable as they are unmodified and of no archaeological significance. By allowing for the total destruction of source samples as a starting point, a full understanding of the elemental makeup of these toolstone sources can be discovered. From this analysis using various multivariate statistical techniques, especially discriminant analysis and principal component analysis, elemental characterization can illuminate specific source areas and allow for additional research into sourcing artifacts found in archaeological sites that are not geographically nearby quarry locations. Total acid digestion inductively-coupled plasma mass spectrometry on this study's source samples resulted in a dataset that produced a number of defining elements that characterized the distinct source sample locations. Fifteen elements (including Ba, Ce, Cr, Cu, La, Li, Nd, Ni, Sr, Th, U, V, Y, Zn and Zr) were found to be the ones that are most likely to characterize distinct source areas of brown chalcedony across the Northern Plains. According to Luedtke's (1992) study of brown chalcedony, she felt that barium and uranium were significant elements with high concentrations.

This analysis has shown that Luedtke's (1992) original analysis was correct along with an additional 13 elements to further aid in distinguishing between source locations. The geochemical analysis has conclusively separated out a number of source locations from one another as well as showing the similarities between 4 major source locations outside the PSA in North Dakota. Additionally, reanalysis of two geochemical studies on source areas relevant to this dissertation was undertaken. One significant issue that arose related to the differences in elements that were reported between studies that were approximately 25 years apart and the detection limits of certain elemental concentrations between the 1991, 1993 and this study's datasets. While detection limits may have some bearing on how well different source areas can be characterized, another issue is the types of elements that were studied between the three studies into KRF, Scenic chalcedony and West Horse chert.

In the Hoard et al. (1993) dataset, Scenic chalcedony and West Horse chert were analysed together rather than being separated out as they were in this study. By separating the two source areas from one another, this study has been able to discern a more accurate geochemical signature for sources of White River Group silicates. This is shown in Table C.4 (Appendix C). When comparing the elements that both the 1993 and this study examined, certain elements show widely varying concentrations between the two source areas that the Hoard et al. (1993) dataset did not. Particularly in terms of elements such as barium (Ba) that are approximately 53×

more concentrated in Scenic chalcedony over West Horse chert samples. Similar variances exist between the source areas for other elements such as cerium (Ce), chromium (Cr), dysprosium (Dy), lanthanum (La), strontium (Sr), neodymium (Nd), samarium (Sm), ytterbium (Yb), and zinc (Zn). By separately characterizing Scenic chalcedony from West Horse chert, both source areas have a more accurate elemental makeup that will aid in tying toolstone to particular sources.

The types of elements included in the geochemical analyses also influenced the results of the comparative analysis between the Hoard et al. (1993) dataset with White River Group silicates but also the KRF dataset from Christensen (1991b). When comparing the Hoard et al. (1993) dataset with this study's analysed element list, they both share 26 individual elements or oxides. This study's dataset included an additional 23 elements and oxides that the Hoard et al. (1993) dataset did not include (Table C.5). Of these additional elements included in this study, 16 are major elements (i.e., those greater than 0.1% per sample) and three rare earth elements for West Horse chert, and three major along with one rare earth element for Scenic chalcedony (Table 8.6). The extra 23 elements analysed for in this study help to better geochemically characterize each source area. The same can be said for the comparison between this study's analysis of KRF and Christensen's (1991b) data. Twenty-four elements are shared between the three KRF datasets (i.e., Christensen 1991b, Hoard et al. 1993, and this study). The dataset analysis diverged with elements such as aluminum (Al), cerium (Ce), chromium (Cr), iron (Fe), sodium (Na), thorium (Th), and ytterbium (Yb) having varying concentrations between the three studies (Table D.4). Twenty-six additional elements were added to this study's analysis of KRF from the Primary Source Area including 12 major elements and four rare earth elements (Table 8.6). All three datasets, whether they analysed White River Group silicates, KRF, or both, included elements that represented major, minor, trace, and rare earth elements; however, the addition of additional elements in this study's geochemical analysis gves a more comprehensive and accurate depiction of each individual source area as can be seen in this study's dataset. The comparison of the three different datasets has shown that even without the extra elements analysed in this study and some divergence between different elemental concentrations, the Hoard et al. (1993) dataset, with regards to White River Group silicates, and the Christensen (1991b) dataset on KRF, are comparable to the results found in the analysis of the same lithic materials in this study. Additionally, the comparable findings for KRF between Christensen's

Table 8.6: Major and Rare Earth Elements Not Included in the Christensen (1991b) and Hoard et al. (1993) Analyses

Knife River flint	West Horse chert	Scenic chalcedony
Y	Li	Li
Pr	Zr	Cu
^{208}Pb	Ag	Y
Ni	Be	
Nb	Bi	
Hf	Cu	
Gd	Er	
Er	Ga	
Cu	Gd	
Zr	Mo	
Li	Nb	
V	Ni	
	Pb	
	V	
	W	
	Y	

[shaded cell] = Rare Earth Elements

(1991b) analysis of 40 samples from the PSA and the five samples analysed in this study from the PSA indicate that despite the smaller sample number used, the results found in this dissertation are accurate.

8.5 Results of the Archaeological Samples

All the archaeological samples were run against the same elemental dataset as the source samples to provide consistency in the analysis. Data was gathered in the form of elemental concentrations in each of the sample points on every artifact. The sample point data was averaged for each artifact for the multivariate statistical analyses in order to compare with the averaged numbers from the source samples analysis. The entire dataset, including averages for each element and oxide can be found in appendix H. Except for three artifacts (Crane #9211 [DiMv-93E], Snyder

II #M491 [DgMg-15A], and Snyder II #1412 [DgMg-15B]) which were removed from the analysis due to likely errors (see below), the remainder of the archaeological sample produced elemental data for all 5 sample points. The first discriminant analysis on artifacts from all three provinces showed a large clustering of many of the artifacts towards the centroid with three outliers: Crane #9211 [DiMv-93E], Snyder II #M491 [DgMg-15A], and Snyder II #1412 [DgMg-15B] (Figure 8.7). There are two possible reasons for these extreme outliers. The first focuses on an error in the elemental analysis.

Two of the artifacts analysed from the Crane site moved during the vacuum process in the sample chamber and had to be reanalyzed in a separate sample run. One of these was #9211, which is a small base from a Bratton projectile point (Figure 8.8).
This artifact was prone to movement in the sample holder despite being remounted. The elemental data retrieved from it, including data on 1 out of 5 sample points and an extremely low Be content (-0.0005 ppm) and an extremely high Fe content (~50,000 ppm) on one sample point, suggests that it moved again during the second analysis. For these reasons, it was prudent to disregard the data gathered from this particular sample.

With the second outlier, Snyder II #M491, data was again only received from 1 out of 5 sample points suggesting that the artifact also moved during the vacuum process. The artifact, #M491, is a projectile point that has been classified as Besant and is missing a portion of the tip (see Appendix F, Figure F.1). The elemental values for this sample are not considerably different from the remainder of the dataset; however, since only one ablation point was sampled the data received from that one point should be treated with caution. The second possible explanation for this is that some samples are truly outliers from the majority of the archaeological dataset indicating that the material they are made of is from a yet unknown source area that is quite different at an elemental level from those analysed in the course of this research.

Unlike the previous outliers, the sample Snyder II #M1412 [DgMg-15B] remained stationary during the analysis. The Snyder II #M1412 sample has higher than average concentrations of Cr, Rb V, and Zr than the rest of the dataset which appears to have been enough elemental change to cause it to be an outlier from the rest of the archaeological samples. Whether or not this material type is geochemically different from anything else is difficult to answer at this point. This sample shares similarities with one of the first outliers, Snyder II

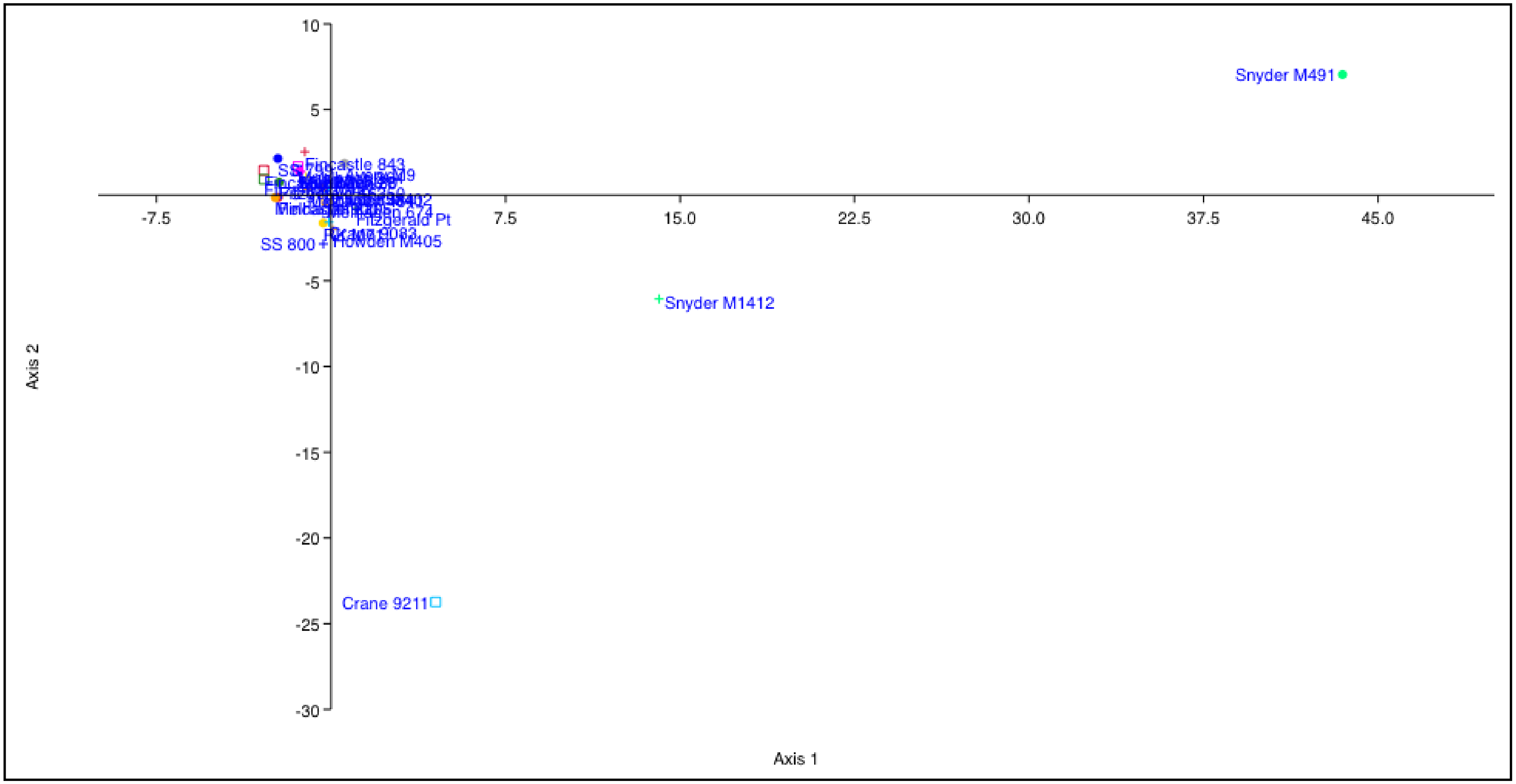

Figure 8.7: First DA of All Archaeological Sample

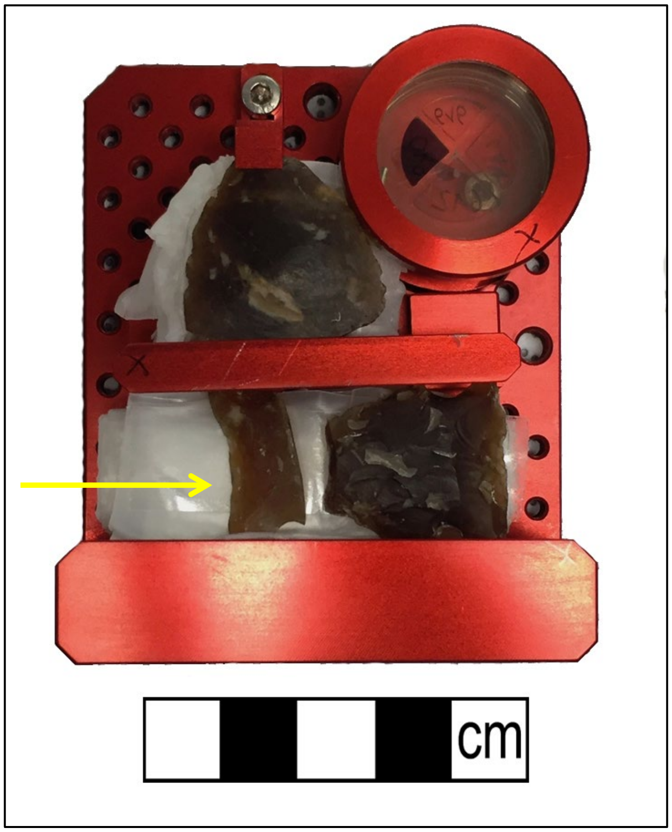

Figure 8.8: Crane Site Samples showing small Bratton Projectile Point Base

#M491, in terms of its elemental makeup. It also did not receive as many ablation points as the majority of the samples with only two out of five producing chemical data. Due to a lack of ablation points in both Snyder II samples, it is not surprising that they are registering as outliers because the elemental data needed to properly and correctly classify them is currently incomplete. For this reason, it is best to discard them from the comparative analysis between archaeological sites and source areas.

A second discriminant analysis without both Snyder II samples and Crane #9211 removed resulted in a better look at the remaining dataset (Figure 8.9). The archaeological samples still cluster around the X-axis and the centroid of the graph, but with the three outliers removed, a better visual understanding of how the artifacts are related to one another becomes apparent. The clustering indicates that all the archaeological samples are to some degree geochemically related to one another in that they share elemental affinities with each other although some differences exist. As would be expected, artifacts from the same archaeological site tend to cluster close to one another. This indicates that closely related source areas were

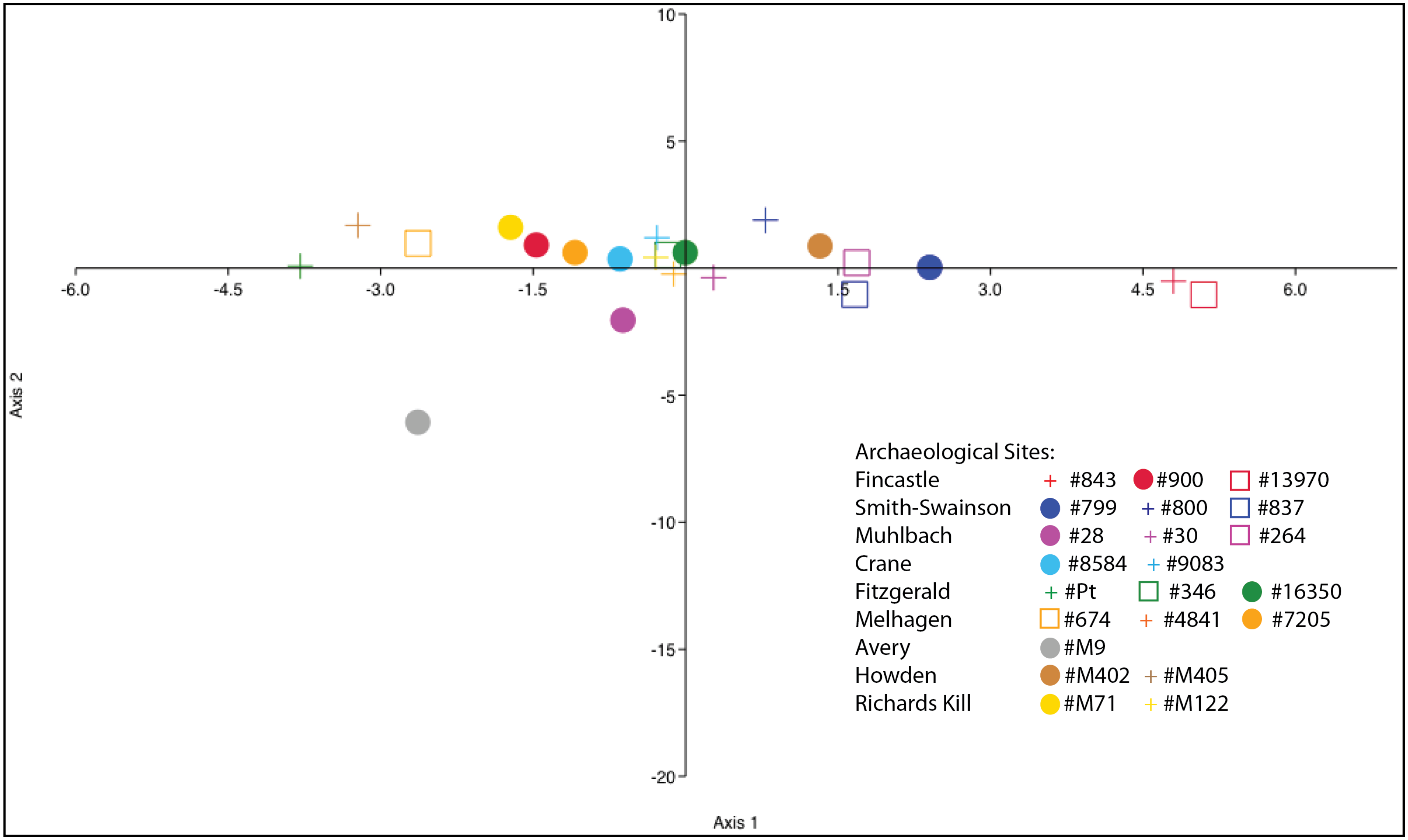

Figure 8.9: Second DA of Archaeological Samples

being utilized by Besant/Sonota groups to obtain lithic raw material. A divergence from this trend is the Fincastle site in that two of its projectile points (#843 and #13970) are on the opposite end of the X-axis from the other one (#900), which is clustered with the rest of the archaeological samples. When looking at the elemental data for these 3 projectile points, #900 has lower levels of Ce, Cr, Ni, U, V, and Zr than the other two artifacts. In fact, #13970 is unique in its very high concentrations of Cr and Y as well as rare earth elements: Ce, Dy, Er, Gd, La, Nd, and Yb.

The Avery #M9 projectile point sample is also unique and separate from the rest of the artifacts along the Y-axis. Avery #M9 has a higher Ag, Be, Ce, Cr, Dy, Er, Gd, La, Nd, Pr, Sm, V, Y, and Yb content than the rest of the samples although it shares higher content values in a number of elements and rare earth elements (e.g., Ce, Cr, Dy, Er, Gd, La, Nd, Pr, Sm, Yb, and Y) with Fincastle #13970. The unique elemental concentrations of the three samples: Avery #M9, Fincastle #843 and Fincastle #13970, suggest that the lithic material from which the three artifacts are formed is geochemically different from the rest of the archaeological dataset. While visually similar to everything else and having been classified as KRF in the past, it is readily apparent that these three lithic materials are quite different from everything else in the dataset.

The next most dissimilar artifacts from the rest of the archaeological dataset are Howden #M405 and the Fitzgerald projectile point (ElNp-8B). The remaining artifacts from the Fitzgerald and Howden sites fit well within the main cluster near the centroid of the graph. The only element that shifts Howden #M405 to the left of the centroid are two isotopes: ^{206}Pb and ^{207}Pb, which are slightly higher than average in this sample. For the Fitzgerald projectile point (ElNp-8B), a slightly higher concentration of V and a higher than average amount of Ba is present. Other than these minor differences and the three artifacts from the Fincastle and Avery sites, the majority of the archaeological samples are very similar to one another geochemically.

8.6 Analysis of Source Locations versus Archaeological Sites

The archaeological samples were plotted against the source samples through discriminant analysis (Figure 8.10). The source areas of brown chalcedony are represented by the coloured 95% ellipses and labeled as to their origin in Figure 8.1. The archaeological sites, minus the three outliers that were removed from analysis (Crane #9211 and Snyder II #M491 and #M1412), are coded based on colour as well, and include symbols to distinguish between the different artifacts from each site.

Many of the artifacts are found around the centroid of the graph indicating that there is a fair degree of similarity between most of the brown chalcedony artifacts analysed during this research. This likely helps to account for the visual similarity of brown chalcedony artifacts. None of the artifacts analysed in this study show strong geochemical affinities with the Nelson Butte, Scenic chalcedony, North Dakota Metcalf Samples or Hand Hills source areas. For this reason, the more extreme located sources areas, Nelson Butte and Scenic chalcedony were removed from Figure 8.10. The Saskatchewan Souris River source area ellipse is so large that it encompasses all the centroid source area ellipses and so was left off the graph as well. This large ellipse for the Saskatchewan Souris River sample indicates that it shows close elemental affinities with many of the source areas likely as the result of the same formation processes. The artifacts found within source area ellipses show the strongest geochemical affinities to these source areas, but also share similarities with other areas. This is especially evident near the centroid of the graph where four source area ellipses intersect: Montana agate, South Saskatchewan River, Manitoba Souris River, and Saskatchewan Wood Mountain (see Figure 8.1). The intersection of these four source areas strongly suggests similar formation processes at some point in the past. Most of the artifacts are clustering within these four ellipses and suggest strong geochemical affinities to these areas and to each other (Table 8.7). With the exclusion of the Montana agate source area, most source areas are located closer to the individual archaeological sites than the Knife River flint Primary Source Area would be.

8.6.1 Crane (DiMv-93)

The two artifacts analysed from the Crane site both show affinities with source areas located in the Montana agate source area and the Manitoba Souris source area. Again, this is expected considering the probable geological origins of brown chalcedonies in these areas are out of the Rocky Mountains of Montana during the Tertiary period. If more information about the Saskatchewan Souris River area were known, it is believed that artifacts from the Crane site would be very closely related to this area as well, considering the Crane site is located in the Souris River valley near Estevan, Saskatchewan.

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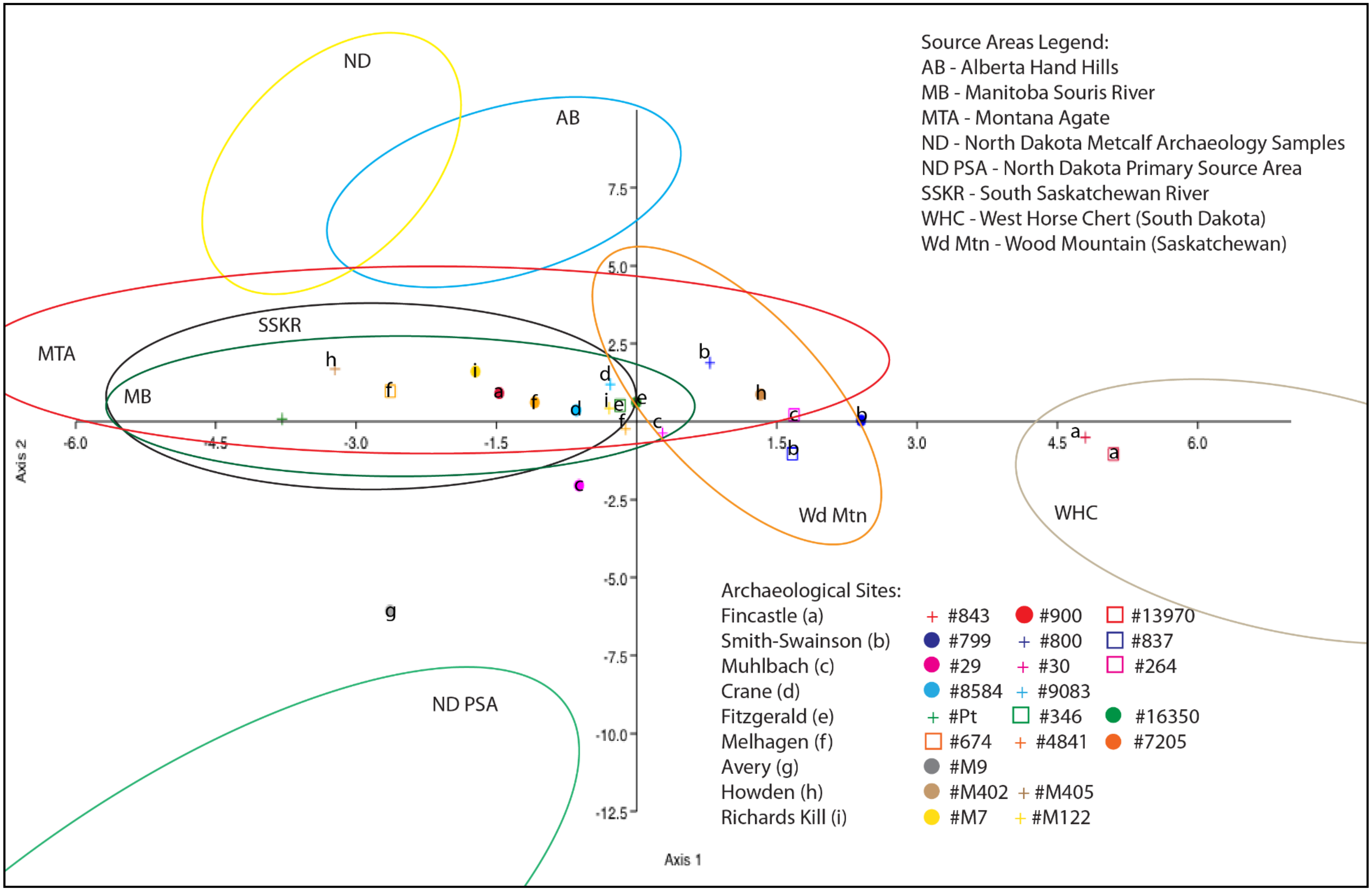

Figure 8.10: Archaeological Samples versus Brown Chalcedony Source Areas

Table 8.7: Major Source Areas and Related Artifacts

Site/Borden	Artifact #	Montana Agate	Manitoba Souris River	South Saskatchewan River	Saskatchewan Wood Mountain
Crane (DiMv-93)	8584	■	■	■	
	9083	■	■	■	
Fincastle (DlOx-5)	900	■	■	■	
Fitzgerald (ElNp-8)	346	■	■	■	
	16350	■	■	■	■
	Pt	■	■	■	
Howden (EbLi-1)	M402	■			■
	M405	■	■		
Melhagen (EgNn-1)	674	■	■	■	
	4841	■	■	■	
	7205	■	■	■	
Richards Kill (DhLw-2)	M71	■	■	■	
	M122	■	■	■	
Smith-Swainson (FeOw-1,2,3)	800	■			■
	837				■

8.6.2 Fincastle (DlOx-5)

The Fincastle artifacts are a bit more ambiguous than the other artifacts in this study. Only one artifact (#900) shared affinities with the other artifacts while the other two Besant projectile points (#843 and #13970) are far removed from the centroid clustering. There definitely appears to be distinct geochemical differences within the Fincastle site artifacts. This may reflect different material being used for different functions. Both of the Besant projectile points (#843 and #13970) show greater affinity with materials found in the West Horse chert source area. This does not necessarily indicate that they are of this type of material. Instead, it suggests that they are different enough from anything else that was analysed to push them away from the rest of the group and towards more geographically and geochemically distinct source areas. The remaining artifact (#900) is a broken secondary flake and falls within the centroid of the rest of the artifact clustering, indicating it is part of the more common geochemical signatures.

8.6.3 Fitzgerald (ElNp-8)

All the artifacts analysed from the Fitzgerald site fit within the overlapping source areas of Montana agate, South Saskatchewan River, Saskatchewan Wood Mountain, and Manitoba Souris River. This is unsurprising as the Fitzgerald site is closely located to the South Saskatchewan River valley and, as such, brown chalcedony procurement would be rather easy (see Figures 4.1 and 7.1). There appears to be no distinction between using different brown chalcedonic lithic materials for different tool types as the artifacts are a utilized flake, a secondary flake, and a Besant projectile point. Both the projectile point and the secondary flake exhibit breakage, indicating use on the part of the projectile point and likely manufacturing breakage on the part of the secondary flake. The utilized flake is not broken, but shows some usewear along the cutting edge. In this case, the same material is being used for a variety of functions, including as formal and expedient tools.

8.6.4 Howden (EbLi-1)

The discovery of this visually similar brown chalcedony in the Manitoba Museum collections and discussions with the Archaeology Curator, Kevin Brownlee, suggested that this material be included in the analysis to see if there were other brown chalcedony deposits in Manitoba outside of the Souris River valley. The two artifacts (#M402 and #M405) from the Howden site are both Besant projectile points although one is considered a flake point (#M402). The material from the Howden site, St. Ambroise chalcedony, is a bit darker in its colour (5 YR 2/1 – Brownish Black) than typical brown chalcedonies used in this study, although thickness of the artifact has a bearing on the colour. Thicker artifacts tend towards the darker colour (5 YR 2/1) while thinner artifacts, such as the flake point (#M402), are far more translucent and visually similar to the other brown chalcedonies used in this study. It was expected that the St. Ambroise chalcedony from the Howden site would be more of an outlier than the rest of the archaeological samples based on the colour differences; yet, the Howden artifacts fit well within the centroid clustering of artifacts. This indicates that it is very similar geochemically to the majority of the archaeological dataset. The results also indicate that St. Ambroise chalcedony is another likely source of visually similar brown chalcedonies in Manitoba and the source areas along the south end of Lake Manitoba should be investigated further.

8.6.5 Melhagen (EgNn-1)

The three artifacts (#674, #4841, and #7205) fit well within the Montana agate, South Saskatchewan River, and Manitoba Souris River source areas. Once again, this is likely due to the site's proximity to the South Saskatchewan River valley and the ease of access in procuring brown chalcedonies locally. All three artifacts are Besant projectile points classified as belonging to the Besant point style, although #7205 may instead be classified as a knife tool. Two of the three projectile points (#4841 and #7205) are broken, which is to be expected at a kill site such as Melhagen. The third artifact (#674) is complete, but was likely used, as there appear to be some impact marks (e.g., hinge fractures) along the point edges.

8.6.6 Richards Kill (DhLw-2)

From the Richards Kill site, two projectile points (#M71 and #M122) were analysed and can be found to have affinities with the Montana agate and Manitoba Souris River source areas. Each also shows some affinity with the South Saskatchewan River source area (#M71). Again, this similar patterning relates back to the source area's similar origins, out of Tertiary deposits in Montana. Both feature breakage indicative of projectile point usage including ears and shoulders broken off as a result of hafting and impact forces.

8.6.7 Smith-Swainson (FeOw-1, 2, 3)

Two broken Besant projectile points (#799 and #800) and a complete secondary flake (#837) were analysed from the Smith-Swainson site. Only one projectile point (#800) shows affinities with both Montana agate and Saskatchewan Wood Mountain source areas. The other projectile point and the secondary flake (#799 and #837 respectively) only fit within the Saskatchewan Wood Mountain source, indicating that these artifacts are a bit different from the rest of the archaeological sample. The relationship between the Saskatchewan Wood Mountain and Montana agate source areas has been established previously as Montana Rocky Mountain materials that were redeposited as early as the Tertiary period. However, the Smith-Swainson materials may indicate more local sources of brown chalcedonies in Alberta separate from the Hand Hills source or actual material from Montana agate sources in the United States. Again, further investigation into more local source areas in Alberta is warranted. The artifact types do not show a preference for particular brown chalcedonies over others. The secondary flake could have been produced as part of projectile point manufacture.

8.6.8 Muhlbach (FbPf-1)

The artifacts from the Muhlbach site represent another interesting anomaly that differs from the more common centroid clustering of the remainder of the artifacts. A sidescraper/biface (#28) and two Besant projectile points (#30 and #264) from the Muhlbach site were chosen for analysis. The first projectile point (#30) can be found within the intersection of the Wood Mountain, South Saskatchewan River, and Montana agate source areas, indicating that its geochemical makeup is more closely related to those areas than others. The last projectile point (#264) is along the positive X-axis within the ellipses for the Montana agate and Wood Mountain source areas. Again, this suggests a closer affinity to these two source areas than any of the others. The sidescraper/biface (#28) is also very close to the South Saskatchewan River source area although lower on the negative Y-axis than the first projectile point (#30).

8.6.9 Avery (DhLs-2)

The Avery site projectile point is the final outlier as part of the main archaeological analysis. This Besant projectile point (#M9) was likely broken from use as seen in the missing tip and one of the ears. One of the ablation point results from this artifact can be found within the KRF Primary Source Area ellipse with the rest of the ablation points scattered nearby, but outside of the ellipse. When the ablation points are averaged, as seen in figure 8.8, the Avery projectile points lies outside of the KRF Primary Source Area ellipse. This suggests that the brown chalcedony of this projectile point has more in common with the geochemical properties of the PSA in North Dakota than any of the other source areas analysed. The Avery point is also the only artifact in this study to come close to the PSA ellipse. Its geographic proximity to the PSA is no greater or less than many of the other points analysed, including those from Crane, Howden, and Richards Kill; however, it remains the only artifact in this study with affinities to the PSA. This may suggest that this point is actually formed from KRF procured from the Primary Source Area in North Dakota. To fully determine what materials were being used at the Avery site, more artifacts from this assemblage need to be geochemically tested.

8.7 Conclusion

Geochemical analysis of archaeological materials from Besant/Sonota sites on the Northern Plains has produced some interesting results. The high degree of elemental affinity between artifacts from archaeological sites in Alberta, Manitoba, and Saskatchewan has allowed this study to conclude that many brown chalcedonies that are visually similar are, indeed, related to one another geochemically and that visual inspection alone cannot determine a particular raw material source area. While the majority of the artifacts share close elemental ties with one another, there are those (e.g., Fincastle, Muhlbach, and Avery) that are very distinctive in their elemental signatures and this may indicate that multiple types of brown chalcedony were being procured for tool usage.

When plotted against the source areas, the majority of the artifacts show a clustering near the centroid of the graph and affinities with sources areas that are likely the result of preglacial drainage of lithic materials from the Rocky Mountains in Montana during the Tertiary period. Again, this suggests that many of the brown chalcedonies found in the archaeological sites used in this study are in fact of more local origin than previously thought. This study shows that affinities exist throughout the source areas and artifacts studied and that basing a lithic classification on visual or macroscopic inspection alone is insufficient. For this reason, lithic artifacts, especially from Besant/Sonota archaeological sites, should only be referred to as brown chalcedony unless geochemical analysis to locate specific source areas (e.g., KRF quarries) has been undertaken.

Chapter 9 – Discussion and Conclusion

The geochemical analysis of brown chalcedony from common source areas compared to that of artifacts from well-known Besant/Sonota complex archaeological sites on the Canadian Plains has shown that assumptions about the wide-scale movement of KRF are not accurate. The total acid digestion inductively-coupled plasma mass spectrometry illustrates that there is enough geochemical distinction between the selected source areas to separate them out based on the relative abundances of 15 particular elements (Ba, Ce, Cr, Cu, La, Li, Mo, Nd, Sr, Th, U, V, Y, Zn, and Zr). The analysis also resulted in determining how interrelated a number of source areas are to one another. The elemental affinities between source areas such as Montana agate, South Saskatchewan River, Manitoba Souris River, and Wood Mountain is not surprising considering their likely origins in the Rocky Mountain Uplift events of the Tertiary Period. Subsequent glaciations as well as preglacial drainage patterns and the presence of buried valleys explains how brown chalcedony materials from the Rocky Mountain Ranges are found in areas across the Northern Plains. These geological events likely also account for brown chalcedony sources in the Hand Hills of east-central Alberta and the Souris River area in southern Saskatchewan. The geochemical analysis shows a possible relationship between the Hand Hills source, the Metcalf Archaeology sample source, and the clustering of Montana agates, South Saskatchewan River, and Manitoba Souris sources. This relationship is probably the result of similar formation processes in the geologic past, yet more research into the origin of these chalcedonies needs to be undertaken to allow any definitive conclusions.

The mass spectrometry results show a distinction in source areas, including those belonging to the White River Badlands in South Dakota (Scenic chalcedony, Nelson Butte chalcedony, and West Horse chert) as well as the PSA located in the Dunn and Mercer Counties of North Dakota. Whether these source areas of brown chalcedony are related to Rocky Mountain uplift processes has not been conclusively determined, but the evidence presented in this study is suggestive that this is the case. The differences in the geochemical signatures of these source areas of brown chalcedony across the Northern Plains is likely related to late diagenetic or rather epigenetic changes that occurred in these geographical regions after original deposition (i.e., post-depositional alteration) (Pollard et al. 2017). Redeposition and weathering in areas with different minerals, and therefore elemental concentrations, could possibly cause enough difference in the geochemical makeup of materials from these source areas to separate them out on the basis of a few elements and their respective concentrations yet maintain visual similarity. Further weathering processes over millions of years, such as oxidation and hydrolysis could further skew elemental concentrations between source areas.

The archaeological samples' geochemical structure is equally as enlightening as the source samples. Discriminant analysis has shown how similar or dissimilar the artifacts studied are. After removal of the data obtained from the three outlier samples that were likely the result of error from movement during the analysis process, the remainder of the artifacts showed a great deal of elemental affinities with one other. Most artifacts from the same archaeological sites tend to be found together in the discriminant analysis indicating that the same lithic raw material source was being utilized for stone tool manufacture. However, there were two aberrations to this trend: Fincastle (DlOx-5) and Muhlbach (FbPf-1). Two of the three Fincastle site artifacts were related to one another and far removed from the rest of the archaeological samples, while the Muhlbach site artifacts were closer in affinity to the main cluster of artifacts than Fincastle, but still distinct from each other as well as the dataset. The possible reasons for these two anomalous sites will be discussed further in sections 9.1.1 and 9.3 respectively.

When comparing the artifacts to the source areas, it is immediately apparent that the artifacts used in the analysis from the Canadian Plains are made of brown chalcedony from outside of the KRF Primary Source Area in North Dakota. However, not all of the artifacts fit into the 95% confidence interval ellipses for the source areas studied. This likely indicates that there are additional brown chalcedony source areas on the Northern Plains that have yet to be geochemically characterized. Again, the occurrence of artifacts within particular source area ellipses is not absolute identification for that particular source area. Instead, it indicates that those artifacts within a particular source area ellipse share the highest probable degree of affinity out of all samples geochemically characterized in this study. The geochemical analysis shows relationships between and within archaeological sites and source areas. Full elemental characterization of other potential source areas across the Northern Plains is absolutely critical in determining the range of visually similar brown chalcedonies that exist.

This analysis has determined that there is far more than trade occurring in terms of lithic raw material procurement on the Canadian and Northern Plains for Besant and Sonota groups.

The research questions posed in chapter two can now be furthered explored based on the results from the geochemical analyses.

9.1 Question One A: Are Besant and Sonota groups the same or different in how they acquire lithic raw material? Are they separate cultural entities or merely separated by time and space?

Based on the review of the known literature regarding Besant and Sonota archaeology, it appears that they are two separate cultural entities that are highly related to each other through time. The date ranges presented in chapter three show that Besant appears in North Dakota as early as c. 2500 BP and expands west and north across the Plains region replacing Pelican Lake groups over time. Besant is indicative of highly mobile and extremely proficient bison hunters with a preference for both atlatl and later bow and arrow technology. Differing projectile point typologies and subphases such as Sandy Creek, Bracken, Bratton and Kenney, reflect adaptations by local bands of Besant hunter-gatherers to differing lithic materials but with an overall reliance and preference for brown chalcedonies that are visually identical to the KRF found in North Dakota. Luckily for Besant groups, geological events have allowed for similar materials to be spread out in multiple source locations across the Plains making brown chalcedony readily available to them. The usage and availability of this visually similar material could also help Besant groups maintain ties to their traditional homeland in the Dakotas despite no longer living in the area. The later adoption of Samantha and Outlook projectile point typologies suggests a move towards bow and arrow technology, likely influenced by rising Avonlea populations.

Sonota groups are descendent Besant populations that remained in the Middle Missouri subarea of North and South Dakota with a small northward expansion into southern Manitoba and southeastern Saskatchewan. They continued to subsist primarily on bison as can be seen in the faunal remains and tools found in archaeological sites. Increasing contact with groups to the east (e.g., Malmo and Laurel and possibly Hopewell) led eastern influences to be incorporated into Sonota culture including pottery characteristics and exotic trade goods in the forms of shell and copper. The only major difference from Besant populations was the construction of burial mounds, which is indicative of populations that are more restricted in their territory and are moving towards increased sedentism. Sonota groups could have traded KRF out of North Dakota eastward where it ended up in Hopewellian burial mounds.

9.1.1 Question One B: Are there the establishment or maintenance of relationships between and within Besant groups and other Plains cultures during this time period? Secondarily to this, are more northern and western Besant groups maintaining kinship ties with ancestors in the Middle Missouri cultural subarea?

Again, when it comes to the analysis of the archaeological samples in this study, there are three artifacts that show affinities to source areas that are considered non-local (e.g., over 150-200 km distant). The Avery projectile point is the only artifact in this study that falls anywhere close to the 95% confidence interval ellipse for the PSA of KRF in North Dakota. It is possible that this artifact was made from KRF and indicates either trade or exchange from the Middle Missouri region is occurring into southern Manitoba or that Besant/Sonota groups are travelling south to the Primary Source Area to procure stone for projectile point manufacture. The reasons for this cannot be determined at this stage as only one brown chalcedony artifact from the Avery site was available for this analysis. More brown chalcedony artifacts from the Avery site should be analysed in order to determine if this archaeological site includes other material from the PSA. At this stage of the research, one can say that only one artifact that was part of this analysis shows affinities to the PSA in North Dakota. No other artifact analysed shows any affinities to the PSA. Based on geographic distance, regular or seasonal trips to the PSA quarries would be possible for Precontact inhabitants of southwestern Manitoba, such as those groups at the Avery site.

The reasons for this could be to maintain ancestral ties to traditional territory, establishing it as an ethnic landscape. These types of landscapes are defined as "spatial and temporal constructs defined by communities whose members create and manipulate material culture and symbols to signify ethnic or cultural boundaries based on customs and shared modes of thoughts and expression that might have no other sanction than tradition" (Anscheutz et al. 2001:179). By continuing to use brown chalcedony out of the PSA of North Dakota, Besant/Sonota groups at the Avery site could be marking or maintaining their social identity to their origins in the Middle Missouri region. This idea of ethnicity could also help to explain maintenance of Besant traits in tool forms, pottery, and subsistence techniques when encountering diverse cultural groups such as Pelican Lake groups during the Late Middle Precontact Period and Avonlea groups during the Late Precontact Period. Continued use of specific brown chalcedony source locations can be seen as an adaptive tactic to retain ancestral or traditional ties and maintain a sense of place. Even if

Besant/Sonota groups, who occupied individual sites such as Avery, are not making the trip to the PSA quarries to obtain KRF, they may be maintaining trading networks with their relatives in that area.

Graham (2014) discussed different trade models described by Clark (1984) and how they may relate to Besant and Sonota groups. These three models of trade include: Down the Line Trade, Directional Trade, and Prestige Chain (Clark 1984). The first, Down the Line Trade, suggests that the frequency of a lithic toolstone decreases the further away from a source area it is found. If the brown chalcedony found in Besant complex sites across the Northern Plains was from the KRF Primary Source Area in North Dakota, one would expect to see decreased frequencies and amounts of this material in archaeological sites across the Canadian Prairie Provinces. Based on artifact recoveries from the most northern archaeological sites analysed in this study (e.g., Fitzgerald, Melhagen, Muhlbach which are over approximately 700 km distant), brown chalcedony is the dominant lithic material in the artifact assemblages, far outnumbering more local lithic materials. As such, the Down the Line Trade model does not explain the occurrence of this material in Canadian Plains archaeological sites.

Directional Trade, according to Graham (2014) also sees frequencies of a raw material type decreasing with distance. However, the distance in this case is not to quarrying locations, but to large population centres that can "exert influence" over desirable goods (Graham 2014:268). Once again, the sites included in this research cannot be described as large population centres with influence over smaller sites. This idea is more applicable to sedentary groups that can be found in the eastern and southern United States during the later periods (e.g., Adena, Hopewell, Ancestral Pueblo, Hohokam, Plains Village, etc.), not the more mobile hunter-gatherer societies on the Northern Plains.

Prestige Chain trade is a more likely model to apply to what is occurring amongst the Besant groups on the Northern Plains. In this model, a highly valued material is traded in lesser amounts over long distances. Graham (2014:271) sees the considerable amounts of brown chalcedony at the Muhlbach site as evidence of Prestige Chain trade. If the lithic material found at the Muhlbach site was KRF, this would be an acceptable explanation for the high quantities of brown chalcedony found in this site's archaeological assemblage. However, since the geochemical analysis indicates that the Muhlbach material is not KRF and likely of more local origin, this trade model is not appropriate. The Muhlbach artifacts also fall outside most of the source areas analysed, which likely indicates that the brown chalcedony material for these artifacts came from an unknown source area that is similar to those local source areas included in this analysis. As such, it is possible that there is an unknown source of brown chalcedony that is located within the vicinity or catchment area of the Muhlbach site and Besant groups were exploiting this local resource instead. The reason for a more local exploitation of raw material is discussed further in section 9.3.

Conversely to the idea of maintaining social relationships is the possibility that Besant/Sonota groups are exploiting local resources to forego reciprocity agreements. As was discussed in chapter two, sharing/reciprocity arrangements can have negative connotations for those involved in them. A negative aspect of trade with group(s) who control a desired lithic raw material quarry may be that the recipients of brown chalcedony material are obligated to share in return. Kelly's (1995) idea of "demand sharing" may have encouraged Besant/Sonota groups on the Northern Plains to seek out more local areas of brown chalcedony to avoid entering into reciprocal arrangements. Another possibility is that northern Besant groups found local sources of lithic materials to avoid prestige hunters/groups as was seen in the "show-off model" proposed by Hawkes' (1993) and Jochim's (1981) discussion of prestige hunting. Having access to high quality lithic material would enhance a group's status amongst other hunter-gatherers. By finding another source area of visually identical material that has the same knapping quality, groups could avoid contact and social obligations with the prestige groups.

In some cases, such as the Avery projectile point, the usage of certain types of brown chalcedony like KRF can be seen as a way to maintain an ethnic affiliation to a particular area. In other cases, exploitation of local areas can allow groups to opt-out of social relationships. However, more research needs to be undertaken with this site and other Besant sites on the Northern Plains to determine if this idea of an ethnic landscape is accurate.

9.1.2 Question One C: What about the Hopewell Interaction Sphere? Is KRF a part of it or are other local sources of brown chalcedony being used? Do the local sources negate the power of the traditional trading network idea?

The Hopewell Interaction Sphere was a wide-ranging trade and exchange network that occurred during the Woodland Period in North America. Trade goods were exchanged across the continental United States and Canada amongst many groups that likely did not all have contact with one another other than through the trade items. Based on the current evidence, it appears that KRF was part of the interaction sphere when found in Hopewell archaeological contexts in the eastern United States. The presence of finished bifaces with characteristic Besant/Sonota side-notching and straight bases reported by Boszhardt (1998a) in Hopewell mounds would suggest that these artifacts are being quarried, formed and finished in the Middle Missouri subarea by Sonota groups before being traded east.

Bleed (1969:13) noted the presence of alternative sources of KRF-like material in Minnesota according to Dr. Herbert Wright, a geology professor at the University of Minnesota, specifically in the glacial drifts of the Des Moines lobe. When questioned by Clark (1984:176), Dr. Wright restated his opinion to include that brown chalcedonic materials may exist in the glacial drift of Minnesota but not necessarily in large enough quantities that would explain the existing record of archaeological usage. Clark (1984) also suggested a possibility of Souris gravels from Manitoba being traded eastward as part of the Hopewell Interaction Sphere or possibly Scenic chalcedony from South Dakota, a component of the White River Group. Until the Hopewell bifaces can be sourced to a specific quarry location, whether that is the Knife River flint PSA of North Dakota or another brown chalcedony source, there will remain a question as to their origin. Since unmodified brown chalcedony has not been found in Hopewell burial mounds to date it is likely it was traded in from Sonota groups in the Dakotas. The small percentages of KRF found in Hopewell habitation sites in Wisconsin (Clark 1984) may be of more local origin than previously thought. Regardless of where the brown chalcedony material came from in this area, the Hopewell Interaction Sphere was still responsible for the diffusion of innovative ideas to different areas throughout North America during the Woodland Period.

9.2 Question two: are certain source areas (e.g., KRF quarries of North Dakota) places of "power" on the landscape? Are they symbolically "special" to Besant groups?

The geochemical analysis of the Fincastle site artifacts shows a usage of local versus non-local lithic raw materials for several types of tools. Local sources are being exploited for utilitarian tools such as the secondary flake, while the two projectile points are fashioned out of lithic material that shows affinities to source areas over 1000 km away. Does such a difference in toolstone selection indicate that some source areas of brown chalcedony are more than quarries and that they may indicate a place of "power" or "meaning" that Besant groups at the Fincastle site sought out? If so, it is important to go beyond the strictly utilitarian theme of lithic raw material procurement in terms of energy, efficiency and time costs. There is a wide body of knowledge on landscapes as places of meaning and how they are culturally constructed in archaeology (see also Ashmore and Knapp 1999; Basso 1996; Feld and Basso 1996; Hirsch and O'Hanlon 1995; and Ucko and Layton 1999). A discussion of exotic versus local toolstone and utilitarian versus non-utilitarian tools with an analysis of ethnographic and archaeological research with Australian Aborigines, the Blackfoot, Clovis groups, Folsom groups, the Mackenzie Inuit, Neolithic populations, the Nunamiut, and the Western Shoshone as well as their applications in North American archaeology was presented in chapter two.

It could well be that certain source areas of brown chalcedony are part of culturally constructed landscapes with symbolic meaning as well as quarrying locations. It is possible that Besant groups at both the Avery and Fincastle archaeological sites were seeking out specific types of brown chalcedony from locations that were not geographically close by due to perceived "power" or "meaning" that they felt these source locations had. Determining what that "meaning" is can be difficult. Source areas of brown chalcedony such as the KRF quarries or even the White River Badland sources could be in powerful locations. If Besant groups moved onto the Canadian Plains from the Middle Missouri region, the PSA in North Dakota would be considered part of their traditional territory and therefore have ancestral ties to later expanding Besant groups. The White River Badlands may also be a powerful landscape similar to the totemic dreaming places as found among Gould's (1979) Australian Aborigines. Badland areas have been described in the ethnographic literature as places of power (Sundstrom 2003) and any toolstone procured from that area would likely be considered "special". The quarry locations themselves may not be considered places of symbolic meaning but may be located near powerful locations. Sundstrom (2003; 2004) has also shown that sacred activities have taken place in relation to nearby resource areas in the Black Hills of South Dakota. It is also possible that Besant groups visited quarry locations while taking part in sacred activities within that local area or none of the above could explain continued usage of KRF in some archaeological sites. Perhaps, instead, it would be better to refer to high quantities of brown chalcedony usage by Besant and Sonota groups on the Northern Plains as indicative of the importance of the rock itself rather than its source quarry.

Additionally, all of the archaeological site selected for analysis included lithic materials (e.g., chert, quartzite, etc.) other than brown chalcedony as part of their assemblages. Many of this additional raw material in varying quantities and qualities can be found in the glacial drift that covers the prairie provinces. Besant and Sonota groups had readily available access to lithic toolstone that could be found in sufficient quantities and of sufficient quality to successfully knap into tools. However, in the archaeological sites studied, brown chalcedony tends to dominate the raw material assemblage especially in kill sites such as Fitzgerald and Melhagen. It is apparent that Besant/Sonota groups from these sites actively sought out and selected brown chalcedony material for tool production. This preference for brown chalcedony speaks to a larger selection strategy for material that was viewed as highly desirable. The dominant usage of brown chalcedony in kill sites may indicate that while the material was easily accessible, it was also preferred and desired. This preference may indicate the powerful importance of this particular lithic toolstone as part of large-scale hunting events.

9.3 Question Three: are Besant groups maximizing their returns by exploiting local source areas of brown chalcedony based on their seasonal round and only procuring KRF from North Dakota on an intermittent basis?

The answer to this question is a matter of availability, efficiency, and practicality. Most of the archaeological sites that were geochemically analysed in this study show a preference for local varieties of brown chalcedony over procurement of material from geographically distant quarries such as the KRF Primary Source Area and the White River Badlands. Local source areas of brown chalcedony are abundant across the Northern Plains as seen in the areas analysed in this study (e.g., St. Ambroise chalcedony, Manitoba Souris River, Saskatchewan Souris River, Wood Mountain, Hand Hills, and South Saskatchewan River) and the discovery that there may be other unknown sources of brown chalcedony found locally (e.g., Muhlbach). Having sources of brown chalcedony within a local area (e.g., <150 km) maximizes a group's efficiency in terms of obtaining valuable resources for stone tool manufacture.

Archaeological site placement and function also play a role in the usage of local lithic raw materials. Sites such as Melhagen, Fitzgerald, Crane, Snyder II, Richards Kill and Howden are all located extremely close to known brown chalcedony source areas. For this reason, procurement of large quantities of raw materials is easily accomplished in a short period of time.

The knowledge that local brown chalcedony varieties are not only visually similar but are free of imperfections and vugs increases the likelihood of Besant groups exploiting local resources. Sites such as Melhagen, Fitzgerald, and Richards Kill have extremely high proportions (over 50% and 90% respectively for Melhagen and Fitzgerald) of brown chalcedony as part of their lithic assemblages. The reason for this is not only that there is a local source of brown chalcedony, but that the sites themselves are large-scale bison kills with processing areas. There would be a substantially increased need for hunting and processing tools at sites of this type. Having a local source of high quality lithic raw material nearby would not only allow Besant groups to hunt and process bison efficiently but would also encourage settlement of these groups in these areas. A future analysis of other Precontact Period archaeological sites in relation to local sources of brown chalcedony would help to determine if these areas were continuously or repeatedly occupied for their toolstone resources.

The high amounts of brown chalcedony at Muhlbach and Smith-Swainson are likely for the same reason as the quantities found in sites such as Fitzgerald and Melhagen – proximity to a local lithic source for bison hunting and processing. However, until local source areas for these two Alberta sites are identified such proximity cannot be conclusively shown to explain the large quantities of brown chalcedony.

The lack of any archaeological material having affinities with the Hand Hills source is a bit unexpected. However, it is possible that none of the archaeological sites studied here exploited raw materials in this area and instead made use of closer source areas. To better understand what is happening with the Hand Hills source area, a survey and analysis of archaeological sites in close proximity (e.g., <100 km) will help to determine if lithic toolstone from this source was used.

Even archaeological sites such as Crane and Snyder II, classified as habitation sites, show a prevalence of local brown chalcedonies as part of their lithic assemblages. This too is explained by the sites' proximity to local source areas. Having viable lithic resources within a small geographic range allowed Besant groups an economic advantage in terms of access to high quality material to aid in bison procurement. The possibility still exists that Besant groups could obtain KRF from North Dakota for other reasons (see sections 9.1 and 9.2). However, the presence of a local source of visually similar lithic raw material negates the need to procure a more geographically exotic material on an ongoing basis.

To reiterate, the three artifacts from the Fincastle site included two projectile points identified as Besant and one secondary flake. The two projectile points are markedly distinct geochemically from the secondary flake. The points share affinities with the West Horse chert source area while the secondary flake appears to be of local origin based on its geochemical signature. Elemental analysis of this flake shows that it fits well within the cluster of local sources including Montana agate, South Saskatchewan River, and Manitoba Souris River.

Kevinsen (2013) and Varsakis (2006) disagree in their identification of the cultural affiliation of the Fincastle site. Varsakis (2006) believed that the site was representative of the earliest expression of Sonota groups in Alberta, evidenced by the elongated Sonota projectile points that are found at the site. Kevinsen (2013) disagreed and instead determined that the difference between elongated Sonota projectile points and shorter Besant ones was the result of usage and raw material quality. He instead suggested that Sonota be subsumed within the Besant complex and only used to refer to the burial mound complex (Kevinsen 2013). This research indicates that the answer to the Besant versus Sonota question at the Fincastle site follows the viewpoint espoused by Kevinsen (2013). It is suggested that the Fincastle site was occupied by Besant groups and Kevinsen (2013) is correct in using Sonota only to refer to the burial mound complex. However, there *is* something different in terms of lithic raw materials occurring at Fincastle as opposed to the other archaeological sites in this study. It is also possible that an unknown brown chalcedony source in Alberta or Montana, that shows affinities with the West Horse chert source area, was utilized by Besant groups at the Fincastle site. Further research into local sources of brown chalcedony in southern Alberta and northern Montana is necessary to determine this.

9.4 Conclusion

The entrenched view of dominant Knife River flint usage in Besant/Sonota sites on the Northern Plains is no longer a viable hypothesis to explain the large quantities of brown chalcedony found in archaeological sites. The geochemical analysis of twelve brown chalcedony source areas across three Canadian Provinces and three American States has shown that while many sources show elemental affinities within and between one another, enough chemical variability exists to distinguish source areas. The inclusion of ten Besant/Sonota archaeological sites on the Canadian Plains in geochemical and comparative analyses with the source areas has demonstrated that

KRF is not the dominant lithic raw material being used in these sites and that instead more local varieties of brown chalcedonies are being exploited. Where KRF or even unknown brown chalcedony varieties are found in archaeological sites it can be explained as either the maintenance of ethnic landscapes and trade relationships or the idea of culturally-constructed landscapes or stones of meaning. The exploitation of local sources of brown chalcedony can explain archaeological site placements for kill sites in the cases of Fitzgerald, Melhagen, and Richards Kill as well as the presence of habitation sites in resource-rich areas. Besant groups were highly adaptive and quickly learned to exploit visually similar toolstone as they established themselves throughout the Prairie provinces. As such a correction of the terminology in Plains archaeology is necessary. Henceforth, all artifacts made from brown chalcedony should be referred to as such and not as KRF unless they have been previously geochemically characterized. The same should be true for all lithic material types in archaeology. To continue to refer to pieces of brown chalcedony as KRF without determining exactly where it came from is a dangerous practice that entrenches itself in lithic material analysis and can lead to erroneous conclusions regarding source areas. While Luedtke (1992) acknowledged this problem, she deemed it unnecessary to correct these errors, especially when it comes to names that are well recognized and have been used for a long time (e.g., KRF). However, by allowing erroneous names and distinctions to be used, uncorrected names will lead to additional confusion. Rapp (2002:72) noted that, occasionally, chert may contain chalcedony, adding more mystification to those trying to identify a particular toolstone. For this reason, it is better to correct long-used terminology before it becomes too entrenched in the literature or at the very least to differentiate between a geological name and a historically-assigned one, and to conclusively determine what the lithic materials found in archaeological sites are.

This research has also shown the applicability of geochemical techniques, especially laser ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS), as a minimally destructive analysis in properly geochemically characterizing lithic materials from archaeological sites. Further analysis of archaeological materials by this method can help to better characterize Besant/Sonota archaeological sites and their usage of local lithic resources. Additionally, more research into using the mineral moganite, a silica polymorph discussed in section 5.1.2.1, as a means of characterizing specific source areas would help to understand formation processes and epigenetic changes to brown chalcedony sources across North America.

Additionally, proper geochemical characterization of brown chalcedony sources *must* be undertaken before archaeologists begin to adopt quick and easy field and laboratory techniques. Researchers need to properly understand geological formation processes of this material first and foremost. It is dangerous and can cloud our understanding of lithic procurement strategies, trade and exchange systems, and even mobility patterns of archaeological groups if we put "the cart before the horse" when it comes to lithic sourcing. That being said, further research into the usage of ultraviolet light and portable XRF should be undertaken along with geochemical studies of lithic materials.

To better understand and determine toolstone resources for Besant/Sonota groups, more archaeological sites dating to this time period need to be analysed. Additionally, this research can be furthered by the discovery and proper elemental characterization of local source areas that are currently unknown. Further geochemical analysis of known source areas to encompass all ranges in elemental variability is also necessary. A deeper analysis of the lithic tools found in Besant/Sonota sites will also help determine if specific sources of brown chalcedony are being used for distinct tool types, such as projectile points, and if those raw material selections can provide deeper understanding into the sociocultural traditions of Besant and Sonota peoples. Ideally, considering brown chalcedony usage during other Precontact periods, such as during Cody Complex times, may allow for further insight into the economic value of this material as well as if certain source locations (e.g., the KRF quarries) are "places of power" to past human populations. This research has shown that determining "places of power" for Besant and Sonota groups is tenuous.

Other archaeologists, and especially geologists and geoscientists, have cautioned against determining a lithic material type based on visual inspection alone. It is hoped that this research has begun to build "a case for rejecting or revising entrenched views of the past" (Wylie 1985:141). Cloutier (2004:9) states "the artifacts do not speak for themselves" and Wylie (1985: 143) believes "it is the researcher who must give them meaning and that meaning is always couched in our own biases and underlying agendas". For this reason, archaeologists need to adopt a "tradition of rational empirical criticism" (Wylie 1985:135) where entrenched beliefs of the past undergo a re-examination of their evidence.

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Appendix A: Basic Petrographic Analyses of Source Area Samples

Table A.1 Source Area Samples, Location and Collector

#	Sample #	Area Collected	Collector
Saskatchewan Source Areas			
1	SSKR1-1	North of Outlook (Gravel pit)	Frank McDougall
2	SSKR1-2	North of Outlook (Gravel pit)	Frank McDougall
3	SSKR1-3	North of Outlook (Gravel pit)	Frank McDougall
4	WM1-1	Wood Mountain Formation (Eastend)	Frank McDougall
5	WM1-2	Wood Mountain Formation (Eastend)	Frank McDougall
6	WM1-3	Wood Mountain Formation (Eastend)	Frank McDougall
7	WM1-4	Wood Mountain Formation (Eastend)	Frank McDougall
8	WM1-5	Wood Mountain Formation (Eastend)	Frank McDougall
9	WM1-6	Wood Mountain Formation (Eastend)	Frank McDougall
10	Petrified Wood	Petrified Wood	Karin Steuber
11	PW1-1	Outlook area	Karin Steuber
12	PW1-2	Outlook area	Karin Steuber
13	PW1-3	Outlook area	Karin Steuber
14	PW1-4	Outlook area	Karin Steuber
15	PW1-5	Outlook area	Karin Steuber
16	BSK1-1	Outlook area	Brent Kevinsen
17	BSK1-2	Outlook area	Brent Kevinsen
18	BSK1-3	Outlook area	Brent Kevinsen
19	BSK1-4	Outlook area	Brent Kevinsen
20	BSK2-1	Outlook area	Brent Kevinsen
21	BSK2-2	Outlook area	Brent Kevinsen
22	BSK2-3	Outlook area	Brent Kevinsen
23	BSK3-1	Outlook area	Brent Kevinsen
24	BSK3-2	Outlook area	Brent Kevinsen
25	BSK3-3	Outlook area	Brent Kevinsen

Table A.1 Source Area Samples, Location and Collector Continued

#	Sample #	Area Collected	Collector
Saskatchewan Source Areas			
26	Kakwa	Riceton area (Souris River, SK)	Jeff Coleclough (Kakwa)
Alberta Source Areas			
27	HH1-1	Hand Hills	SAS
28	HH1-2	Hand Hills	SAS
29	HH1-3	Hand Hills	SAS
30	HH1-4	Hand Hills	SAS
31	HH1-5	Hand Hills	SAS
32	HH1-6	Hand Hills	SAS
33	HH1-7	Hand Hills	SAS
34	HH1-8	Hand Hills	SAS
Manitoba Source Areas			
35	Souris1-1	Souris Gravel Pit	Karin Steuber
36	Souris1-2	Souris Gravel Pit	Karin Steuber
37	Souris1-3	Souris Gravel Pit	Karin Steuber
38	Souris1-4	Souris Gravel Pit	Karin Steuber
39	Souris1-5	Souris Gravel Pit	Karin Steuber
40	Souris2-1	Souris Gravel Pit	Karin Steuber
41	Souris2-2	Souris Gravel Pit	Karin Steuber
42	Souris2-3	Souris Gravel Pit	Karin Steuber
43	Souris2-4	Souris Gravel Pit	Karin Steuber
44	Souris2-5	Souris Gravel Pit	Karin Steuber
45	Souris3-1	Souris Gravel Pit	Karin Steuber
46	Souris3-2	Souris Gravel Pit	Karin Steuber
47	Souris 3-2 R	Souris Gravel Pit	Karin Steuber
48	Souris3-3	Souris Gravel Pit	Karin Steuber

Table A.1 Source Area Samples, Location and Collector Continued

#	Sample #	Area Collected	Collector
Manitoba Source Areas			
49	Souris3-4	Souris Gravel Pit	Karin Steuber
50	Souris3-5	Souris Gravel Pit	Karin Steuber
51	Souris4-1	Souris Gravel Pit	Karin Steuber
52	Souris4-2	Souris Gravel Pit	Karin Steuber
53	Souris4-3	Souris Gravel Pit	Karin Steuber
54	Souris4-4	Souris Gravel Pit	Karin Steuber
Montana Source Areas			
55	MTA1-1	Montana agate	SAS
56	MTA1-2	Montana agate	SAS
57	MTA1-3	Montana agate	SAS
North Dakota Source Areas			
58	Crowley	KRF PSA	Karin Steuber
59	Horse Nose Butte	KRF PSA	Karin Steuber
60	Lynch Quarries N=1	KRF PSA	Karin Steuber
61	Lynch Quarries N=2	KRF PSA	Karin Steuber
62	Medicine Butte ND	KRF PSA	Karin Steuber
63	JH1-1	32DU2216 F.20	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
64	JH1-2	32DU2216 F.20	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
65	JH1-3	32DU2216 F.20	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)

Table A.1 Source Area Samples, Location and Collector Continued

#	Sample #	Area Collected	Collector
		North Dakota Source Areas	
66	JH1-4	32DU2216 F.20	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
67	JH2-1	32DU2216 XU57	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
68	JH2-1 R	32DU2216 XU57	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
69	JH2-2	32DU2216 XU57	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
70	JH2-3	32DU2216 XU57	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
71	JH2-4	32DU2216 XU57	Metcalf Archaeology Consultants, Inc. (Jennifer Harty)
		South Dakota Source Areas	
72	WHC1-1	West Horse chert	Robert Hoard
73	WHC1-2	West Horse chert	Robert Hoard
74	WHC1-3	West Horse chert	Robert Hoard
75	WHC1-4	West Horse chert	Robert Hoard
76	WHC2	West Horse chert	Robert Hoard
77	WHC2-2	West Horse chert	Robert Hoard
78	WHC2-3	West Horse chert	Robert Hoard
79	WHC3-1	West Horse chert	Robert Hoard
80	WHC3-2	West Horse chert	Robert Hoard
81	WHC3-3	West Horse chert	Robert Hoard
82	WHC4-1	West Horse chert	Robert Hoard
83	WHC4-2	West Horse chert	Robert Hoard
84	WHC8-1	West Horse chert	Robert Hoard

Table A.1 Source Area Samples, Location and Collector Continued

#	**Sample #**	**Area Collected**	**Collector**
South Dakota Source Areas			
85	WHC 8-1 R	West Horse chert	Robert Hoard
86	WHC8-2	West Horse chert	Robert Hoard
87	WHC10-1	West Horse chert	Robert Hoard
88	WHC10-2	West Horse chert	Robert Hoard
89	WHC10-3	West Horse chert	Robert Hoard
90	WHC10-4	West Horse chert	Robert Hoard
91	N10TXX	Nelson Butte chert	Robert Hoard
92	SC1-1	Scenic chalcedony	Adrian Hannus
93	SC1-2	Scenic chalcedony	Adrian Hannus
94	SC1-3	Scenic chalcedony	Adrian Hannus
95	SC2-1	Scenic chalcedony	Adrian Hannus
96	SC2-2	Scenic chalcedony	Adrian Hannus
97	SC2-3	Scenic chalcedony	Adrian Hannus
98	SC2-4	Scenic chalcedony	Adrian Hannus

Appendix A: Basic Petrographic Analyses of Source Area Samples

Table A.2. Basic Petrographic Analyses of Source Area Samples

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
Saskatchewan Source Areas							
1	SSKR1-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.5
2	SSKR1-2	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.6
3	SSKR1-3	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.3
4	WM1-1	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.0
5	WM1-2	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.1
6	WM1-3	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.5
7	WM1-4	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8
8	WM1-5	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.3
9	WM1-6	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	2.0
10	Petrified Wood	5 YR 3/2 (Grayish Brown)	Waxy	7	Cryptocrystalline	Translucent	2.0
11	PW1-1	5 YR 3/2 (Grayish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.7
12	PW1-2	5 YR 3/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
13	PW1-3	5 YR 3/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.5
14	PW1-4	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8
15	PW1-5	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	1.1
16	BSK1-1	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	3.0
17	BSK1-2	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.9
18	BSK1-3	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	2.4
19	BSK1-4	10 YR 2/2 (Dusty Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.3
20	BSK2-1	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
21	BSK2-2	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1

Table A.2. Basic Petrographic Analyses of Source Area Samples Continued

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
Saskatchewan Source Areas							
22	BSK2-3	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.7
23	BSK3-1	5 YR 4/1 (Brownish Gray)	Waxy	7	Cryptocrystalline	Translucent	0.4
24	BSK3-2	5 YR 4/1 (Brownish Gray)	Waxy	7	Cryptocrystalline	Translucent	1.6
25	BSK3-3	5 YR 4/1 (Brownish Gray)	Waxy	7	Cryptocrystalline	Translucent	0.8
26	Kakwa	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.5
Alberta Source Areas							
27	HH1-1	5 YR 5/6 (Light Brown)	Waxy	6.5	Cryptocrystalline	Translucent	2.3
28	HH1-2	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.7
29	HH1-3	5 YR 4/4 (Moderate Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.9
30	HH1-4	5 YR 4/4 (Moderate Brown)	Waxy	6.5	Cryptocrystalline	Translucent	2.6
31	HH1-5	5 YR 4/4 (Moderate Brown)	Waxy	6.5	Cryptocrystalline	Translucent	2.4
32	HH1-6	5 YR 4/4 (Moderate Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.9
33	HH1-7	5 YR 4/4 (Moderate Brown)	Waxy	6.5	Cryptocrystalline	Translucent	2.2
34	HH1-8	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.4
Manitoba Source Areas							
35	Souris1-1	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.3
36	Souris1-2	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.7
37	Souris1-3	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.2
38	Souris1-4	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.1
39	Souris1-5	5 YR 3/2 (Grayish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.1
40	Souris2-1	10 YR 4/2 (Dark Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.7

Table A.2. Basic Petrographic Analyses of Source Area Samples Continued

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
Manitoba Source Areas							
41	Souris2-2	10 YR 4/2 (Dark Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.8
42	Souris2-3	10 YR 5/4 (Moderate Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.1
43	Souris2-4	10 YR 5/4 (Moderate Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	1.6
44	Souris2-5	10 YR 5/4 (Moderate Yellowish Brown)	Waxy	6.5	Cryptocrystalline	Translucent	0.9
45	Souris3-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	2.1
46	Souris3-2	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.7
47	Souris 3-2 R	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.7
48	Souris3-3	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.2
49	Souris3-4	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	1.6
50	Souris3-5	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	1.4
51	Souris4-1	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8
52	Souris4-2	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	1.9
53	Souris4-3	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	1.2
54	Souris4-4	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.5
Montana Source Areas							
55	MTA1-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	4.0
56	MTA1-2	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.7
57	MTA1-3	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	2.8

Table A.2. Basic Petrographic Analyses of Source Area Samples Continued

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
North Dakota Source Areas							
58	Crowley	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	2.6
59	Horse Nose Butte	11 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	4.5
60	Lynch Quarries N=1	12 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	3.2
61	Lynch Quarries N=2	13 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	4.1
62	Medicine Butte ND	14 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.5
63	JH1-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	2.3
64	JH1-2	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.2
65	JH1-3	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	3.1
66	JH1-4	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	1.0
67	JH2-1	10 YR 6/2 (Pale Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	3.5
68	JH2-1 R	10 YR 6/2 (Pale Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	3.5
69	JH2-2	5 YR 3/2 (Grayish Brown)	Waxy	7	Cryptocrystalline	Translucent	2.7
70	JH2-3	5 YR 3/2 (Grayish Brown)	Waxy	7	Cryptocrystalline	Translucent	3.1
71	JH2-4	5 YR 4/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	3.3
South Dakota Source Areas							
72	WHC1-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
73	WHC1-2	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.2
74	WHC1-3	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
75	WHC1-4	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.4

Table A.2. Basic Petrographic Analyses of Source Area Samples Continued

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
South Dakota Source Areas							
76	WHC2	5 YR 3/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.6
77	WHC2-2	5 YR 3/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.9
78	WHC2-3	5 YR 3/4 (Moderate Brown)	Waxy	7	Cryptocrystalline	Translucent	0.3
79	WHC3-1	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
80	WHC3-2	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.4
81	WHC3-3	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.5
82	WHC4-1	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.9
83	WHC4-2	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.7
84	WHC8-1	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.3
85	WHC8-1 R	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	0.3
86	WHC8-2	5 YR 5/2 (Pale Brown)	Waxy	7	Cryptocrystalline	Translucent	1.0
87	WHC10-1	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.1
88	WHC10-2	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.2
89	WHC10-3	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	0.7
90	WHC10-4	5 YR 2/2 (Dusky Brown)	Waxy	7	Cryptocrystalline	Translucent	1.1
91	N10TXX	10 YR 4/2 (Dark Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8
92	SC1-1	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.5
93	SC1-2	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.2
94	SC1-3	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8
95	SC2-1	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.1
96	SC2-2	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.7

Table A.2. Basic Petrographic Analyses of Source Area Samples Continued

#	Sample #	Munsell Rock Colour	Lustre	Hardness	Texture	Translucency	Weight (g)
South Dakota Source Areas							
97	SC2-3	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.7
98	SC2-4	10 YR 2/2 (Dusky Yellowish Brown)	Waxy	7	Cryptocrystalline	Translucent	0.8

Appendix B: Source Sample Photographs

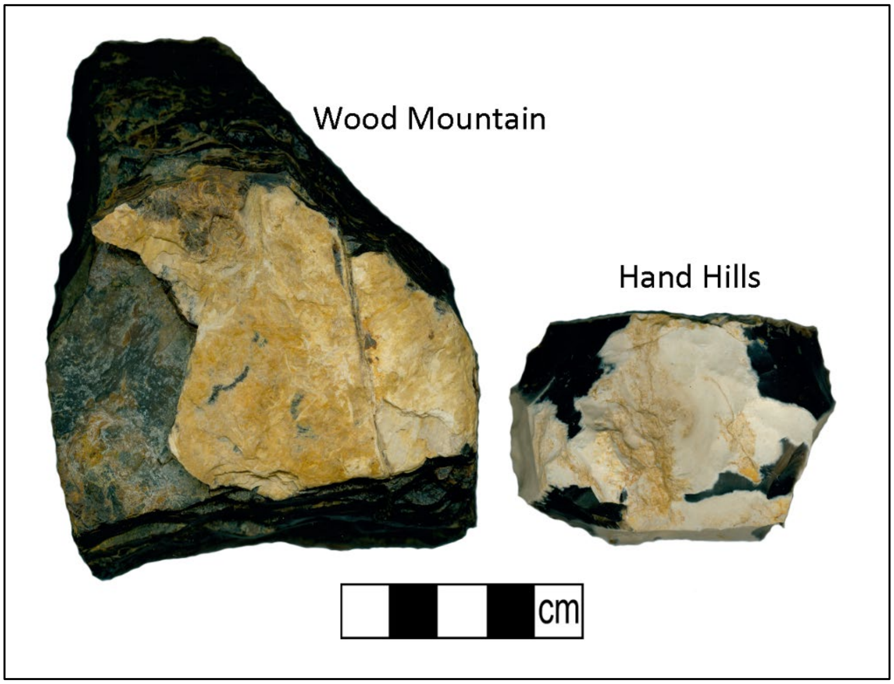

Figure B.1: Wood Mountain (SK) and Hand Hills (AB) Samples

Figure B.2: South Saskatchewan River Samples

Figure B.3: Petrified Wood Samples

Figure B.4: Saskatchewan Souris River Samples (*Kakwa*)

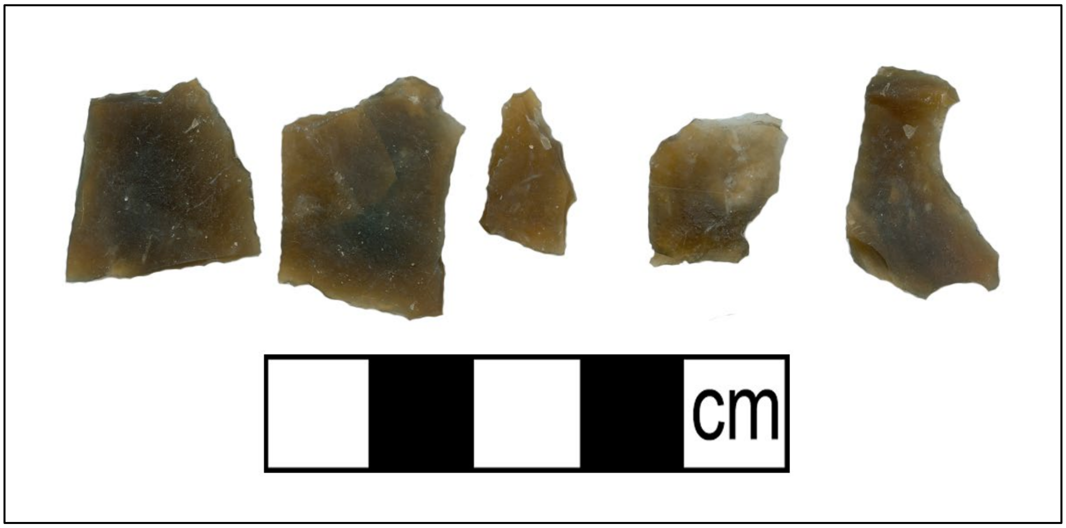

Figure B.5: Manitoba Souris River Samples

Figure B.6: Montana Agate Samples

Figure B.7: North Dakota Primary Source Area Samples

Figure B.8: North Dakota Metcalf Archaeology Consultants, Inc. Samples

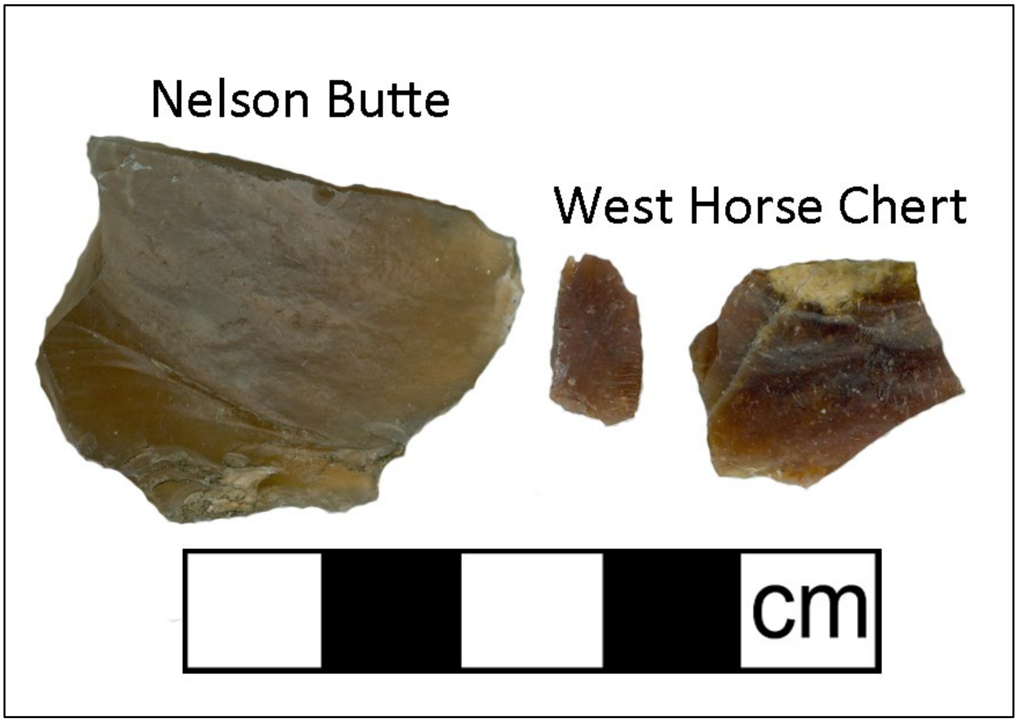

Figure B.9: Nelson Butte and West Horse chert Samples (South Dakota)

Figure B.10: Scenic chalcedony Samples (South Dakota)

Appendix C: Hoard et al. (1993) West Horse Chert Samples

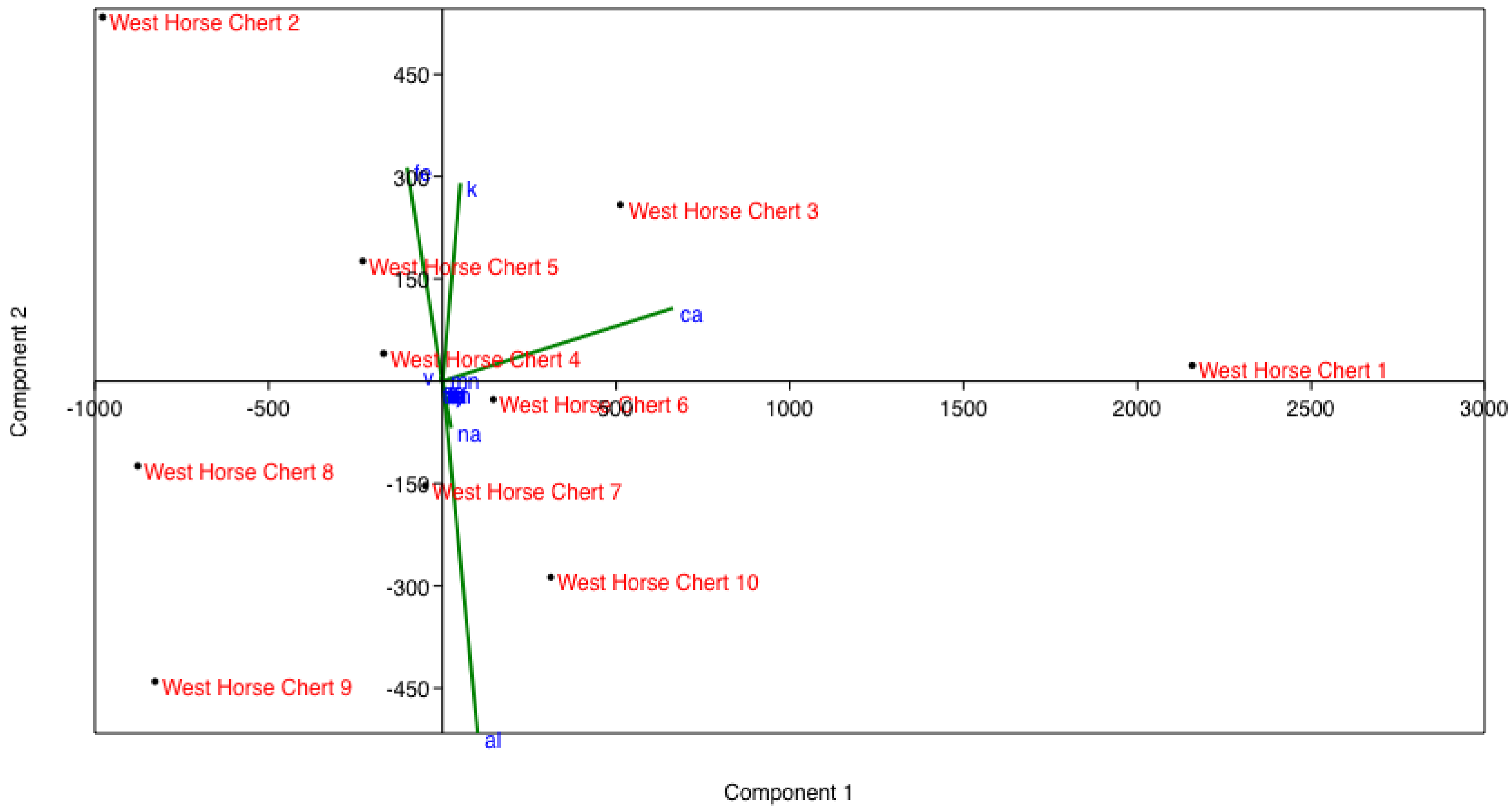

Figure C.1: Principle Component Biplot of Data from Hoard et al. (1993)

Appendix C: Hoard et al. (1993) West Horse Chert Samples

Table C.1: Hoard et al. (1993) West Horse Chert Principle Component Analysis

PC	1	2	3	4	5	6	7	8	9
Eigenvalue	836714	77880.2	49946.1	26023.4	2879.99	341.463	87.9255	10.2136	1.74546
% Variance	84.186	7.8359	5.0253	2.6184	0.28977	0.034356	0.0088466	0.0010276	0.00017562

Elements	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9
As	-0.001066	0.006759	0.001271	0.001136	0.033562	0.097941	0.019534	-0.082277	**0.951220**
Ba	-0.001035	0.000984	-0.083981	0.045940	**0.290700**	**0.937110**	0.082281	0.004990	-0.123880
La	0.000254	-0.000175	0.000102	0.000875	0.000697	-0.004554	-0.016914	-0.071725	0.039655
Lu	0.000031	-0.000025	0.000024	0.000182	-0.000138	-0.000351	-0.002816	-0.006809	0.005306
Nd	0.000101	0.000046	0.000197	0.000325	-0.000324	-0.000132	0.000869	0.006469	-0.001361
Sm	-0.000296	0.000654	-0.001779	0.001254	0.017790	-0.011166	0.060221	-0.042551	-0.010422
U	-0.004080	0.008871	-0.023173	0.014605	**0.228770**	-0.137830	**0.790150**	-0.456700	-0.038972
Yb	0.000034	-0.000016	0.000023	0.000138	-0.000282	-0.000621	-0.004418	-0.007808	-0.002128
Ce	0.000400	-0.000178	0.000420	0.001091	-0.001915	-0.003541	-0.023736	-0.062569	0.039646
Co *(ppb)*	0.000002	0.000038	0.000068	-0.000007	0.000105	-0.000165	0.000097	-0.001490	0.007301
Cr	0.000033	0.000350	0.000490	-0.000578	0.003981	-0.005092	0.022039	-0.028474	0.020668
Cs *(ppb)*	-0.000001	-0.000013	0.000045	-0.000027	-0.000136	-0.000013	0.000126	-0.000906	-0.000224
Eu *(ppb)*	0.000005	-0.000002	0.000016	0.000022	-0.000081	-0.000070	-0.000633	-0.001476	-0.001127
Fe	-0.150110	**0.459170**	**0.632830**	-0.586080	**0.144050**	0.040261	-0.010017	0.001383	-0.009933
Hf *(ppb)*	0.000014	-0.000017	0.000073	-0.000023	-0.000218	-0.000126	-0.000231	-0.001167	0.000157
Ni	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Appendix C: Hoard et al. (1993) West Horse Chert Samples

Table C.1: Hoard et al. (1993) West Horse Chert Principle Component Analysis Continued

Elements	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9
Rb	0.000072	-0.000208	0.001370	-0.000375	-0.003779	-0.000060	-0.000569	-0.027491	0.028173
Sb	0.000166	-0.000237	-0.000251	0.000831	0.003710	-0.006957	0.002286	-0.040930	0.098371
Sc *(ppb)*	0.000026	-0.000070	0.000199	-0.000151	-0.000547	0.000109	-0.000588	-0.008068	-0.009126
Sr	-0.000361	-0.000578	-0.005828	-0.000363	-0.000565	0.070019	-0.097280	**0.346920**	**0.148730**
Ta *(ppb)*	0.000002	0.000000	0.000012	-0.000012	-0.000061	-0.000012	-0.000010	-0.000450	-0.000476
Tb *(ppb)*	0.000005	0.000000	0.000007	0.000043	-0.000068	-0.000082	-0.000734	-0.001769	-0.001697
Th *(ppb)*	0.000016	-0.000009	0.000131	-0.000118	-0.000479	-0.000258	-0.001012	-0.003820	-0.008471
Zn	0.000050	0.000069	-0.000162	0.000096	0.000650	0.004038	0.001024	0.000687	0.012329
Al *(%)*	**0.148570**	-0.757090	**0.597000**	**0.064272**	**0.207370**	-0.010201	-0.020662	0.019694	0.003272
Ca *(%)*	**0.973720**	**0.156820**	-0.035873	-0.158740	0.026441	-0.001784	-0.002000	-0.000542	0.001435
Dy	0.000035	0.000027	0.000003	0.000589	-0.000707	-0.000631	-0.006624	-0.011944	-0.021776
K	0.076404	**0.425470**	**0.440740**	**0.786390**	-0.013812	0.003159	0.004229	0.012051	-0.005261
Mn	0.004892	0.000286	-0.005619	-0.013113	0.056346	-0.109350	0.066361	**0.333100**	-0.172770
Na	0.036737	-0.100760	**0.199300**	-0.078959	-0.890470	**0.269630**	**0.247770**	-0.069595	-0.022704
Tl	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
V	-0.005427	0.009483	-0.014044	-0.005871	0.030082	-0.041116	**0.536340**	**0.730380**	**0.103230**

= PCA Significant Elements

= Strong Elemental Eigenvalues

**All element values above are in parts per million (ppm) unless otherwise stated.*

Table C.2: Cumulated Variance of the First 9 Principle Components

PC	Eigenvalue	% Variance	% Cumulative Variance
1	836714	84.186	84.186
2	77880.2	7.8359	92.0219
3	49946.1	5.0253	97.0472
4	26023.4	2.6184	99.6656
5	2879.99	0.28977	99.95537
6	341.463	0.034356	99.989726
7	87.9255	0.0088466	99.9985726
8	10.2136	0.0010276	99.9996002
9	1.74546	0.00017562	99.99977582

Table C.3: Comparison between Shared Elements

Elements *(ppm)*	**Hoard et al. (1993) Average**	**This Study Average**
Ba	51.70	6.42
La	1.21	0.38
Nd	1.24	0.41
Sm	1.14	0.06
U	11.60	14.75
Yb	0.21	0.09
Ce	1.76	0.84
Co	0.03	0.11
Er	1.12	6.53
Eu	0.03	0.01
Ni	0	3.04
Rb	0.76	0.81
Sc	0.08	0.11
Sr	13.80	4.11
Tb	0.03	0.01
Th	0.10	0.12
Zn	0.62	1.11
***Al**	0.27	0.11
***Ca**	0.12	0.15
Dy	0.26	0.11
***K**	0.02	0.04
***Na**	0.04	0.04
V	19.90	12.73
***Fe**	0.004	0.05

* = indicates elements were analysed as oxides (wt %) in this study's dataset. These oxides have been converted to elements for this analysis.

All ppb values for elements listed in Hoard et al. (1993) have been converted to ppm.

Table C.4: Compared Elements and Their Variances

Elements & Oxides *(ppm and wt %)*	**Scenic Chalcedony**	**West Horse Chert**	**Hoard et al. 1993**
	n=19	*n=7*	*n=10*
$*Al_2O_3$	0.211	0.110	0.270
Ba	344.857	6.421	20.800
***CaO**	0.229	0.147	0.120
Ce	16.000	0.794	0.407
Cr	2.857	6.526	0.971
$*Fe_2O_3$	0.011	0.054	0.004
K_2O	0.031	0.036	0.020
La	8.714	0.323	0.782
***MnO**	0.000	0.001	0.000
$*Na_2O$	0.087	0.043	0.040
Sr	33.857	4.105	4.388
$*TiO_2$	0.009	0.004	0.000
Co	0.113	0.114	0.027
Cs	0.010	0.010	0.022
Dy	2.227	0.114	0.073
Eu	0.394	0.014	0.013
Nd	6.914	0.412	0.050
Rb	0.829	0.805	0.624
Sc	0.300	0.109	0.097
Sm	1.371	0.064	1.863
Ta	0.005	0.002	0.007
Tb	0.314	0.011	0.014
Th	0.269	0.123	0.082
U	11.454	14.753	22.917
Yb	1.159	0.089	0.068
Zn	4.343	1.105	0.424

* = indicates elements were analysed as oxides (wt %) in this study's dataset. All conversion (elements to oxides) have taken place for this analysis.

All ppb values for elements listed in Hoard et al. (1993) have been converted to ppm

Table C.5: Variance in Elemental Concentrations in This Study

Elements & Oxides *(ppm and wt %)*	**Scenic Chalcedony**	**West Horse Chert**
	n=7	*n=19*
Li	11.714	6.368
MgO	0.001	0.005
P_2O_5	0.164	0.011
Zr	2.143	3.958
Ag	0.037	0.093
Be	1.229	0.069
Bi	0.243	0.216
Cd	0.010	0.010
Cu	5.786	2.426
Er	1.356	0.075
Ga	0.330	0.279
Gd	1.886	0.069
Hf	0.023	0.019
Ho	0.473	0.022
Mo	0.137	0.145
Nb	0.243	0.181
Ni	1.214	3.037
^{204}Pb	0.033	0.026
^{206}Pb	0.580	0.419
^{207}Pb	0.479	0.322
^{208}Pb	1.188	0.781
PbSUM	2.277	1.549
Pr	1.743	0.099
Sn	0.066	0.042
V	1.186	12.732
W	0.049	0.054
Y	19.514	0.695

Appendix D: Christensen's (1991b) Knife River Flint Primary Source Area Samples

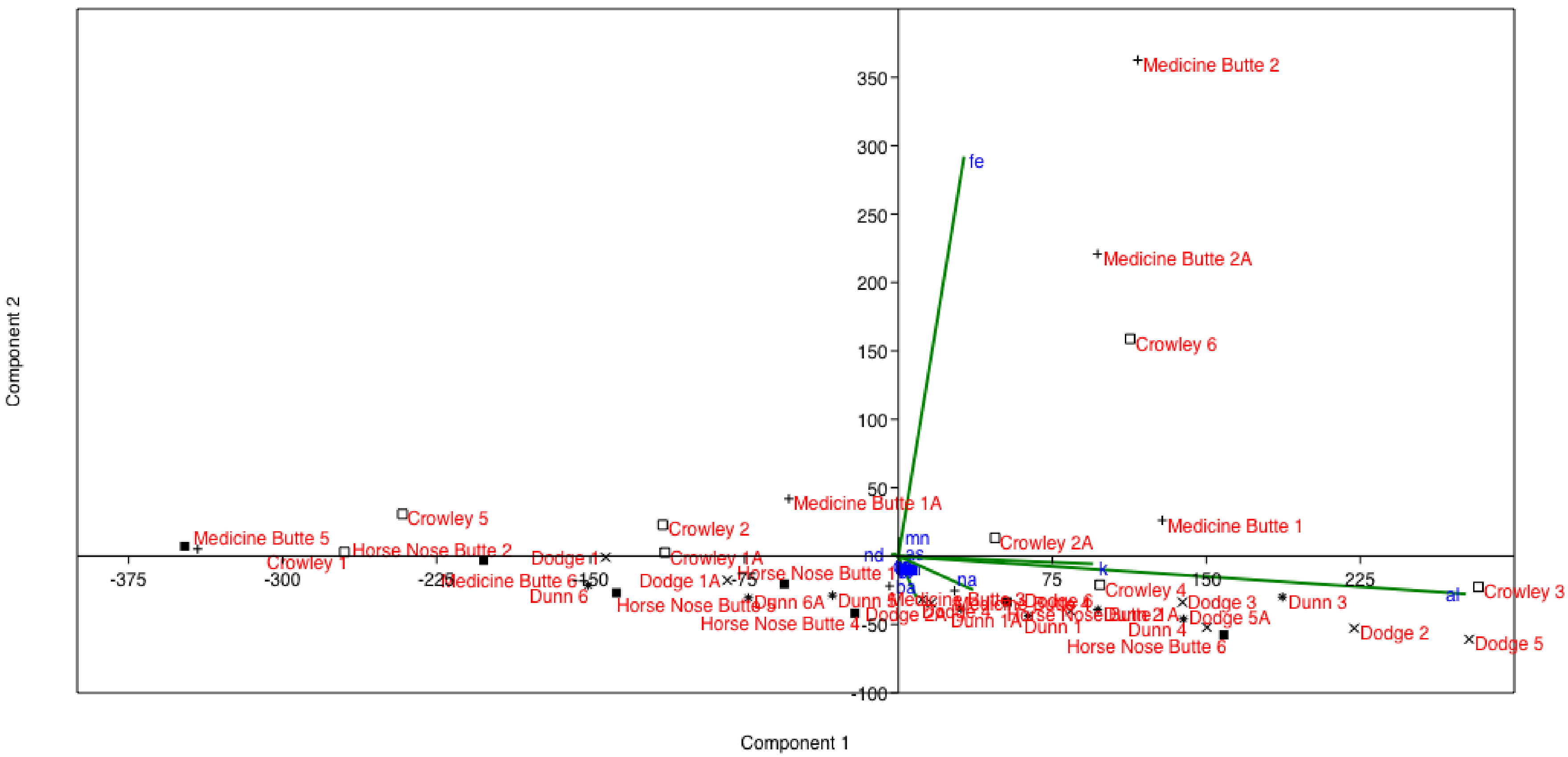

Figure D.1: Principle Component Biplot of Data from Christensen (1991b)

Appendix D: Christensen's (1991b) Knife River Flint Primary Source Area Samples

Table D.1: Christensen's 1991 Knife River Flint Primary Source Area Principle Component Analysis

PC	1	2	3	4	5	6	7	8	9	10
Eigenvalue	24563.3	6258.01	2933.94	815.481	559.614	203.308	25.7445	5.1092	2.55705	0.910993
% Variance	69.45	17.694	8.2954	2.3057	1.5822	0.57483	0.072789	0.014446	0.0072297	0.0025757

Elements	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
As	0.000845	0.0082553	-0.0003457	0.0003292	0.0040834	0.0077054	0.010102	0.013565	0.017012	-0.046519
Ba	**0.029404**	-0.10157	**0.25695**	**0.80102**	**0.52075**	0.033138	-0.0192	-0.057681	-0.067561	-0.0085127
La	-0.0056193	0.0025733	-0.022171	-0.0043306	**0.03411**	0.16011	**0.16012**	-0.034343	**0.38212**	**0.41121**
Lu	-0.000199	0.0001208	-0.0010499	-0.0007592	0.0020063	0.0090176	0.0098747	0.0015033	0.010043	-0.0075271
Nd	-0.011978	0.0047632	-0.040974	-0.0072513	**0.075818**	**0.27876**	**0.47357**	-0.31342	**0.36013**	**0.34352**
Sm	-0.0022532	0.0007624	-0.010767	-0.006984	0.017319	0.08486	0.099627	0.021876	0.0033605	0.018523
U	-0.004343	-0.0008721	-0.044005	-0.045542	**0.046294**	**0.28426**	**0.34462**	**0.40004**	-0.69018	**0.38397**
Yb	-0.0009951	0.0004982	-0.0042933	-0.0023699	0.0070331	0.035679	0.037226	0.000057	0.048875	0.0006902
Ce	-0.0086784	0.0064736	-0.045999	-0.044469	**0.085511**	**0.40565**	**0.46466**	**0.10208**	0.071041	-0.7265
Co	-0.0001391	0.0004921	-0.0013994	-0.0018696	0.0026054	0.014536	0.010226	0.013706	0.0056513	-0.031538
Cr	-0.0001187	0.0008979	-0.0003022	-0.0015828	0.0020899	0.0069401	0.0034434	-0.0002364	0.033439	-0.06644
Cs	0.0000017	0.0000126	0.0000101	0.0000098	0.0000034	-0.0000204	-0.0000889	-0.0000995	-0.0001065	-0.0002778
Eu	-0.0005292	0.000244	-0.0021867	-0.0011927	0.0040744	0.018517	0.02135	-0.0011498	0.015168	-0.0048643
Fe	**0.10797**	**0.98554**	**0.012006**	**0.049889**	**0.10808**	-0.047582	0.015485	0.012306	-0.0025737	0.0020954
Hf	-0.0001108	-0.0002678	0.0001543	0.0006033	-0.0006813	-0.0004102	-0.0025726	0.0082356	-0.014995	-0.0070573
Ni	0	0	0	0	0	0	0	0	0	0
Rb	0.0003134	0.0001657	0.0003499	-0.0003252	-0.0001734	-0.0031843	-0.0025851	-0.004882	0.015055	-0.036637
Sb	0.0001163	-0.0003535	-0.0007902	-0.0015232	0.0015418	0.0030991	0.0009408	0.0011998	-0.019526	0.0077249
Sc	-0.0001229	0.0005781	0.0007836	-0.001284	-0.0013092	-0.0020779	0.0034869	-0.015195	-0.0022126	-0.031749

Appendix D: Christensen's (1991b) Knife River Flint Primary Source Area Samples

Table D.1: Christensen's 1991 Knife River Flint Primary Source Area Principle Component Analysis Continued

Elements	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9	PC 10
Sr	-0.000002	-0.0077291	**0.0063005**	**0.063892**	**0.042669**	0.12939	-0.19554	**0.82296**	**0.45382**	0.054129
Ta	0.0000007	-0.0000015	0.0000021	0.0000006	0.0000043	-0.000006	-0.0000012	0.0000619	-0.0001173	0.0001433
Tb	-0.0003537	0.0001688	-0.0014642	-0.000776	0.0025999	0.012	0.013523	-0.0010166	0.013699	0.002259
Th	-0.0001573	-0.0002586	-0.0000075	0.0014469	-0.0014265	-0.0029201	-0.0011769	-0.0019435	-0.010802	0.035469
Zn	-0.0010087	0.0014814	-0.0074045	-0.0097468	0.014907	0.053764	0.074093	-0.024689	-0.024988	-0.11377
Al	**0.93249**	-0.093181	-0.31624	**0.11423**	-0.091897	0.015204	-0.0002132	-0.0061693	0.0020266	-0.0022296
Ca	0	0	0	0	0	0	0	0	0	0
Dy	-0.0021363	0.001212	-0.0096498	-0.0021382	0.016369	0.083245	0.070906	-0.011578	0.13885	0.097031
K	**0.3201**	-0.019162	**0.90796**	-0.22319	-0.12515	0.061393	0.056025	0.012261	0.012155	0.0098054
Mn	0.0013391	**0.045968**	-0.025414	-0.099351	0.070616	**0.76049**	-0.59048	-0.21721	-0.083288	0.020728
Na	**0.12326**	-0.083826	-0.047285	-0.52418	**0.8179**	-0.17216	-0.044221	0.0093619	0.0081356	0.0072618
Ti	0	0	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0	0	0

= PCA Significant Elements   = Strong Elemental Values

**All element values above are in parts per million (ppm)*

Table D.2: Cumulated Variance of the First 10 Principle Components

PC	Eigenvalue	% Variance	% Cumulative Variance
1	24563.3	69.45	69.45
2	6258.01	17.694	87.144
3	2933.94	8.2954	95.4394
4	815.481	2.3057	97.7451
5	559.614	1.5822	99.3273
6	203.308	0.57483	99.90213
7	25.7445	0.072789	99.974919
8	5.1092	0.014446	99.989365
9	2.55705	0.0072297	99.9965947
10	0.910993	0.0025757	99.9991704

Appendix D: Christensen's (1991b) Knife River Flint Primary Source Area Samples

Table D.3 Comparison between Shared Elements

Elements *(ppm)*	**Christensen's 1991 Average**	**This Study's Average**
Ba	39.905	51.40
La	1.18	4.02
Nd	2.28	4.00
Sm	0.86	0.84
U	4.70	3.09
Yb	0.26	0.79
Ce	2.54	9.60
Co	0.07	0.10
Cr	0.26	30.2
Eu	0.14	0.15
*** Fe**	44.70	392.00
Ni	0.00	0.74
Rb	0.20	0.34
Sc	0.19	0.28
Sr	4.19	3.80
Tb	0.09	0.14
Th	0.25	1.05
Zn	0.34	0.46
*** Al**	1438.40	476.00
*** Ca**	0.00	472.00
Dy	0.62	0.98
*** K**	185.80	208.00
*** Na**	131.08	163.00
V	0.00	1.00

* = indicates elements were analysed as oxides (wt %) in this study's dataset. These oxides have been converted to elements for this analysis.

Table D.4: Comparison between Shared Elements from 1991, 1993 and This Study

Element *(ppm)*	**Christensen 1991 Average**	**Hoard et al. 1993 Average**	**This Study Average**
	n=40	*n=1*	*n=5*
Ba	39.91	42.90	51.40
La	1.18	1.05	4.02
Nd	2.28	2.84	4.00
Sm	0.86	0.78	0.84
U	4.70	4.40	3.09
Yb	0.26	221.00	0.79
Ce	2.54	2.16	9.60
Co	0.07	0.05	0.10
Cr	0.26	0.23	30.2
Eu	0.14	0.12	0.15
*** Fe**	44.70	42.10	280.00
Ni	0	0	0.74
Rb	0.20	0.22	0.34
Sc	0.19	0.20	0.28
Sr	4.19	4.80	3.80
Tb	0.09	0.08	0.14
Th	0.25	0.27	1.05
Zn	0.34	0.76	0.46
*** Al**	1438.40	0.14	265.00
*** Ca**	0	0	357.00
Dy	0.62	0.54	0.98
*** K**	185.80	194.00	166.00
*** Na**	131.08	126.00	74.00
V	0	0	1.00

* = indicates elements were analysed as oxides (wt %) in this study's dataset. These oxides have been converted to elements for this analysis.

All ppb values for elements listed in Hoard et al. (1993) have been converted to ppm.

Appendix E: Archaeological Samples

Table E.1: Artifacts Coded with Sample Name and LA-ICP-MS Analysis Information

#	Site	Borden	Catalogue #	Sample #	Run # & Date	Type	Comments
Alberta							
1	Fincastle	DlOx-5	843	DlOx5B	Run1 09/05/2017	Projectile Point	
2			900	DlOx5	Run1 09/05/2017	Flake, Secondary	
3			13970	DlOx5C	Run1 09/05/2017	Projectile Point	
4	Muhlbac h	FbPf-1	28	FfPb1A	Run3 09/06/2017	Biface/Sidescraper	
5			30	FfPb1B	Run3 09/06/2017	Projectile Point	
6			264	FfPb1C	Run3 09/06/2017	Projectile Point	
7	Smith-Swainson	FeOw-1,2,3	H.72.7.799	FeOw1A	Run1 09/06/2017	Projectile Point	
8			H.72.7.800	FeOw1B	Run1 09/06/2017	Projectile Point	
9			H.72.7.837	FeOw1C	Run1 09/06/2017	Flake, Secondary	
Saskatchewan							
10	Crane	DiMv-93	8584	DiMv93A	Run2 09/07/2017	Endscraper, Thumbnail	cell moved
11			9083	DiMv93C; DiMv93D	Run2 09/07/2017; Run1 09/08/2017	Projectile Point	cell moved; rerun with Richards Kill (DiMv93C second run on 09/08/2017 as DiMv93D)
12			9211	DiMv93B; DiMv93E	Run2 09/07/2017; Run2 09/08/2017	Projectile Point	cell moved; rerun with Snyder II (DiMv93B second run on 09/08/2017 as DiMv93E); sample almost to small and needs a separate holder (hard to stabilize so it doesn't move

Table E.1: Artifacts Coded with Sample Name and LA-ICP-MS Analysis Information Continued

#	Site	Borden	Catalogue #	Sample #	Run # & Date	Type	Comments
Saskatchewan							
13	Fitzgerald	ElNp-8	346	ElNp8C	Run2 09/06/2017	Flake, Utilized	
14			16350	ElNp8A	Run2 09/06/2017	Flake, Secondary	
15			No Cat #	ElNp8B	Run2 09/06/2017	Projectile Point	
16	Melhagen	EgNn-1	674	EgNn1C	Run1 09/07/2017	Projectile Point	sample got stuck
17			4841	EgNn1B	Run1 09/07/2017	Projectile Point	sample got stuck
18			7205	EgNn1A	Run1 09/07/2017	Projectile Point/Knife	sample got stuck
Manitoba							
19	Avery	DhLs-2	M9	DhLs2	Run3 09/07/2017	Projectile Point	
20	Howden	EbLi-1	M402	EbLi1A	Run3 09/07/2017	Flake Projectile Point	
21			M405	EbLi1B	Run3 09/07/2017	Projectile Point	
25	Richards Kill	DhLw-2	M71	DhLw2A	Run1 09/08/2017	Projectile Point	run with Crane C
28			M122	DhLw2B	Run1 09/08/2017	Projectile Point	run with Crane C
29	Snyder II	DgMg-15	M491	DgMg15A	Run2 09/08/2017	Projectile Point	run with Crane B
31			M1412	DgMg15B	Run2 09/08/2017	Projectile Point	run with Crane B

Table E.2: NIST 614 Standards for Elements Analysed

Name	Sample #	Li7	Int2SE	Be9	Int2SE	P31	Int2SE	K39	Int2SE
Preferred Values	*NIST614*	***1.69***	*0.09*	***0.753***	*0.051*	***11.4***	*3.9*	***30***	*1*
Standard	NIST614-1-1	**1.672**	0.074	**0.712**	0.099	**11.21**	0.47	**30.11**	0.93
Standard	NIST614-1-2-1	**1.75**	0.076	**0.82**	0.13	**10.54**	0.56	**29.63**	0.62
Standard	NIST614-1-1	**1.675**	0.077	**0.72**	0.11	**9.36**	0.44	**30.2**	1.1
Standard	NIST614-1-2-1	**1.74**	0.081	**0.79**	0.11	**9.95**	0.56	**29.52**	0.67
Standard	NIST614-1-1	**1.686**	0.072	**0.696**	0.08	**9.82**	0.4	**29.96**	0.75
Standard	NIST614-1-2-1	**1.729**	0.074	**0.676**	0.081	**9.49**	0.37	**30.03**	0.9
Standard	NIST614-1	**1.773**	0.072	**0.819**	0.078	**9.61**	0.38	**30.9**	0.89
Standard	NIST614-2	**1.765**	0.079	**0.826**	0.093	**9.63**	0.32	**29.98**	0.68
Standard	NIST614-1	**1.782**	0.053	**0.651**	0.068	**11.8**	1.1	**32.5**	1.7
Standard	NIST614-2	**1.714**	0.061	**0.724**	0.075	**15.4**	3	**32.4**	1.6

Name	Sample #	Sc45	Int2SE	Ti49	Int2SE	V51	Int2SE	Cr52	Int2SE
Preferred Values	*NIST614*	***0.74***		***3.61***	*0.25*	***1.01***	*0.04*	***1.19***	*0.12*
Standard	NIST614-1-1	**1.99**	0.11	**2.85**	0.2	**1.1**	0.035	**0.37**	0.16
Standard	NIST614-1-2-1	**1.78**	0.091	**3.39**	0.23	**1.095**	0.042	**-0.25**	0.14
Standard	NIST614-1-1	**1.554**	0.095	**2.9**	0.21	**1.056**	0.037	**1.24**	0.12
Standard	NIST614-1-2-1	**1.504**	0.095	**2.83**	0.2	**1.06**	0.033	**0.49**	0.12
Standard	NIST614-1-1	**1.808**	0.087	**2.77**	0.24	**1.039**	0.033	**1.21**	0.11
Standard	NIST614-1-2-1	**1.606**	0.072	**3.08**	0.22	**1.029**	0.032	**1.22**	0.11
Standard	NIST614-1	**2.15**	0.11	**3.02**	0.21	**1.043**	0.033	**1.18**	0.11

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Sc45	Int2SE	Ti49	Int2SE	V51	Int2SE	Cr52	Int2SE
Preferred Values	*NIST614*	***0.74***		***3.61***	*0.25*	***1.01***	*0.04*	***1.19***	*0.12*
Standard	NIST614-2	**1.961**	0.094	**3.33**	0.19	**1.052**	0.035	**1.15**	0.1
Standard	NIST614-1	**2.249**	0.091	**3.47**	0.33	**1.027**	0.031	**2.08**	0.27
Standard	NIST614-2	**1.962**	0.071	**3.47**	0.2	**1.02**	0.024	**2.12**	0.16

Name	Sample #	Cr53	Int2SE	Mn55	Int2SE	Fe57	Int2SE	Co59	Int2SE
Preferred Values	*NIST614*	***1.19***	*0.12*	***1.42***	*0.07*	***18.8***	*6*	***0.79***	*0.09*
Standard	NIST614-1-1	**0.99**	0.11	**1.432**	0.058	**21.6**	9.8	**0.767**	0.029
Standard	NIST614-1-2-1	**0.76**	0.13	**1.437**	0.036	**12.17**	0.72	**0.714**	0.023
Standard	NIST614-1-1	**0.864**	0.094	**1.466**	0.056	**10.22**	0.9	**0.747**	0.026
Standard	NIST614-1-2-1	**0.697**	0.085	**1.434**	0.046	**11.28**	0.97	**0.751**	0.028
Standard	NIST614-1-1	**0.92**	0.11	**1.432**	0.054	**16.4**	7.1	**0.756**	0.026
Standard	NIST614-1-2-1	**0.94**	0.11	**1.415**	0.047	**9.92**	0.73	**0.719**	0.024
Standard	NIST614-1	**0.97**	0.11	**1.47**	0.044	**9.83**	0.75	**0.776**	0.024
Standard	NIST614-2	**0.994**	0.09	**1.443**	0.046	**11.8**	2.4	**0.794**	0.026
Standard	NIST614-1	**1.27**	0.16	**1.531**	0.076	**48**	22	**0.746**	0.021
Standard	NIST614-2	**2.4**	2.7	**1.448**	0.056	**46**	20	**0.748**	0.031

Name	Sample #	Ni60	Int2SE	Ga69	Int2SE	Rb85	Int2SE	Sr88	Int2SE
Preferred Values	*NIST614*	***1.1***	*0.1*	***1.31***	*0.09*	***0.855***	*0.005*	***45.8***	*0.1*
Standard	NIST614-1-1	**1.43**	0.16	**1.362**	0.042	**0.859**	0.031	**44.64**	0.69
Standard	NIST614-1-2-1	**1.24**	0.1	**1.397**	0.046	**0.869**	0.027	**51.2**	1
Standard	NIST614-1-1	**1.064**	0.064	**1.339**	0.044	**0.85**	0.03	**44.8**	1.2

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Ni60	Int2SE	Ga69	Int2SE	Rb85	Int2SE	Sr88	Int2SE
Preferred Values	*NIST614*	***1.1***	*0.1*	***1.31***	*0.09*	***0.855***	*0.005*	***45.8***	*0.1*
Standard	NIST614-1-2-1	**1.072**	0.063	**1.395**	0.041	**0.899**	0.033	**44.9**	1
Standard	NIST614-1-1	**1.187**	0.083	**1.402**	0.049	**0.915**	0.037	**44**	1.3
Standard	NIST614-1-2-1	**1**	0.061	**1.42**	0.05	**0.879**	0.03	**44.26**	0.97
Standard	NIST614-1	**1.186**	0.071	**1.447**	0.038	**0.889**	0.027	**47.3**	1.1
Standard	NIST614-2	**1.253**	0.088	**1.463**	0.046	**0.909**	0.028	**47.54**	0.95
Standard	NIST614-1	**1.4**	0.14	**1.471**	0.079	**0.9**	0.025	**46.12**	0.9
Standard	NIST614-2	**6.5**	6.1	**1.388**	0.03	**0.882**	0.021	**46.12**	0.92

Name	Sample #	Y89	Int2SE	Zr90	Int2SE	Nb93	Int2SE	Mo95	Int2SE
Preferred Values	*NIST614*	***0.79***	*0.032*	***0.848***	*0.028*	***0.824***	*0.03*	***0.8***	*0.03*
Standard	NIST614-1-1	**0.758**	0.02	**0.817**	0.034	**0.792**	0.027	**0.782**	0.045
Standard	NIST614-1-2-1	**0.92**	0.033	**0.989**	0.04	**0.905**	0.028	**0.817**	0.05
Standard	NIST614-1-1	**0.761**	0.036	**0.824**	0.045	**0.793**	0.028	**0.836**	0.043
Standard	NIST614-1-2-1	**0.787**	0.03	**0.842**	0.043	**0.816**	0.023	**0.847**	0.046
Standard	NIST614-1-1	**0.696**	0.03	**0.77**	0.039	**0.773**	0.027	**0.845**	0.05
Standard	NIST614-1-2-1	**0.713**	0.027	**0.773**	0.028	**0.795**	0.026	**0.81**	0.045
Standard	NIST614-1	**0.798**	0.031	**0.894**	0.039	**0.839**	0.026	**0.878**	0.045
Standard	NIST614-2	**0.802**	0.031	**0.862**	0.048	**0.842**	0.026	**0.861**	0.049
Standard	NIST614-1	**0.819**	0.031	**0.98**	0.16	**0.836**	0.022	**0.774**	0.032
Standard	NIST614-2	**0.83**	0.031	**1.06**	0.32	**0.846**	0.024	**0.777**	0.031

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Mo98	Int2SE	Ag107	Int2SE	Cd111	Int2SE	Cd114	Int2SE
Preferred Values	*NIST614*	***0.8***	*0.03*	***0.42***	*0.04*	***0.56***	*0.05*	***0.56***	*0.05*
Standard	NIST614-1-1	**0.773**	0.035	**0.416**	0.02	**0.492**	0.042	**0.548**	0.027
Standard	NIST614-1-2-1	**0.765**	0.043	**0.429**	0.029	**0.562**	0.041	**0.59**	0.038
Standard	NIST614-1-1	**0.809**	0.04	**0.424**	0.02	**0.498**	0.043	**0.574**	0.029
Standard	NIST614-1-2-1	**0.809**	0.033	**0.438**	0.025	**0.547**	0.044	**0.56**	0.026
Standard	NIST614-1-1	**0.875**	0.045	**0.425**	0.024	**0.539**	0.045	**0.536**	0.029
Standard	NIST614-1-2-1	**0.845**	0.038	**0.428**	0.023	**0.539**	0.042	**0.578**	0.03
Standard	NIST614-1	**0.848**	0.035	**0.432**	0.02	**0.565**	0.043	**0.638**	0.032
Standard	NIST614-2	**0.849**	0.035	**0.446**	0.025	**0.631**	0.04	**0.639**	0.035
Standard	NIST614-1	**0.808**	0.026	**0.433**	0.018	**0.615**	0.058	**0.597**	0.027
Standard	NIST614-2	**0.837**	0.037	**0.436**	0.016	**0.614**	0.042	**0.635**	0.036

Name	Sample #	Sn122	Int2SE	Cs133	Int2SE	Ba137	Int2SE	La139	Int2SE
Preferred Values	*NIST614*	***1.68***	*0.15*	***0.664***	*0.034*	***3.2***	*0.09*	***0.72***	*0.013*
Standard	NIST614-1-1	**1.57**	0.075	**0.705**	0.026	**3.35**	0.22	**0.715**	0.017
Standard	NIST614-1-2-1	**1.434**	0.099	**0.69**	0.021	**3.5**	0.13	**0.801**	0.027
Standard	NIST614-1-1	**1.332**	0.07	**0.685**	0.023	**3.17**	0.13	**0.689**	0.023
Standard	NIST614-1-2-1	**1.428**	0.088	**0.723**	0.02	**3.19**	0.11	**0.718**	0.024
Standard	NIST614-1-1	**1.387**	0.091	**0.707**	0.024	**3.27**	0.13	**0.672**	0.026
Standard	NIST614-1-2-1	**1.469**	0.092	**0.722**	0.024	**3.27**	0.11	**0.67**	0.025
Standard	NIST614-1	**1.381**	0.066	**0.719**	0.02	**3.25**	0.1	**0.725**	0.023
Standard	NIST614-2	**1.475**	0.089	**0.725**	0.022	**3.25**	0.13	**0.731**	0.026
Standard	NIST614-1	**1.457**	0.058	**0.704**	0.019	**3.29**	0.1	**0.742**	0.022

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Sn122	Int2SE	Cs133	Int2SE	Ba137	Int2SE	La139	Int2SE
Preferred Values	*NIST614*	***1.68***	*0.15*	***0.664***	*0.034*	***3.2***	*0.09*	***0.72***	*0.013*
Standard	NIST614-2	**1.345**	0.069	**0.706**	0.014	**3.21**	0.096	**0.747**	0.026
Name	**Sample #**	**Ce140**	**Int2SE**	**Pr141**	**Int2SE**	**Nd146**	**Int2SE**	**Sm147**	**Int2SE**
Preferred Values	*NIST614*	***0.813***	*0.025*	***0.768***	*0.015*	***0.752***	*0.014*	***0.754***	
Standard	NIST614-1-1	**0.771**	0.024	**0.746**	0.017	**0.729**	0.031	**0.74**	0.032
Standard	NIST614-1-2-1	**0.855**	0.024	**0.854**	0.026	**0.859**	0.033	**0.858**	0.047
Standard	NIST614-1-1	**0.796**	0.028	**0.764**	0.027	**0.712**	0.028	**0.755**	0.043
Standard	NIST614-1-2-1	**0.801**	0.023	**0.774**	0.022	**0.741**	0.039	**0.78**	0.036
Standard	NIST614-1-1	**0.78**	0.02	**0.734**	0.027	**0.658**	0.028	**0.715**	0.039
Standard	NIST614-1-2-1	**0.793**	0.023	**0.742**	0.021	**0.708**	0.035	**0.728**	0.035
Standard	NIST614-1	**0.799**	0.023	**0.796**	0.021	**0.785**	0.036	**0.786**	0.044
Standard	NIST614-2	**0.818**	0.025	**0.788**	0.018	**0.78**	0.038	**0.767**	0.036
Standard	NIST614-1	**0.776**	0.017	**0.776**	0.018	**0.759**	0.033	**0.8**	0.038
Standard	NIST614-2	**0.779**	0.018	**0.777**	0.021	**0.778**	0.035	**0.786**	0.033
Name	**Sample #**	**Eu153**	**Int2SE**	**Gd157**	**Int2SE**	**Tb159**	**Int2SE**	**Dy163**	**Int2SE**
Preferred Values	*NIST614*	***0.77***	*0.016*	***0.763***	*0.021*	***0.739***	*0.02*	***0.746***	*0.022*
Standard	NIST614-1-1	**0.754**	0.021	**0.726**	0.045	**0.732**	0.018	**0.736**	0.028
Standard	NIST614-1-2-1	**0.88**	0.03	**0.867**	0.043	**0.882**	0.028	**0.862**	0.038
Standard	NIST614-1-1	**0.739**	0.024	**0.734**	0.038	**0.727**	0.029	**0.727**	0.042
Standard	NIST614-1-2-1	**0.759**	0.025	**0.784**	0.042	**0.75**	0.028	**0.743**	0.038
Standard	NIST614-1-1	**0.738**	0.029	**0.701**	0.041	**0.695**	0.027	**0.685**	0.035

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Eu153	Int2SE	Gd157	Int2SE	Tb159	Int2SE	Dy163	Int2SE
Preferred Values	*NIST614*	***0.77***	*0.016*	***0.763***	*0.021*	***0.739***	*0.02*	***0.746***	*0.022*
Standard	NIST614-1-2-1	**0.738**	0.021	**0.672**	0.042	**0.69**	0.025	**0.685**	0.029
Standard	NIST614-1	**0.797**	0.026	**0.767**	0.038	**0.782**	0.024	**0.785**	0.031
Standard	NIST614-2	**0.792**	0.026	**0.777**	0.045	**0.755**	0.025	**0.759**	0.039
Standard	NIST614-1	**0.799**	0.024	**0.816**	0.044	**0.786**	0.026	**0.788**	0.035
Standard	NIST614-2	**0.783**	0.022	**0.784**	0.033	**0.792**	0.026	**0.774**	0.03

Name	Sample #	Ho165	Int2SE	Er166	Int2SE	Yb172	Int2SE	Hf178	Int2SE
Preferred Values	*NIST614*	***0.749***	*0.015*	***0.74***	*0.017*	***0.777***	*0.021*	***0.711***	*0.022*
Standard	NIST614-1-1	**0.741**	0.019	**0.723**	0.025	**0.739**	0.026	**0.701**	0.026
Standard	NIST614-1-2-1	**0.896**	0.031	**0.882**	0.037	**0.919**	0.033	**0.851**	0.037
Standard	NIST614-1-1	**0.733**	0.029	**0.71**	0.033	**0.743**	0.045	**0.73**	0.04
Standard	NIST614-1-2-1	**0.744**	0.028	**0.756**	0.034	**0.736**	0.037	**0.716**	0.035
Standard	NIST614-1-1	**0.69**	0.028	**0.693**	0.036	**0.705**	0.038	**0.628**	0.029
Standard	NIST614-1-2-1	**0.685**	0.024	**0.667**	0.028	**0.709**	0.036	**0.665**	0.038
Standard	NIST614-1	**0.785**	0.029	**0.768**	0.03	**0.79**	0.033	**0.73**	0.035
Standard	NIST614-2	**0.771**	0.03	**0.753**	0.036	**0.788**	0.035	**0.715**	0.034
Standard	NIST614-1	**0.786**	0.025	**0.781**	0.037	**0.768**	0.033	**0.725**	0.033
Standard	NIST614-2	**0.768**	0.027	**0.759**	0.028	**0.788**	0.036	**0.754**	0.033

Name	Sample #	Ta181	Int2SE	W182	Int2SE	W184	Int2SE	Pb204	Int2SE
Preferred Values	*NIST614*	***0.808***	*0.026*	***0.806***	*0.071*	***0.806***	*0.071*	***2.32***	*0.04*
Standard	NIST614-1-1	**0.743**	0.02	**0.8**	0.024	**0.835**	0.034	**2.34**	0.2

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Ta181	Int2SE	W182	Int2SE	W184	Int2SE	Pb204	Int2SE
Preferred Values	*NIST614*	***0.808***	*0.026*	***0.806***	*0.071*	***0.806***	*0.071*	***2.32***	*0.04*
Standard	NIST614-1-2-1	**0.888**	0.027	**0.773**	0.037	**0.79**	0.025	**2.87**	0.23
Standard	NIST614-1-1	**0.762**	0.027	**0.776**	0.037	**0.779**	0.033	**2.45**	0.16
Standard	NIST614-1-2-1	**0.782**	0.028	**0.812**	0.03	**0.784**	0.028	**2.45**	0.22
Standard	NIST614-1-1	**0.706**	0.026	**0.821**	0.029	**0.818**	0.032	**1.74**	0.35
Standard	NIST614-1-2-1	**0.715**	0.021	**0.785**	0.033	**0.784**	0.036	**3.31**	0.3
Standard	NIST614-1	**0.798**	0.027	**0.826**	0.041	**0.821**	0.03	**2.62**	0.2
Standard	NIST614-2	**0.775**	0.028	**0.827**	0.031	**0.814**	0.033	**2.56**	0.16
Standard	NIST614-1	**0.796**	0.027	**0.765**	0.024	**0.78**	0.021	**3.16**	0.18
Standard	NIST614-2	**0.811**	0.028	**0.773**	0.024	**0.783**	0.024	**3.16**	0.18
Name	**Sample #**	**Pb206**	**Int2SE**	**Pb207**	**Int2SE**	**Pb208**	**Int2SE**	**Bi209**	**Int2SE**
Preferred Values	*NIST614*	***2.32***	*0.04*	***2.32***	*0.04*	***2.32***	*0.04*	***0.581***	*0.043*
Standard	NIST614-1-1	**2.389**	0.065	**2.294**	0.068	**2.265**	0.053	**0.565**	0.018
Standard	NIST614-1-2-1	**2.504**	0.074	**2.409**	0.076	**2.421**	0.054	**0.629**	0.021
Standard	NIST614-1-1	**2.422**	0.075	**2.286**	0.079	**2.344**	0.075	**0.574**	0.017
Standard	NIST614-1-2-1	**2.471**	0.067	**2.336**	0.066	**2.379**	0.071	**0.587**	0.019
Standard	NIST614-1-1	**2.439**	0.08	**2.347**	0.075	**2.398**	0.077	**0.603**	0.019
Standard	NIST614-1-2-1	**2.49**	0.071	**2.359**	0.078	**2.396**	0.075	**0.589**	0.018
Standard	NIST614-1	**2.49**	0.07	**2.478**	0.06	**2.607**	0.063	**0.606**	0.016
Standard	NIST614-2	**2.519**	0.06	**2.468**	0.064	**2.482**	0.056	**0.602**	0.016
Standard	NIST614-1	**2.511**	0.062	**2.409**	0.053	**2.414**	0.046	**0.609**	0.013
Standard	NIST614-2	**2.484**	0.049	**2.373**	0.042	**2.438**	0.042	**0.606**	0.012

Table E.2: NIST 614 Standards for Elements Analysed Continued

Name	Sample #	Th232	Int2SE	U238	Int2SE
Preferred Values	*NIST614*	***0.748***	*0.006*	***0.823***	*0.002*
Standard	NIST614-1-1	**0.94**	0.4	**0.844**	0.026
Standard	NIST614-1-2-1	**0.44**	0.4	**0.893**	0.024
Standard	NIST614-1-1	**0.24**	0.22	**0.821**	0.026
Standard	NIST614-1-2-1	**0.96**	0.54	**0.835**	0.025
Standard	NIST614-1-1	**0.69**	0.34	**0.857**	0.03
Standard	NIST614-1-2-1	**0.54**	0.36	**0.866**	0.028
Standard	NIST614-1	**0.58**	0.29	**0.868**	0.028
Standard	NIST614-2	**0.91**	0.45	**0.849**	0.025
Standard	NIST614-1	**0.56**	0.2	**0.828**	0.016
Standard	NIST614-2	**0.6**	0.21	**0.82**	0.018

**Int2SE refers to the Standard Deviation for each Elemental Value. All quantities are in parts per million (ppm).*

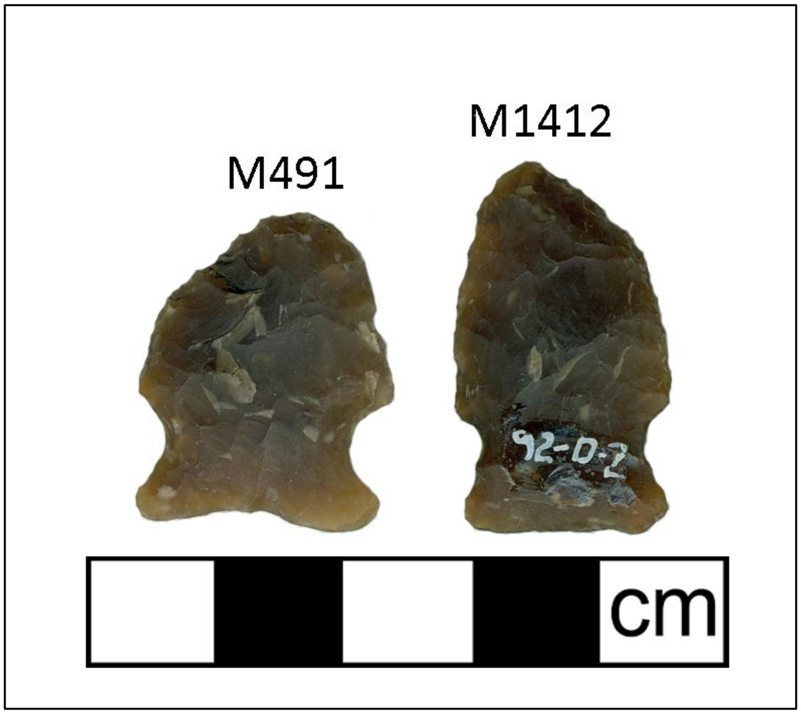

Figure F.1: Snyder II (DgMg-15) Artifacts

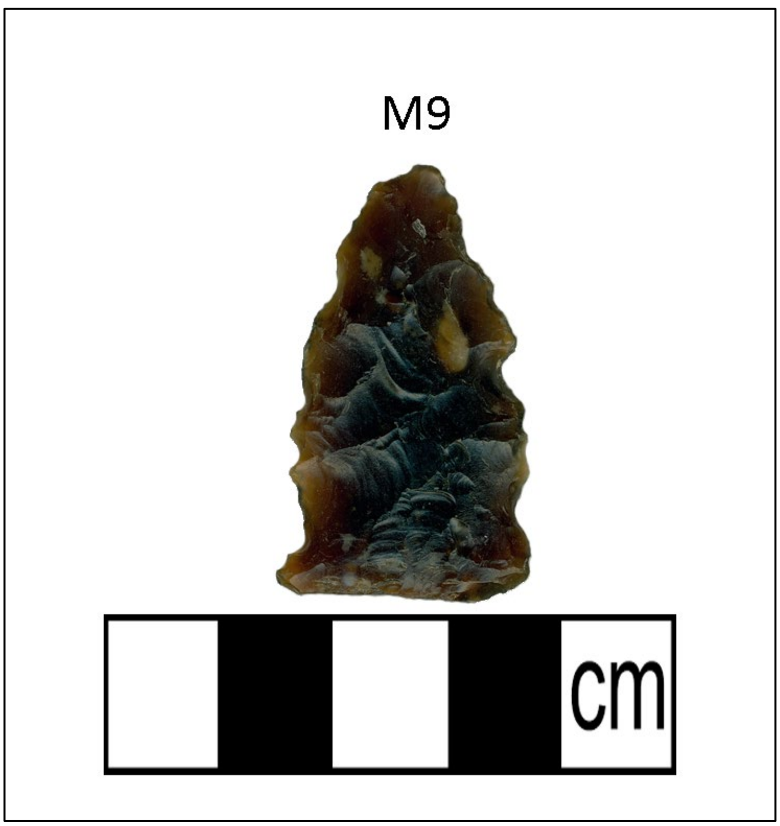

Figure F.2: Avery Site Projectile Point (DhLs-2)

Figure F.3: Richards Kill (DhLw-2) Artifacts

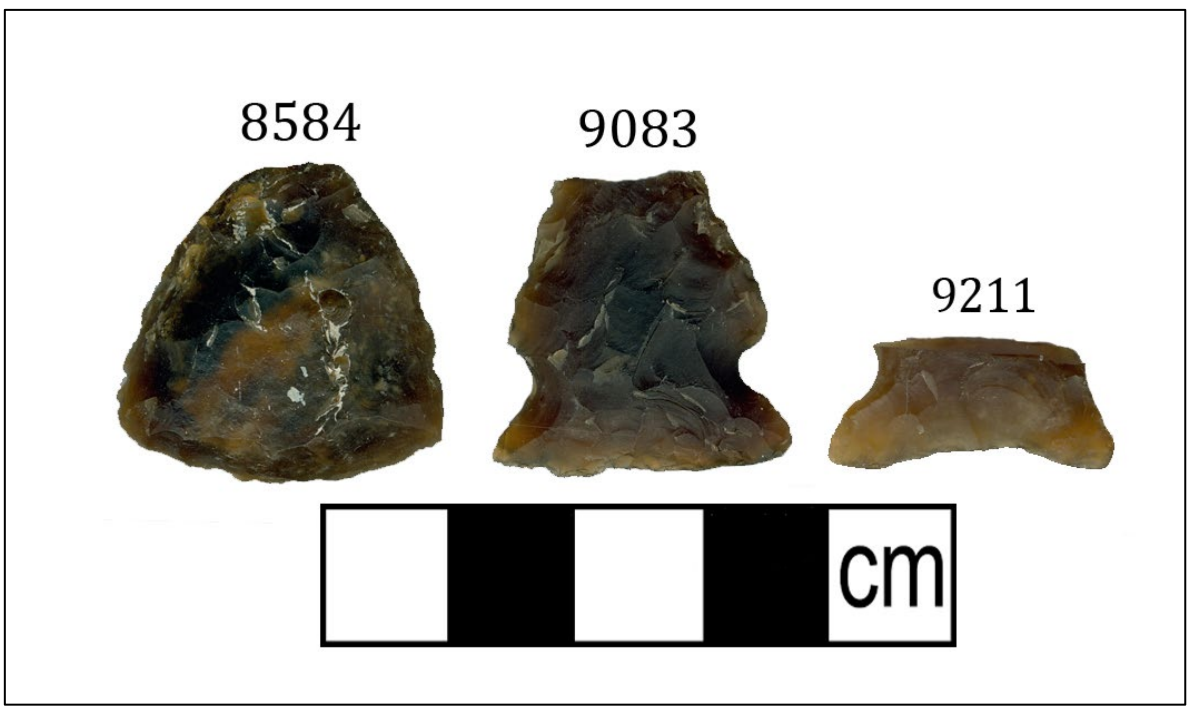

Figure F.4: Crane (DiMv-93) Artifacts

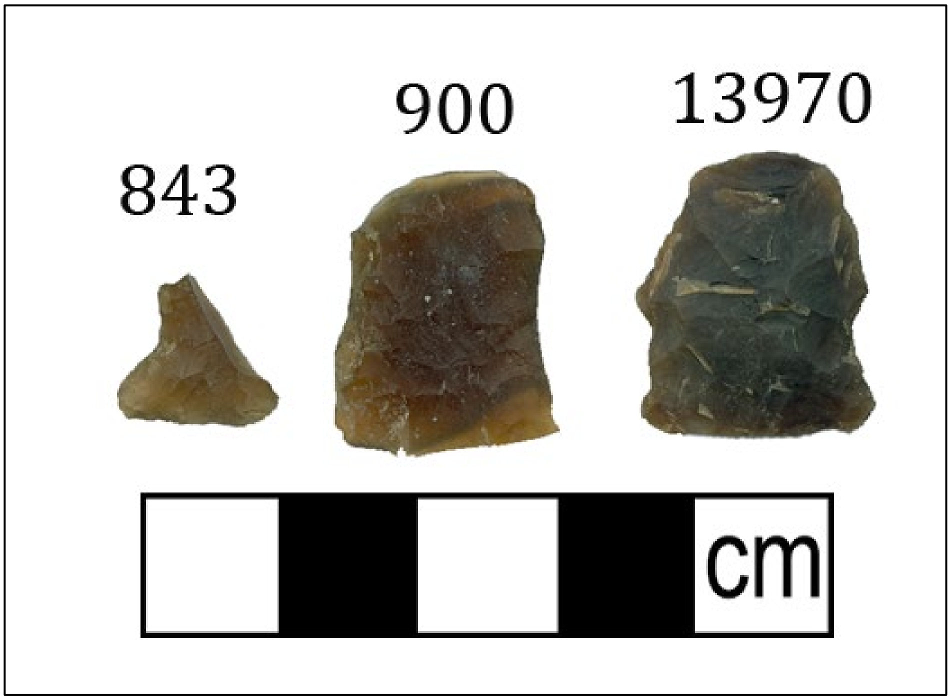

Figure F.5: Fincastle (DlOx-5) Artifacts

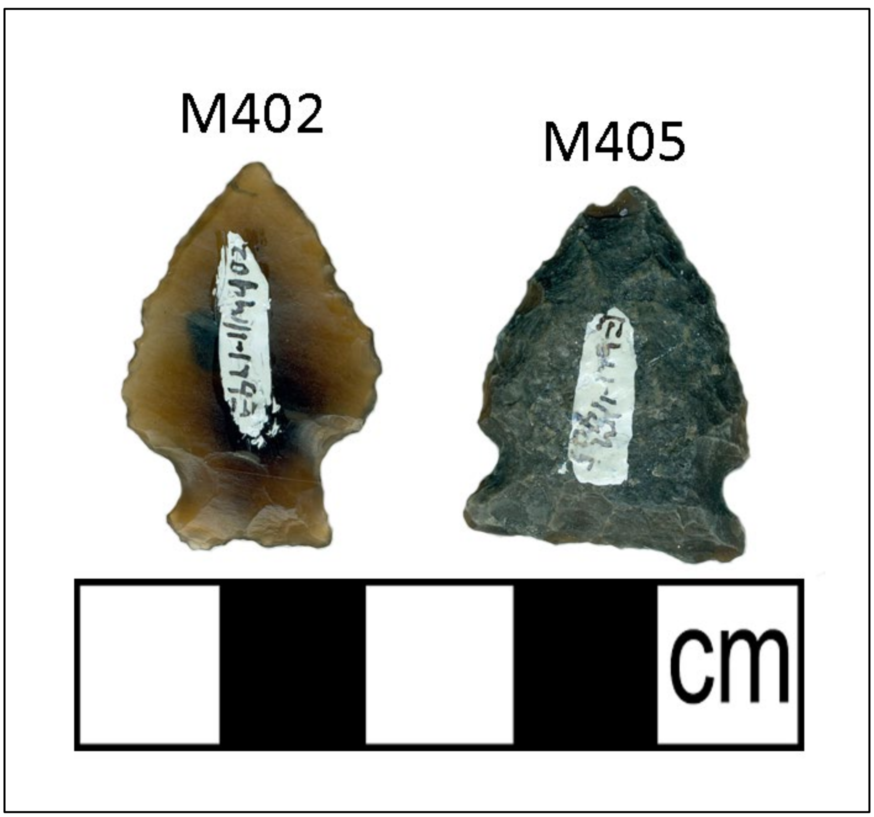

Figure F.6: Howden (EbLi-1) Artifacts

Figure F.7: Melhagen (EgNn-1) Artifacts

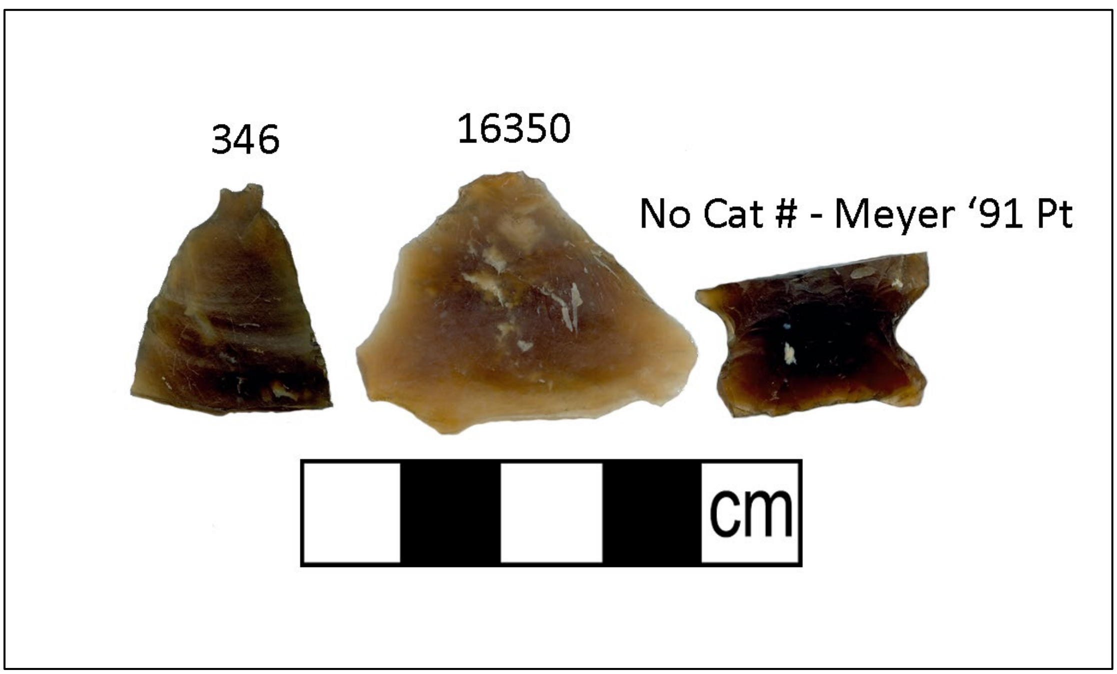

Figure F.8: Fitzgerald (ElNp-8) Artifacts

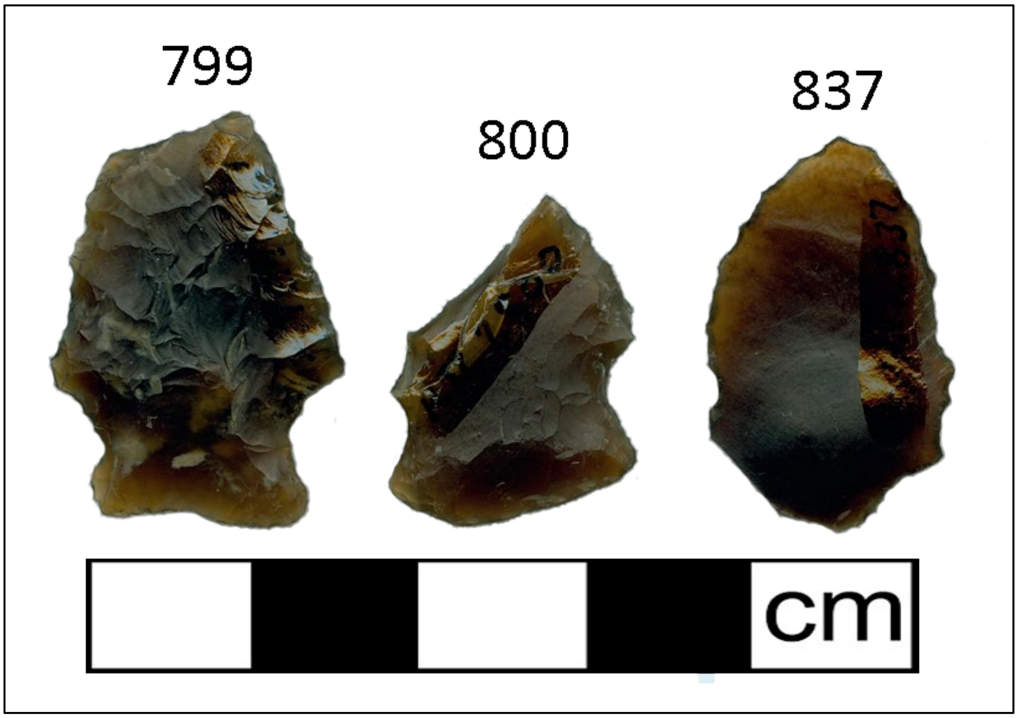

Figure F.9: Smith-Swainson (FeOw-1, 2, and 3) Artifacts

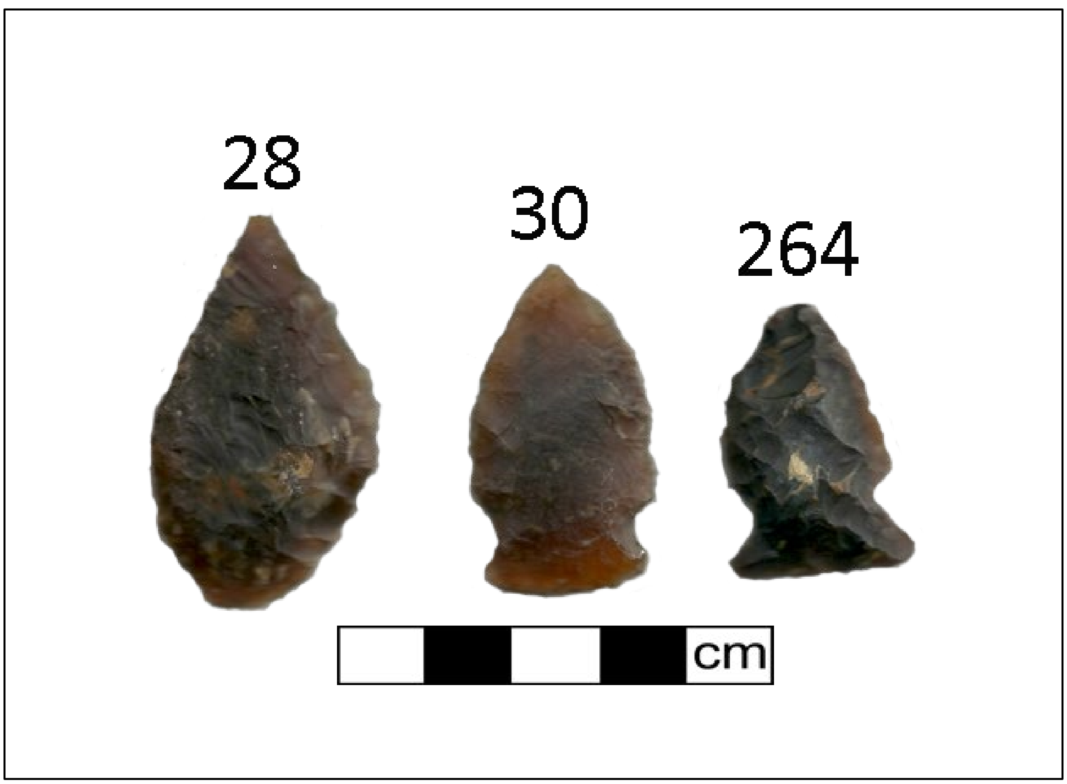

Figure F.10: Muhlbach (FbPf-1) Artifacts

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
1	BSK 1-1	0.07	9	0.02	8	2	0.03	0.014	5	1
2	BSK 1-2	0.02	53	0.02	3	6	0.04	0.011	2	<1
3	BSK 1-3	0.02	13	0.02	2	1	0.02	0.011	1	1
4	BSK 1-4	0.04	16	0.02	2	4	0.03	0.014	1	1
5	BSK 2-1	0.06	144	0.02	2	<1	0.02	0.014	1	8
6	BSK 2-2	0.05	127	0.04	3	7	0.09	0.021	2	8
7	BSK 2-3	0.06	512	0.03	1	3	0.11	0.017	1	10
8	BSK 3-1	0.01	8	<0.01	1	2	0.02	0.006	<1	<1
9	BSK 3-2	0.01	10	0.01	<1	3	0.01	0.007	<1	1
10	BSK 3-3	0.02	87	0.01	1	1	0.02	0.008	1	1
11	Crowley	0.09	28	0.05	37	38	0.08	0.025	17	3
12	Frank SSKR 1-1	0.02	353	0.01	5	2	0.11	0.01	3	<1
13	Frank Wd MTN 1-1	0.02	8	0.02	2	3	0.07	0.01	<1	<1
14	HH 1-1	0.1	14	0.01	4	<1	0.03	0.027	2	2
15	HH 1-2	0.09	14	0.01	5	1	0.03	0.026	2	2
16	HH 1-3	0.11	22	0.02	3	<1	0.05	0.033	1	2
17	HH 1-4	0.12	24	0.02	2	2	0.03	0.034	1	3
18	HH 1-5	0.09	14	0.02	1	5	0.04	0.03	<1	2
19	HH 1-6	0.1	13	0.02	3	5	0.07	0.032	1	2

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
20	HH 1-7	0.11	12	0.02	3	6	0.06	0.03	2	2
21	HH 1-8	0.1	12	0.02	9	4	0.02	0.03	4	2
22	Horse Nose Butte	0.07	69	0.06	3	29	0.04	0.017	1	1
23	JH1-1	0.1	14	0.01	7	1	<0.01	0.035	1	3
24	JH1-2	0.06	13	0.01	58	1	<0.01	0.023	7	1
25	JH1-3	0.06	10	0.01	19	1	0.05	0.023	3	1
26	JH1-4	0.06	10	0.01	11	1	0.02	0.022	2	1
27	JH2-1	0.02	14	<0.01	3	1	0.03	0.01	<1	<1
28	JH2-2	0.02	4	<0.01	5	5	0.03	0.01	1	<1
29	JH2-3	0.02	4	<0.01	3	5	0.08	0.011	<1	<1
30	JH2-4	0.01	4	<0.01	4	4	0.05	0.01	1	<1
31	kakwa	0.08	43	0.02	4	25	0.04	0.024	2	2
32	JH2-1 R	0.02	13	<0.01	4	1	0.02	0.01	1	<1
33	Lynch Quarries N=1	0.11	68	0.18	2	27	0.07	0.029	<1	2
34	Lynch Quarries N=2	0.08	54	0.02	3	24	0.04	0.028	1	2
35	Medicine Butte ND	0.1	38	0.02	3	33	0.05	0.026	1	4
36	MT (HT?) Agate 1-1	0.08	12	0.02	2	2	0.04	0.024	1	2
37	MTA 1-2	0.1	18	0.02	1	1	0.01	0.026	<1	3

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
38	MTA 1-3	0.08	8	0.02	1	1	0.02	0.038	<1	2
39	NI TXX	0.13	40	0.08	7	24	0.05	0.027	3	<1
40	Petr-Wd 1-1	0.03	15	0.01	1	2	0.04	0.012	<1	1
41	Petrified wood	0.04	38	0.03	9	41	0.3	0.01	6	<1
42	PW 1-2	0.04	22	0.01	<1	2	0.03	0.014	<1	1
43	PW 1-3	0.07	20	0.01	<1	1	0.02	0.022	<1	2
44	PW 1-4	0.05	529	0.02	2	7	0.68	0.014	1	<1
45	PW 1-5	0.06	735	0.02	2	6	0.89	0.015	1	<1
46	SC 1-1	0.18	60	0.34	21	2	0.02	0.026	13	9
47	SC 1-2	0.2	105	0.08	4	7	0.02	0.03	2	12
48	SC 1-3	0.19	195	0.26	20	2	<0.01	0.027	10	10
49	SC 2-1	0.23	1770	0.5	37	2	<0.01	0.032	21	12
50	SC 2-2	0.24	5	0.3	19	1	<0.01	0.032	11	14
51	SC 2-3	0.22	153	0.07	6	1	<0.01	0.032	2	13
52	SC 2-4	0.22	126	0.05	5	5	0.03	0.036	2	12
53	Souris 1-1	0.07	20	0.01	<1	9	0.02	0.019	<1	1
54	Souris 1-2	0.08	44	0.01	<1	1	<0.01	0.021	<1	1
55	Souris 1-3	0.07	14	0.01	<1	1	<0.01	0.02	<1	1

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
56	Souris 1-4	0.06	76	0.01	<1	1	<0.01	0.017	<1	1
57	Souris 1-5	0.08	29	0.01	<1	2	0.01	0.024	<1	1
58	Souris 2-1	0.06	97	0.09	<1	2	0.01	0.021	<1	1
59	Souris 2-2	0.07	191	0.02	<1	2	0.12	0.02	<1	2
60	Souris 2-3	0.06	114	<0.01	<1	6	0.06	0.02	<1	2
61	Souris 2-4	0.06	169	0.03	<1	1	0.05	0.019	<1	2
62	Souris 2-5	0.06	107	0.02	<1	3	0.01	0.019	<1	2
63	Souris 3-1	0.07	14	0.02	<1	3	<0.01	0.022	<1	1
64	Souris 3-2	0.08	10	0.02	<1	2	<0.01	0.022	<1	1
65	Souris 3-3	0.07	17	0.01	<1	2	<0.01	0.02	<1	1
66	Souris 3-4	0.07	14	0.01	<1	7	0.03	0.02	<1	1
67	Souris 3-5	0.08	19	0.02	<1	34	0.04	0.022	<1	1
68	Souris 4-1	0.08	11	0.01	<1	13	0.04	0.023	<1	1
69	Souris 4-2	0.08	31	0.01	<1	1	<0.01	0.021	<1	1
70	Souris 3-2 R	0.08	10	0.02	<1	2	<0.01	0.022	<1	1
71	Souris 4-3	0.1	11	0.02	<1	4	0.1	0.029	<1	1
72	Souris 4-4	0.08	42	0.01	<1	1	<0.01	0.022	<1	1
73	SSKR 1-2	0.02	329	0.01	2	2	0.05	0.01	1	<1

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
74	SSKR 1-3	0.02	279	0.01	4	2	0.14	0.01	2	<1
75	WHC 1-1	0.15	34	0.17	2	86	0.12	0.051	1	11
76	WHC 1-2	0.14	3	0.18	1	2	0.01	0.042	1	10
77	WHC 1-3	0.16	5	0.11	1	5	0.02	0.047	<1	12
78	WHC 1-4	0.16	7	0.17	1	4	0.04	0.047	<1	10
79	WHC 10-1	0.11	3	0.12	2	2	0.03	0.032	1	7
80	WHC 10-2	0.11	2	0.19	2	2	0.08	0.032	1	6
81	WHC 10-3	0.09	6	0.15	2	1	<0.01	0.029	1	5
82	WHC 10-4	0.12	3	0.15	2	2	<0.01	0.036	1	9
83	WHC 2	0.03	2	0.03	<1	2	0.09	0.026	<1	2
84	WHC 2-2	0.05	6	0.07	<1	2	0.12	0.03	<1	2
85	WHC 2-3	0.21	25	0.45	1	2	0.1	0.058	<1	3
86	WHC 3-1	0.12	5	0.04	<1	1	0.05	0.038	<1	7
87	WHC 3-2	0.12	3	0.11	1	2	0.06	0.036	<1	6
88	WHC 3-3	0.12	3	0.05	<1	2	0.06	0.038	<1	6
89	WHC 4-1	0.08	2	0.04	<1	2	0.06	0.028	<1	5
90	WHC 4-2	0.09	1	0.06	<1	2	0.07	0.03	<1	5
91	WHC 8-1	0.09	5	0.34	<1	2	0.04	0.03	<1	6

Appendix G: Source Samples Raw Data

#	Sample Name	Al2O3 ICP Total Digestion	Ba ICP Total Digestion	CaO ICP Total Digestion	Ce ICP Total Digestion	Cr ICP Total Digestion	Fe2O3 ICP Total Digestion	K2O ICP Total Digestion	La ICP Total Digestion	Li ICP Total Digestion
		wt %	ppm	wt %	ppm	ppm	wt %	wt %	ppm	ppm
92	WHC 8-2	0.05	1	0.02	<1	1	0.03	0.021	<1	3
93	WM 1-2	0.04	34	0.02	<1	5	0.23	0.014	<1	<1
94	WM 1-3	0.05	64	0.02	1	5	0.43	0.012	1	<1
95	WM 1-4	0.02	91	0.03	1	8	1.25	0.008	2	<1
96	WM 1-5	0.02	47	0.02	4	5	0.46	0.009	1	<1
97	WM 1-6	0.03	74	0.03	5	8	2.65	0.01	1	<1
98	WHC 8-1 R	0.09	6	0.35	<1	2	0.04	0.031	<1	6

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
1	BSK 1-1	0.004	<0.001	0.01	<0.002	1	0.012	8	0.1	0.2
2	BSK 1-2	0.004	<0.001	0.01	<0.002	5	<0.002	7	0.08	0.3
3	BSK 1-3	0.003	<0.001	<0.01	<0.002	2	<0.002	5	0.06	0.1
4	BSK 1-4	0.003	<0.001	0.02	<0.002	2	0.017	3	0.05	0.2

Appendix G: Source Samples Raw Data

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
5	BSK 2-1	0.004	<0.001	0.02	<0.002	8	<0.002	5	0.05	<0.1
6	BSK 2-2	0.015	<0.001	0.02	<0.002	8	<0.002	5	0.06	<0.1
7	BSK 2-3	0.004	0.003	0.02	<0.002	29	<0.002	5	0.04	<0.1
8	BSK 3-1	<0.002	<0.001	<0.01	<0.002	1	<0.002	23	0.04	0.1
9	BSK 3-2	<0.002	<0.001	<0.01	<0.002	1	<0.002	15	0.04	<0.1
10	BSK 3-3	0.002	<0.001	0.01	<0.002	5	<0.002	19	0.04	0.1
11	Crowley	0.007	<0.001	0.03	<0.002	3	0.008	68	0.11	0.4
12	Frank SSKR 1-1	0.003	<0.001	<0.01	<0.002	10	<0.002	45	0.02	0.2
13	Frank Wd MTN 1-1	0.006	0.002	0.01	<0.002	1	<0.002	1	0.06	0.2
14	HH 1-1	0.007	<0.001	0.02	<0.002	3	<0.002	4	0.12	0.6
15	HH 1-2	0.005	<0.001	0.02	<0.002	2	<0.002	4	0.09	0.5
16	HH 1-3	0.006	<0.001	0.03	<0.002	4	<0.002	7	0.13	0.7
17	HH 1-4	0.007	<0.001	0.03	<0.002	3	<0.002	7	0.09	0.6
18	HH 1-5	0.007	<0.001	0.05	<0.002	2	<0.002	6	0.16	0.5
19	HH 1-6	0.007	<0.001	0.03	<0.002	2	<0.002	145	0.1	0.4
20	HH 1-7	0.007	<0.001	0.03	<0.002	2	<0.002	5	0.09	0.4
21	HH 1-8	0.006	<0.001	0.05	0.003	3	<0.002	4	0.04	0.5
22	Horse Nose Butte	0.013	<0.001	0.02	<0.002	6	<0.002	18	0.04	<0.1
23	JH1-1	0.003	<0.001	0.02	<0.002	2	<0.002	2	0.03	0.2
24	JH1-2	0.003	<0.001	0.01	0.01	3	<0.002	<1	0.04	0.2

Appendix G: Source Samples Raw Data

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
25	JH1-3	0.004	<0.001	0.01	0.003	2	<0.002	1	0.04	<0.1
26	JH1-4	0.004	<0.001	0.01	0.002	1	<0.002	1	0.03	0.1
27	JH2-1	0.002	<0.001	<0.01	<0.002	2	<0.002	<1	<0.02	0.2
28	JH2-2	<0.002	<0.001	0.01	<0.002	1	<0.002	<1	<0.02	0.6
29	JH2-3	<0.002	<0.001	0.01	<0.002	<1	<0.002	<1	<0.02	0.6
30	JH2-4	<0.002	<0.001	0.02	<0.002	<1	<0.002	4	<0.02	0.7
31	kakwa	0.007	<0.001	0.04	<0.002	1	<0.002	16	0.03	0.7
32	JH2-1 R	<0.002	<0.001	<0.01	<0.002	1	<0.002	<1	<0.02	0.1
33	Lynch Quarries N=1	0.01	<0.001	0.02	<0.002	5	0.003	12	0.1	0.1
34	Lynch Quarries N=2	0.003	<0.001	0.02	<0.002	3	<0.002	6	0.06	0.2
35	Medicine Butte ND	0.004	<0.001	0.02	<0.002	2	<0.002	17	0.04	0.3
36	MT (HT?) Agate 1-1	0.004	<0.001	0.02	<0.002	3	<0.002	2	0.03	0.1
37	MTA 1-2	0.004	<0.001	0.02	<0.002	4	<0.002	2	0.03	0.2
38	MTA 1-3	0.004	<0.001	0.04	<0.002	3	<0.002	3	0.02	0.2
39	NI TXX	0.007	0.002	0.05	0.002	6	<0.002	12	0.05	0.1
40	Petr-Wd 1-1	0.002	<0.001	<0.01	<0.002	1	<0.002	3	<0.02	<0.1
41	Petrified wood	0.009	0.002	<0.01	0.006	3	<0.002	5	0.09	0.1
42	PW 1-2	0.003	0.002	<0.01	<0.002	1	<0.002	6	<0.02	<0.1
43	PW 1-3	0.004	<0.001	0.01	<0.002	2	<0.002	9	<0.02	<0.1
44	PW 1-4	0.01	0.001	<0.01	0.014	14	<0.002	2	0.03	0.2

Appendix G: Source Samples Raw Data

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
45	PW 1-5	0.013	0.002	<0.01	0.014	19	0.002	6	<0.02	0.1
46	SC 1-1	<0.002	<0.001	0.08	0.248	13	0.008	2	<0.02	1.4
47	SC 1-2	<0.002	<0.001	0.08	0.041	10	0.008	2	<0.02	1
48	SC 1-3	0.002	<0.001	0.08	0.189	21	0.008	2	<0.02	1.4
49	SC 2-1	<0.002	<0.001	0.09	0.383	159	0.012	2	<0.02	1.4
50	SC 2-2	<0.002	<0.001	0.1	0.222	8	0.008	2	<0.02	1.2
51	SC 2-3	<0.002	<0.001	0.08	0.04	14	0.008	2	<0.02	1.1
52	SC 2-4	0.002	<0.001	0.1	0.026	12	0.009	3	0.25	1.1
53	Souris 1-1	0.004	<0.001	0.02	<0.002	2	<0.002	1	0.06	0.3
54	Souris 1-2	0.004	<0.001	0.02	<0.002	3	<0.002	1	0.05	0.4
55	Souris 1-3	0.003	<0.001	0.02	<0.002	2	<0.002	1	0.04	0.3
56	Souris 1-4	0.003	<0.001	0.02	<0.002	5	<0.002	<1	0.02	0.4
57	Souris 1-5	0.003	<0.001	0.03	<0.002	3	<0.002	1	<0.02	0.5
58	Souris 2-1	0.005	<0.001	0.02	<0.002	9	<0.002	4	0.06	<0.1
59	Souris 2-2	0.005	<0.001	0.02	<0.002	15	<0.002	3	0.05	<0.1
60	Souris 2-3	0.004	<0.001	0.02	<0.002	11	<0.002	5	0.1	<0.1
61	Souris 2-4	0.004	<0.001	0.02	<0.002	15	<0.002	4	0.05	<0.1
62	Souris 2-5	0.005	<0.001	0.06	<0.002	11	<0.002	5	0.06	<0.1
63	Souris 3-1	0.003	<0.001	0.02	<0.002	2	<0.002	1	0.02	0.3
64	Souris 3-2	0.003	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.4

Appendix G: Source Samples Raw Data

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
65	Souris 3-3	0.003	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.2
66	Souris 3-4	0.004	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.4
67	Souris 3-5	0.004	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.4
68	Souris 4-1	0.003	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.4
69	Souris 4-2	0.004	<0.001	0.02	<0.002	3	<0.002	1	0.02	0.4
70	Souris 3-2 R	0.004	<0.001	0.02	<0.002	2	<0.002	1	<0.02	0.4
71	Souris 4-3	0.008	<0.001	0.02	<0.002	2	<0.002	2	0.41	0.1
72	Souris 4-4	0.004	<0.001	0.02	<0.002	4	<0.002	1	0.08	0.4
73	SSKR 1-2	0.003	<0.001	<0.01	<0.002	9	<0.002	42	0.06	0.2
74	SSKR 1-3	0.003	<0.001	<0.01	<0.002	10	<0.002	43	0.05	0.1
75	WHC 1-1	0.006	0.003	0.05	0.007	6	0.006	8	0.23	<0.1
76	WHC 1-2	0.006	0.002	0.05	0.006	4	0.006	7	0.17	<0.1
77	WHC 1-3	0.006	0.001	0.06	0.009	3	0.006	9	0.33	<0.1
78	WHC 1-4	0.007	0.002	0.05	0.006	4	0.007	11	0.2	<0.1
79	WHC 10-1	0.003	0.001	0.04	0.014	3	0.005	4	0.07	<0.1
80	WHC 10-2	0.005	0.002	0.04	0.016	4	0.004	4	0.08	<0.1
81	WHC 10-3	0.004	0.001	0.04	0.012	3	0.004	4	0.07	0.1
82	WHC 10-4	0.004	0.001	0.05	0.013	4	0.005	5	0.08	<0.1
83	WHC 2	0.002	<0.001	0.03	0.01	2	<0.002	<1	0.02	<0.1
84	WHC 2-2	0.004	<0.001	0.03	0.008	3	<0.002	<1	0.04	<0.1

Appendix G: Source Samples Raw Data

#	Sample Name	MgO ICP Total Digestion	MnO ICP Total Digestion	Na2O ICP Total Digestion	P2O5 ICP Total Digestion	Sr ICP Total Digestion	TiO2 ICP Total Digestion	Zr ICP Total Digestion	Ag ICP MS Total Digestion	Be ICP MS Total Digestion
		wt %	wt %	wt %	wt %	ppm	wt %	ppm	ppm	ppm
85	WHC 2-3	0.016	0.004	0.06	0.014	17	0.004	4	0.07	<0.1
86	WHC 3-1	0.005	<0.001	0.04	0.014	3	0.006	5	0.03	0.2
87	WHC 3-2	0.004	<0.001	0.04	0.021	4	0.006	2	0.04	0.2
88	WHC 3-3	0.004	<0.001	0.05	0.02	4	0.006	3	0.03	0.2
89	WHC 4-1	0.003	<0.001	0.04	0.006	2	0.004	1	0.02	0.1
90	WHC 4-2	0.003	<0.001	0.04	0.005	2	0.004	1	0.08	<0.1
91	WHC 8-1	0.005	0.003	0.04	0.011	4	0.003	2	0.08	0.2
92	WHC 8-2	0.002	<0.001	0.03	0.008	1	0.002	3	0.07	0.2
93	WM 1-2	0.009	0.013	0.01	0.003	2	<0.002	1	0.26	0.2
94	WM 1-3	0.008	0.025	0.02	<0.002	3	<0.002	1	0.17	0.2
95	WM 1-4	0.014	0.008	<0.01	0.013	4	<0.002	16	0.22	0.5
96	WM 1-5	0.008	0.024	<0.01	0.005	3	<0.002	3	0.18	0.3
97	WM 1-6	0.024	0.022	0.01	0.013	4	<0.002	1	0.23	0.5
98	WHC 8-1 R	0.005	0.003	0.04	0.012	5	0.004	2	0.06	<0.1

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	BSK 1-1	0.1	<0.1	0.11	<0.1	1.6	0.58	0.43	0.07	0.1
2	BSK 1-2	0.1	<0.1	0.24	<0.1	2.4	0.38	0.26	0.06	<0.1
3	BSK 1-3	0.1	<0.1	0.09	<0.1	2.1	0.18	0.13	0.03	0.1
4	BSK 1-4	0.1	<0.1	0.14	<0.1	2.8	0.21	0.16	0.03	<0.1
5	BSK 2-1	0.1	<0.1	0.09	<0.1	0.3	0.15	0.11	0.05	0.3
6	BSK 2-2	0.1	<0.1	0.31	<0.1	1.5	0.26	0.19	0.06	0.3
7	BSK 2-3	0.1	<0.1	0.28	<0.1	1.8	0.16	0.11	0.12	0.1
8	BSK 3-1	0.1	<0.1	0.07	<0.1	0.7	0.08	0.06	<0.02	0.5
9	BSK 3-2	0.1	<0.1	0.06	<0.1	0.5	0.06	0.04	<0.02	0.2
10	BSK 3-3	0.1	<0.1	0.08	<0.1	0.6	0.09	0.08	0.04	0.2
11	Crowley	0.1	<0.1	0.11	<0.1	2.2	3.49	2.7	0.44	<0.1
12	Frank SSKR 1-1	0.1	<0.1	0.14	<0.1	0.9	0.3	0.14	0.16	<0.1
13	Frank Wd MTN 1-1	0.1	<0.1	0.1	<0.1	0.8	0.13	0.08	0.03	<0.1
14	HH 1-1	0.2	<0.1	0.08	<0.1	2.5	0.51	0.21	0.15	<0.1
15	HH 1-2	0.2	<0.1	0.06	<0.1	2.7	0.61	0.24	0.18	<0.1
16	HH 1-3	0.3	<0.1	0.06	<0.1	2	0.31	0.14	0.1	<0.1
17	HH 1-4	0.1	<0.1	0.08	<0.1	2.1	0.26	0.12	0.09	<0.1
18	HH 1-5	0.5	<0.1	0.1	<0.1	3.1	0.65	0.48	0.11	<0.1
19	HH 1-6	0.5	<0.1	0.2	<0.1	4.2	0.32	0.18	0.08	<0.1
20	HH 1-7	0.3	<0.1	0.13	<0.1	2.2	0.29	0.12	0.07	<0.1

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
21	HH 1-8	0.3	<0.1	0.06	<0.1	4.3	0.91	0.38	0.27	<0.1
22	Horse Nose Butte	0.1	<0.1	0.12	<0.1	0.8	0.29	0.22	0.06	0.1
23	JH1-1	0.1	<0.1	0.02	<0.1	0.7	0.82	0.36	0.23	<0.1
24	JH1-2	0.1	<0.1	0.05	<0.1	0.5	4.98	2.49	1.46	<0.1
25	JH1-3	0.1	<0.1	0.1	<0.1	1.5	1.9	0.89	0.58	<0.1
26	JH1-4	0.1	<0.1	0.05	<0.1	0.6	1.44	0.7	0.4	<0.1
27	JH2-1	0.1	<0.1	0.08	<0.1	0.9	0.57	0.32	0.12	<0.1
28	JH2-2	0.1	<0.1	0.15	<0.1	1.8	1.04	0.61	0.2	<0.1
29	JH2-3	0.1	<0.1	0.72	<0.1	2.2	0.57	0.36	0.09	<0.1
30	JH2-4	0.1	<0.1	0.26	<0.1	1.9	1.01	0.65	0.18	<0.1
31	kakwa	0.1	<0.1	0.08	<0.1	3.4	0.21	0.2	0.03	<0.1
32	JH2-1 R	0.1	<0.1	0.1	<0.1	0.8	0.6	0.4	0.14	<0.1
33	Lynch Quarries N=1	0.2	<0.1	0.14	<0.1	2.1	0.21	0.16	0.05	0.1
34	Lynch Quarries N=2	0.1	<0.1	0.06	<0.1	1.2	0.31	0.21	0.08	<0.1
35	Medicine Butte ND	0.1	<0.1	0.09	<0.1	1.3	0.62	0.5	0.1	<0.1
36	MT (HT?) Agate 1-1	0.2	<0.1	0.08	<0.1	2	0.35	0.22	0.09	<0.1
37	MTA 1-2	0.1	<0.1	0.04	<0.1	1.1	0.15	0.11	0.04	<0.1
38	MTA 1-3	0.1	<0.1	0.04	<0.1	1.6	0.18	0.12	0.05	<0.1
39	NI TXX	0.1	<0.1	0.1	<0.1	0.9	1.25	0.91	0.13	0.3

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
40	Petr-Wd 1-1	0.1	<0.1	0.07	<0.1	2	0.17	0.08	0.05	<0.1
41	Petrified wood	0.1	<0.1	1.12	<0.1	3.5	0.26	0.19	0.05	0.4
42	PW 1-2	0.1	<0.1	0.07	<0.1	1.4	0.12	0.06	0.04	<0.1
43	PW 1-3	0.1	<0.1	0.02	<0.1	0.9	0.11	0.05	0.03	<0.1
44	PW 1-4	0.3	<0.1	1.06	<0.1	2.5	0.22	0.14	0.16	0.1
45	PW 1-5	0.1	<0.1	1.66	<0.1	2.9	0.26	0.17	0.23	0.2
46	SC 1-1	0.2	<0.1	0.08	<0.1	2.6	2.73	1.78	0.39	0.4
47	SC 1-2	0.2	<0.1	0.17	<0.1	10	0.67	0.38	0.13	0.4
48	SC 1-3	0.2	<0.1	0.14	<0.1	10.1	2.64	1.61	0.41	0.6
49	SC 2-1	0.2	<0.1	0.12	<0.1	4.5	5.47	3.28	1.17	<0.1
50	SC 2-2	0.2	<0.1	0.06	<0.1	2.4	2.65	1.62	0.36	0.3
51	SC 2-3	0.2	<0.1	0.08	<0.1	4.8	0.81	0.45	0.16	0.2
52	SC 2-4	0.5	<0.1	0.14	<0.1	6.1	0.62	0.37	0.14	0.4
53	Souris 1-1	0.1	<0.1	0.14	<0.1	0.9	0.06	0.03	0.02	<0.1
54	Souris 1-2	0.1	<0.1	0.03	<0.1	0.6	0.09	0.03	0.03	<0.1
55	Souris 1-3	0.1	<0.1	0.02	<0.1	0.5	0.1	0.06	0.03	<0.1
56	Souris 1-4	0.1	<0.1	0.02	<0.1	0.4	0.12	0.05	0.05	<0.1
57	Souris 1-5	0.1	<0.1	0.04	<0.1	0.6	0.08	0.03	0.03	<0.1
58	Souris 2-1	0.1	<0.1	0.04	<0.1	0.2	0.06	0.03	0.04	0.2

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
59	Souris 2-2	0.1	<0.1	0.16	<0.1	1.2	0.1	0.04	0.06	0.3
60	Souris 2-3	0.5	<0.1	0.13	<0.1	1.4	0.06	0.04	0.05	0.2
61	Souris 2-4	0.1	<0.1	0.08	<0.1	0.7	0.08	0.03	0.06	0.3
62	Souris 2-5	0.4	<0.1	0.14	<0.1	0.4	0.1	0.05	0.05	0.2
63	Souris 3-1	0.1	<0.1	<0.02	<0.1	2.4	0.06	0.04	<0.02	<0.1
64	Souris 3-2	0.1	<0.1	<0.02	<0.1	1.4	0.06	0.03	<0.02	<0.1
65	Souris 3-3	0.1	<0.1	0.02	<0.1	0.9	0.08	0.03	0.03	<0.1
66	Souris 3-4	0.1	<0.1	0.1	<0.1	1.7	0.07	0.04	0.02	<0.1
67	Souris 3-5	0.1	<0.1	0.37	<0.1	1.9	0.06	0.03	0.02	<0.1
68	Souris 4-1	0.1	<0.1	0.16	<0.1	1.6	0.03	<0.02	<0.02	<0.1
69	Souris 4-2	0.1	<0.1	0.03	<0.1	0.5	0.06	0.02	0.02	<0.1
70	Souris 3-2 R	0.1	<0.1	<0.02	<0.1	1.5	0.07	0.03	<0.02	<0.1
71	Souris 4-3	0.5	<0.1	0.16	<0.1	3.6	0.08	0.05	0.02	<0.1
72	Souris 4-4	0.1	<0.1	0.03	<0.1	0.8	0.12	0.05	0.05	<0.1
73	SSKR 1-2	0.1	<0.1	0.07	<0.1	0.6	0.19	0.08	0.12	<0.1
74	SSKR 1-3	0.1	<0.1	0.18	<0.1	1	0.26	0.1	0.14	<0.1
75	WHC 1-1	0.5	<0.1	1.03	<0.1	6.6	0.17	0.14	0.04	0.4
76	WHC 1-2	0.3	<0.1	0.07	<0.1	3.8	0.16	0.11	0.02	0.3
77	WHC 1-3	0.5	<0.1	0.1	<0.1	6.3	0.2	0.11	0.02	0.4

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
78	WHC 1-4	0.4	<0.1	0.11	<0.1	3.3	0.16	0.09	0.03	0.5
79	WHC 10-1	0.1	<0.1	0.07	<0.1	2.8	0.21	0.16	0.03	0.3
80	WHC 10-2	0.1	<0.1	0.14	<0.1	4	0.24	0.16	0.03	0.3
81	WHC 10-3	0.1	<0.1	0.04	<0.1	2	0.2	0.14	0.02	0.3
82	WHC 10-4	0.2	<0.1	0.04	<0.1	3.6	0.21	0.15	0.03	0.4
83	WHC 2	0.1	<0.1	0.06	<0.1	1.2	0.02	<0.02	<0.02	<0.1
84	WHC 2-2	0.1	<0.1	0.1	<0.1	1.9	0.04	0.03	<0.02	0.1
85	WHC 2-3	0.4	<0.1	0.14	<0.1	1.6	0.15	0.09	0.02	0.4
86	WHC 3-1	0.2	<0.1	0.02	<0.1	1.1	0.05	0.03	<0.02	0.4
87	WHC 3-2	0.1	<0.1	0.04	<0.1	1.9	0.1	0.06	<0.02	0.2
88	WHC 3-3	0.2	<0.1	0.05	<0.1	1	0.08	0.05	<0.02	0.3
89	WHC 4-1	0.2	<0.1	0.03	<0.1	1.4	0.05	0.03	<0.02	0.2
90	WHC 4-2	0.2	<0.1	0.04	<0.1	1.1	0.04	0.03	<0.02	0.2
91	WHC 8-1	0.1	<0.1	0.04	<0.1	1.1	0.03	0.02	<0.02	0.2
92	WHC 8-2	0.2	<0.1	<0.02	<0.1	0.4	0.02	<0.02	<0.02	0.2
93	WM 1-2	0.3	<0.1	0.31	<0.1	3.3	0.22	0.17	0.06	<0.1
94	WM 1-3	0.2	<0.1	0.83	<0.1	4	0.28	0.16	0.07	0.1
95	WM 1-4	0.1	<0.1	0.74	<0.1	11.4	1.35	0.88	0.27	<0.1
96	WM 1-5	0.1	<0.1	0.6	<0.1	5.3	0.59	0.35	0.14	<0.1

Appendix G: Source Samples Raw Data

#	Sample Name	Bi ICP MS Total Digestion	Cd ICP MS Total Digestion	Co ICP MS Total Digestion	Cs ICP MS Total Digestion	Cu ICP MS Total Digestion	Dy ICP MS Total Digestion	Er ICP MS Total Digestion	Eu ICP MS Total Digestion	Ga ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
97	WM 1-6	0.2	0.2	3.67	<0.1	11.1	1.18	0.89	0.22	0.1
98	WHC 8-1 R	0.1	<0.1	0.04	<0.1	1	0.03	0.03	<0.02	0.2

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	BSK 1-1	0.5	0.2	0.13	0.07	1.1	2.5	1.3	0.011	0.219
2	BSK 1-2	0.3	0.1	0.08	0.04	0.6	1.3	1.2	0.013	0.258
3	BSK 1-3	0.1	<0.1	0.04	0.03	0.3	0.6	0.5	0.007	0.136
4	BSK 1-4	0.2	<0.1	0.05	0.11	0.3	0.8	2.2	0.007	0.113
5	BSK 2-1	0.1	0.1	0.04	0.04	0.3	0.8	0.5	0.01	0.164
6	BSK 2-2	0.2	0.1	0.06	0.16	0.6	1.3	3.2	0.006	0.155
7	BSK 2-3	0.1	0.2	0.04	0.13	0.4	0.8	2.2	0.003	0.074
8	BSK 3-1	<0.1	0.3	<0.02	0.06	0.2	0.4	1.1	0.013	0.224
9	BSK 3-2	<0.1	0.2	<0.02	0.06	0.2	0.2	1.3	0.004	0.081
10	BSK 3-3	<0.1	0.3	0.02	0.03	0.2	0.5	0.9	0.004	0.074

Appendix G: Source Samples Raw Data

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
11	Crowley	2.8	1.4	0.82	0.13	4.2	14.6	0.8	0.004	0.2
12	Frank SSKR 1-1	0.4	0.5	0.05	0.28	0.2	2.6	1.1	0.01	0.17
13	Frank Wd MTN 1-1	0.1	<0.1	0.03	0.24	<0.1	0.6	1.2	0.009	0.225
14	HH 1-1	0.6	0.1	0.08	0.06	0.1	2.6	1	0.006	0.121
15	HH 1-2	0.8	0.1	0.1	0.04	0.1	3.3	0.7	0.006	0.116
16	HH 1-3	0.4	0.1	0.06	0.04	0.2	1.7	0.6	0.007	0.126
17	HH 1-4	0.3	0.1	0.05	0.08	0.1	1.6	1.3	0.011	0.184
18	HH 1-5	0.8	0.5	0.16	0.2	0.2	1.4	2.4	0.012	0.258
19	HH 1-6	0.3	3.2	0.06	0.13	0.2	1.6	2.3	0.023	0.596
20	HH 1-7	0.3	0.1	0.05	0.1	0.2	1.6	2	0.012	0.249
21	HH 1-8	1.1	0.1	0.15	0.05	0.1	4.4	3.1	0.01	0.266
22	Horse Nose Butte	0.2	0.5	0.06	0.12	0.3	1.5	0.7	0.006	0.127
23	JH1-1	1	<0.1	0.14	0.04	<0.1	5.3	0.2	0.004	0.087
24	JH1-2	6.2	<0.1	0.91	0.04	0.1	32.3	0.4	0.02	0.356
25	JH1-3	2.4	<0.1	0.33	0.08	0.1	12.5	0.9	0.016	0.297
26	JH1-4	1.7	<0.1	0.24	0.04	<0.1	8.6	0.4	0.01	0.188
27	JH2-1	0.6	<0.1	0.12	0.05	<0.1	2.2	0.5	0.002	0.068
28	JH2-2	0.9	<0.1	0.2	0.13	<0.1	4.1	1.3	0.004	0.097

Appendix G: Source Samples Raw Data

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
29	JH2-3	0.5	<0.1	0.11	0.34	<0.1	1.9	2.2	0.004	0.073
30	JH2-4	0.8	<0.1	0.22	0.22	<0.1	3.4	0.9	0.006	0.104
31	kakwa	0.2	0.8	0.06	0.16	0.3	1.3	1.2	0.005	0.107
32	JH2-1 R	0.7	<0.1	0.15	0.1	<0.1	2.8	0.6	0.002	0.072
33	Lynch Quarries N=1	0.2	0.3	0.05	0.15	0.2	0.9	1	0.013	0.247
34	Lynch Quarries N=2	0.3	0.1	0.06	0.08	0.2	1.5	0.5	0.006	0.115
35	Medicine Butte ND	0.4	0.6	0.15	0.12	0.2	1.5	0.7	0.014	0.28
36	MT (HT?) Agate 1-1	0.3	<0.1	0.07	0.1	<0.1	1.6	1	0.009	0.163
37	MTA 1-2	0.1	<0.1	0.03	0.04	<0.1	0.6	0.5	0.006	0.124
38	MTA 1-3	0.2	<0.1	0.04	0.03	<0.1	0.8	0.6	0.008	0.135
39	NI TXX	0.7	0.3	0.27	0.09	2.1	3.4	0.7	0.011	0.292
40	Petr-Wd 1-1	0.2	<0.1	0.03	0.06	<0.1	0.7	1	0.006	0.106
41	Petrified wood	0.3	<0.1	0.06	2.51	0.2	2.5	3.3	0.005	0.131
42	PW 1-2	0.1	<0.1	0.02	0.08	<0.1	0.5	0.7	0.008	0.155
43	PW 1-3	0.1	<0.1	<0.02	0.03	<0.1	0.4	0.6	0.004	0.096
44	PW 1-4	0.2	<0.1	0.04	0.22	0.1	1.2	6.2	0.039	0.694
45	PW 1-5	0.2	0.1	0.05	0.26	0.3	1.4	8.2	0.045	0.75
46	SC 1-1	2.4	<0.1	0.6	0.18	0.2	8.5	0.7	0.04	0.675
47	SC 1-2	0.5	<0.1	0.14	0.12	0.2	2.2	3.5	0.016	0.329

Appendix G: Source Samples Raw Data

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
48	SC 1-3	2.2	<0.1	0.56	0.14	0.2	8.4	0.8	0.033	0.607
49	SC 2-1	4.6	0.1	1.14	0.17	0.4	16.2	0.6	0.058	0.996
50	SC 2-2	2.2	<0.1	0.58	0.12	0.2	8.1	0.4	0.041	0.72
51	SC 2-3	0.8	<0.1	0.16	0.06	0.2	2.7	0.3	0.02	0.321
52	SC 2-4	0.5	<0.1	0.13	0.17	0.3	2.3	2.2	0.02	0.41
53	Souris 1-1	<0.1	<0.1	<0.02	0.16	0.1	0.3	5.3	0.013	0.242
54	Souris 1-2	<0.1	<0.1	<0.02	0.04	0.1	0.4	0.4	0.006	0.079
55	Souris 1-3	0.1	<0.1	<0.02	0.03	0.3	0.4	0.5	0.004	0.086
56	Souris 1-4	0.1	<0.1	<0.02	0.02	0.1	0.5	0.4	0.003	0.059
57	Souris 1-5	<0.1	<0.1	<0.02	0.03	0.1	0.3	0.9	0.003	0.056
58	Souris 2-1	<0.1	0.1	<0.02	0.03	<0.1	0.4	0.9	0.011	0.157
59	Souris 2-2	<0.1	<0.1	<0.02	0.31	<0.1	0.5	1.5	0.013	0.245
60	Souris 2-3	0.1	0.1	<0.02	0.09	<0.1	0.5	2.2	0.014	0.286
61	Souris 2-4	<0.1	0.1	<0.02	0.13	<0.1	0.5	0.8	0.01	0.189
62	Souris 2-5	0.1	0.1	<0.02	0.1	<0.1	0.5	1.1	0.01	0.511
63	Souris 3-1	<0.1	<0.1	<0.02	0.02	<0.1	0.2	0.4	0.002	0.054
64	Souris 3-2	<0.1	<0.1	<0.02	0.01	0.1	0.2	0.2	0.002	0.057
65	Souris 3-3	0.1	<0.1	<0.02	0.04	<0.1	0.4	0.7	0.002	0.048

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
66	Souris 3-4	<0.1	<0.1	<0.02	0.1	0.1	0.3	3.6	0.002	0.056
67	Souris 3-5	<0.1	<0.1	<0.02	0.39	0.1	0.3	18.2	0.003	0.057
68	Souris 4-1	<0.1	<0.1	<0.02	0.18	<0.1	0.1	6.6	0.002	0.047
69	Souris 4-2	<0.1	<0.1	<0.02	0.02	0.1	0.2	0.7	0.003	0.067
70	Souris 3-2 R	<0.1	<0.1	<0.02	0.02	0.1	0.2	0.4	0.002	0.06
71	Souris 4-3	<0.1	<0.1	0.02	0.25	0.2	0.3	1.6	0.035	0.605
72	Souris 4-4	0.1	<0.1	<0.02	0.06	0.2	0.6	0.5	0.004	0.109
73	SSKR 1-2	0.2	0.4	0.03	0.16	<0.1	1.4	0.9	0.007	0.123
74	SSKR 1-3	0.3	0.4	0.04	0.39	0.2	2.1	0.8	0.009	0.152
75	WHC 1-1	0.1	0.1	0.04	1.11	0.3	0.8	45.6	0.036	0.613
76	WHC 1-2	0.1	<0.1	0.04	0.15	0.2	0.6	0.6	0.056	0.944
77	WHC 1-3	0.1	<0.1	0.03	0.14	0.2	0.7	1.1	0.056	1.02
78	WHC 1-4	0.1	0.1	0.04	0.14	0.3	0.7	1.7	0.056	0.962
79	WHC 10-1	0.2	<0.1	0.05	0.07	0.2	0.8	0.8	0.012	0.207
80	WHC 10-2	0.2	<0.1	0.06	0.14	0.2	0.8	1.2	0.021	0.307
81	WHC 10-3	0.2	<0.1	0.04	0.06	0.1	0.6	0.6	0.017	0.282
82	WHC 10-4	0.2	<0.1	0.05	0.05	0.2	0.7	0.6	0.019	0.331
83	WHC 2	<0.1	<0.1	<0.02	0.06	0.1	<0.1	0.3	0.017	0.44
84	WHC 2-2	<0.1	<0.1	<0.02	0.09	0.2	0.1	0.4	0.015	0.336

Appendix G: Source Samples Raw Data

#	Sample Name	Gd ICP MS Total Digestion	Hf ICP MS Total Digestion	Ho ICP MS Total Digestion	Mo ICP MS Total Digestion	Nb ICP MS Total Digestion	Nd ICP MS Total Digestion	Ni ICP MS Total Digestion	Pb204 ICP MS Total Digestion	Pb206 ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
85	WHC 2-3	<0.1	<0.1	0.04	0.08	0.5	0.4	0.5	0.038	0.745
86	WHC 3-1	<0.1	<0.1	<0.02	0.06	0.2	0.3	0.4	0.024	0.355
87	WHC 3-2	<0.1	<0.1	<0.02	0.1	0.2	0.4	0.7	0.025	0.297
88	WHC 3-3	<0.1	<0.1	<0.02	0.09	0.2	0.4	0.8	0.022	0.304
89	WHC 4-1	<0.1	<0.1	<0.02	0.08	0.1	0.2	0.5	0.014	0.217
90	WHC 4-2	<0.1	<0.1	<0.02	0.1	0.2	0.2	0.4	0.015	0.268
91	WHC 8-1	<0.1	<0.1	<0.02	0.05	<0.1	<0.1	0.6	0.018	0.114
92	WHC 8-2	<0.1	<0.1	<0.02	0.04	<0.1	<0.1	0.4	0.022	0.114
93	WM 1-2	0.2	<0.1	0.05	2.2	<0.1	0.6	1.9	0.422	6.2
94	WM 1-3	0.2	<0.1	0.06	4.4	<0.1	0.9	2.3	0.041	0.745
95	WM 1-4	1	<0.1	0.28	9.04	<0.1	3.1	2.4	0.042	0.774
96	WM 1-5	0.6	<0.1	0.13	4.12	<0.1	2.2	1.7	0.032	0.601
97	WM 1-6	0.9	<0.1	0.27	23.4	<0.1	2.6	9.9	0.022	0.498
98	WHC 8-1 R	<0.1	<0.1	<0.02	0.15	<0.1	0.1	0.5	0.016	0.107

Appendix G: Source Samples Raw Data

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	BSK 1-1	0.171	0.437	0.838	0.7	0.4	0.2	0.5	0.06	0.07
2	BSK 1-2	0.186	0.455	0.912	0.3	0.2	0.4	0.3	0.04	0.03
3	BSK 1-3	0.104	0.261	0.508	0.2	0.2	0.2	0.1	0.02	<0.02
4	BSK 1-4	0.085	0.229	0.434	0.2	0.2	0.2	0.1	0.05	<0.02
5	BSK 2-1	0.145	0.368	0.687	0.2	0.2	0.3	0.1	0.03	<0.02
6	BSK 2-2	0.077	0.208	0.445	0.4	0.2	0.3	0.2	0.16	0.02
7	BSK 2-3	0.051	0.134	0.262	0.2	0.2	0.2	0.1	0.14	<0.02
8	BSK 3-1	0.189	0.462	0.887	0.1	<0.1	0.5	<0.1	0.02	<0.02
9	BSK 3-2	0.068	0.17	0.323	<0.1	0.1	0.4	<0.1	<0.02	<0.02
10	BSK 3-3	0.053	0.146	0.278	0.2	0.1	0.5	<0.1	0.03	<0.02
11	Crowley	0.075	0.319	0.599	4.1	0.5	0.2	2.9	0.1	0.15
12	Frank SSKR 1-1	0.14	0.356	0.675	0.7	<0.1	0.4	0.4	0.27	<0.02
13	Frank Wd MTN 1-1	0.122	0.294	0.65	0.2	0.2	0.7	0.1	<0.02	<0.02
14	HH 1-1	0.084	0.209	0.42	0.6	0.3	0.2	0.6	0.07	<0.02
15	HH 1-2	0.08	0.202	0.405	0.7	0.2	0.1	0.8	0.03	<0.02
16	HH 1-3	0.089	0.26	0.482	0.4	0.3	0.2	0.4	0.03	<0.02
17	HH 1-4	0.153	0.376	0.725	0.4	0.3	0.1	0.4	0.06	<0.02
18	HH 1-5	0.178	0.459	0.908	0.3	0.3	0.1	0.3	0.08	0.02
19	HH 1-6	0.374	0.954	1.95	0.4	0.3	0.3	0.3	0.68	<0.02

Appendix G: Source Samples Raw Data

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
20	HH 1-7	0.193	0.486	0.94	0.4	0.3	<0.1	0.3	0.05	<0.02
21	HH 1-8	0.171	0.412	0.859	1	0.3	0.1	1.1	0.12	<0.02
22	Horse Nose Butte	0.094	0.228	0.455	0.4	0.2	0.2	0.3	0.05	<0.02
23	JH1-1	0.064	0.16	0.315	1.2	0.4	0.1	1.2	0.02	<0.02
24	JH1-2	0.296	0.766	1.44	7.3	0.3	<0.1	7.3	<0.02	<0.02
25	JH1-3	0.234	0.566	1.11	2.8	0.3	<0.1	2.8	0.09	<0.02
26	JH1-4	0.148	0.37	0.716	1.9	0.3	<0.1	2	0.03	<0.02
27	JH2-1	0.056	0.13	0.256	0.5	0.2	0.1	0.5	0.03	<0.02
28	JH2-2	0.074	0.186	0.362	0.9	<0.1	0.1	1	<0.02	<0.02
29	JH2-3	0.051	0.136	0.264	0.4	0.1	0.1	0.5	0.03	<0.02
30	JH2-4	0.072	0.192	0.373	0.8	<0.1	0.2	0.8	<0.02	<0.02
31	kakwa	0.072	0.184	0.368	0.4	0.3	0.2	0.2	0.04	<0.02
32	JH2-1 R	0.065	0.129	0.268	0.6	0.2	0.1	0.7	<0.02	<0.02
33	Lynch Quarries N=1	0.164	0.409	0.834	0.2	0.4	<0.1	0.2	0.05	<0.02
34	Lynch Quarries N=2	0.09	0.223	0.434	0.4	0.3	0.2	0.4	0.03	<0.02
35	Medicine Butte ND	0.228	0.593	1.12	0.4	0.3	0.8	0.4	0.05	<0.02
36	MT (HT?) Agate 1-1	0.13	0.316	0.618	0.3	0.2	0.1	0.4	0.07	<0.02
37	MTA 1-2	0.088	0.211	0.428	0.1	0.2	0.2	0.1	0.02	<0.02

Appendix G: Source Samples Raw Data

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
38	MTA 1-3	0.098	0.245	0.486	0.2	0.2	0.1	0.2	0.03	<0.02
39	NI TXX	0.151	0.376	0.83	0.9	0.6	<0.1	0.8	0.04	0.05
40	Petr-Wd 1-1	0.084	0.216	0.412	0.2	0.2	1.4	0.2	0.04	<0.02
41	Petrified wood	0.08	0.212	0.428	0.9	0.2	0.4	0.3	0.04	<0.02
42	PW 1-2	0.113	0.29	0.566	0.1	0.3	1.5	0.2	<0.02	<0.02
43	PW 1-3	0.073	0.183	0.357	0.1	0.4	2	0.1	<0.02	<0.02
44	PW 1-4	0.583	1.47	2.78	0.3	0.4	0.4	0.2	0.02	<0.02
45	PW 1-5	0.627	1.59	3.01	0.4	0.6	0.4	0.3	<0.02	<0.02
46	SC 1-1	0.555	1.38	2.64	2.2	0.7	0.4	1.6	0.06	<0.02
47	SC 1-2	0.281	0.683	1.31	0.6	0.8	0.1	0.4	0.06	<0.02
48	SC 1-3	0.493	1.21	2.34	2.1	0.7	0.4	1.7	0.04	<0.02
49	SC 2-1	0.857	2.11	4.02	4	0.9	0.4	3.2	0.04	0.02
50	SC 2-2	0.562	1.45	2.77	2	0.9	0.3	1.6	0.03	<0.02
51	SC 2-3	0.27	0.652	1.26	0.7	0.9	0.2	0.6	0.03	<0.02
52	SC 2-4	0.336	0.831	1.6	0.6	0.9	0.3	0.5	0.2	<0.02
53	Souris 1-1	0.208	0.486	0.95	<0.1	0.3	0.3	<0.1	0.02	<0.02
54	Souris 1-2	0.059	0.147	0.29	<0.1	0.3	0.3	0.1	<0.02	<0.02
55	Souris 1-3	0.066	0.164	0.32	<0.1	0.2	0.3	0.1	<0.02	<0.02
56	Souris 1-4	0.037	0.089	0.189	0.1	0.2	0.4	0.1	<0.02	<0.02

Appendix G: Source Samples Raw Data

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
57	Souris 1-5	0.039	0.092	0.189	<0.1	0.2	0.3	<0.1	0.02	<0.02
58	Souris 2-1	0.137	0.342	0.647	<0.1	0.2	<0.1	<0.1	<0.02	<0.02
59	Souris 2-2	0.207	0.499	0.964	0.1	0.2	0.2	0.1	<0.02	<0.02
60	Souris 2-3	0.228	0.587	1.12	0.1	0.2	<0.1	0.1	0.12	<0.02
61	Souris 2-4	0.153	0.382	0.735	0.1	0.2	0.1	0.1	0.03	<0.02
62	Souris 2-5	0.231	0.575	1.33	0.1	0.2	0.1	0.1	<0.02	<0.02
63	Souris 3-1	0.036	0.081	0.172	<0.1	0.3	0.2	<0.1	<0.02	<0.02
64	Souris 3-2	0.038	0.081	0.178	<0.1	0.3	0.3	<0.1	<0.02	<0.02
65	Souris 3-3	0.03	0.088	0.169	<0.1	0.3	0.2	<0.1	<0.02	<0.02
66	Souris 3-4	0.039	0.093	0.191	<0.1	0.2	0.3	0.1	0.04	<0.02
67	Souris 3-5	0.035	0.098	0.193	<0.1	0.3	0.3	<0.1	0.04	<0.02
68	Souris 4-1	0.032	0.074	0.155	<0.1	0.3	0.2	<0.1	0.06	<0.02
69	Souris 4-2	0.046	0.119	0.236	<0.1	0.2	0.2	<0.1	<0.02	<0.02
70	Souris 3-2 R	0.039	0.08	0.181	<0.1	0.3	0.3	<0.1	<0.02	<0.02
71	Souris 4-3	0.491	1.16	2.29	<0.1	0.4	0.2	<0.1	0.2	0.02
72	Souris 4-4	0.06	0.146	0.319	0.1	0.3	0.4	0.2	<0.02	<0.02
73	SSKR 1-2	0.092	0.231	0.453	0.4	0.1	0.3	0.3	<0.02	<0.02
74	SSKR 1-3	0.124	0.296	0.582	0.6	0.1	0.4	0.4	0.02	<0.02

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
75	WHC 1-1	0.493	1.25	2.39	0.2	1	0.2	0.2	0.16	<0.02
76	WHC 1-2	0.775	1.89	3.67	0.2	1	0.2	0.1	0.04	<0.02
77	WHC 1-3	0.892	2.14	4.11	0.2	1	0.2	0.1	0.05	<0.02
78	WHC 1-4	0.803	1.91	3.73	0.2	1.1	0.2	0.1	0.12	<0.02
79	WHC 10-1	0.148	0.363	0.731	0.2	0.8	0.1	0.2	0.06	<0.02
80	WHC 10-2	0.237	0.58	1.14	0.2	0.7	0.1	0.2	0.13	<0.02
81	WHC 10-3	0.228	0.544	1.07	0.2	0.6	0.1	0.1	<0.02	<0.02
82	WHC 10-4	0.262	0.645	1.26	0.2	0.8	0.2	0.1	<0.02	<0.02
83	WHC 2	0.236	0.552	1.25	<0.1	0.3	<0.1	<0.1	0.03	<0.02
84	WHC 2-2	0.194	0.472	1.02	<0.1	0.5	<0.1	<0.1	<0.02	<0.02
85	WHC 2-3	0.552	1.32	2.65	0.1	1.8	0.2	<0.1	0.02	<0.02
86	WHC 3-1	0.281	0.693	1.35	<0.1	1	0.1	<0.1	0.02	<0.02
87	WHC 3-2	0.239	0.569	1.13	0.1	0.8	0.2	<0.1	0.03	<0.02
88	WHC 3-3	0.23	0.566	1.12	<0.1	0.9	0.2	<0.1	0.04	<0.02
89	WHC 4-1	0.156	0.394	0.78	<0.1	0.6	<0.1	<0.1	0.04	<0.02
90	WHC 4-2	0.188	0.448	0.92	<0.1	0.5	<0.1	<0.1	0.02	<0.02
91	WHC 8-1	0.075	0.166	0.373	<0.1	0.7	<0.1	<0.1	<0.02	<0.02
92	WHC 8-2	0.071	0.175	0.382	<0.1	0.5	<0.1	<0.1	<0.02	<0.02
93	WM 1-2	5.79	13.7	26.1	0.1	0.2	0.6	0.1	<0.02	<0.02

Appendix G: Source Samples Raw Data

#	Sample Name	Pb207 ICP MS Total Digestion	Pb208 ICP MS Total Digestion	PbSUM ICP MS Total Digestion	Pr ICP MS Total Digestion	Rb ICP MS Total Digestion	Sc ICP MS Total Digestion	Sm ICP MS Total Digestion	Sn ICP MS Total Digestion	Ta ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
94	WM 1-3	0.56	1.34	2.69	0.2	0.2	0.8	0.2	0.02	<0.02
95	WM 1-4	0.573	1.4	2.79	0.7	0.1	2	0.8	<0.02	<0.02
96	WM 1-5	0.442	1.09	2.16	0.5	0.1	1.1	0.5	0.02	<0.02
97	WM 1-6	0.348	0.863	1.73	0.6	0.2	1.2	0.6	<0.02	<0.02
98	WHC 8-1 R	0.067	0.171	0.361	<0.1	0.7	<0.1	<0.1	0.03	<0.02

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	BSK 1-1	0.08	0.68	1.27	<0.1	0.1	3.5	0.36	1
2	BSK 1-2	0.05	0.28	2.11	0.3	<0.1	2	0.23	1
3	BSK 1-3	0.02	0.13	1.47	<0.1	<0.1	1.1	0.13	1
4	BSK 1-4	0.02	0.15	1.36	<0.1	<0.1	1.2	0.15	<1
5	BSK 2-1	0.02	0.23	0.61	<0.1	<0.1	0.9	0.08	<1
6	BSK 2-2	0.04	0.42	1.21	<0.1	<0.1	1.6	0.17	1

Appendix G: Source Samples Raw Data

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
7	BSK 2-3	0.02	0.24	0.54	0.1	<0.1	0.9	0.09	14
8	BSK 3-1	<0.02	0.11	1.65	<0.1	<0.1	0.4	0.05	<1
9	BSK 3-2	<0.02	0.06	1.11	0.2	<0.1	0.3	0.04	<1
10	BSK 3-3	<0.02	0.13	1.23	<0.1	<0.1	0.6	0.07	<1
11	Crowley	0.49	3.82	3.12	0.7	<0.1	24	2.6	1
12	Frank SSKR 1-1	0.05	0.12	1.9	2.6	0.1	1.3	0.11	1
13	Frank Wd MTN 1-1	0.02	0.06	26	1.3	<0.1	0.8	0.11	<1
14	HH 1-1	0.08	5.23	4.52	0.6	<0.1	1.5	0.18	<1
15	HH 1-2	0.11	6.19	3.65	0.4	<0.1	1.9	0.19	7
16	HH 1-3	0.05	2.8	3.81	0.5	<0.1	1	0.14	<1
17	HH 1-4	0.05	2.64	3.24	0.8	<0.1	0.9	0.1	<1
18	HH 1-5	0.12	2.03	4.8	1	0.1	1	0.47	3
19	HH 1-6	0.05	2.67	6.06	0.4	0.1	1.3	0.19	3
20	HH 1-7	0.04	2.09	3.54	0.6	<0.1	1.1	0.14	16
21	HH 1-8	0.16	8.5	3.84	1.2	<0.1	2.7	0.27	118
22	Horse Nose Butte	0.05	0.36	2.78	0.9	<0.1	1.8	0.25	<1
23	JH1-1	0.14	0.13	2.54	<0.1	<0.1	3.1	0.31	<1
24	JH1-2	0.86	0.11	3.36	0.5	<0.1	21.6	2.15	<1

Appendix G: Source Samples Raw Data

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
25	JH1-3	0.33	0.12	3.31	0.5	<0.1	7.7	0.79	<1
26	JH1-4	0.25	0.09	2.96	0.3	<0.1	5.6	0.6	<1
27	JH2-1	0.09	0.05	2.17	<0.1	<0.1	2.5	0.29	<1
28	JH2-2	0.16	0.06	5.06	1.4	<0.1	4.3	0.66	<1
29	JH2-3	0.09	0.05	3.16	3.1	<0.1	2.5	0.4	<1
30	JH2-4	0.15	0.05	4.68	3	<0.1	4.7	0.79	<1
31	kakwa	0.03	0.27	2.86	0.7	<0.1	1.9	0.27	<1
32	JH2-1 R	0.12	0.06	2.24	0.1	<0.1	2.7	0.31	<1
33	Lynch Quarries N=1	0.03	0.36	4.42	1.2	<0.1	1.3	0.2	1
34	Lynch Quarries N=2	0.05	0.35	2.67	0.8	<0.1	1.5	0.24	<1
35	Medicine Butte ND	0.08	0.38	2.47	1.4	<0.1	3.6	0.68	<1
36	MT (HT?) Agate 1-1	0.05	0.22	2.59	0.7	<0.1	1	0.23	<1
37	MTA 1-2	0.02	0.12	2.09	0.6	<0.1	0.5	0.11	<1
38	MTA 1-3	0.03	0.14	2.65	0.4	<0.1	0.5	0.12	<1
39	NI TXX	0.17	0.75	23.4	20	<0.1	5.6	0.88	1
40	Petr-Wd 1-1	0.03	6.65	1.5	1.2	<0.1	0.7	0.08	<1
41	Petrified wood	0.03	0.41	3.98	4.9	1	1.8	0.23	6
42	PW 1-2	0.02	3.66	1.57	1.1	<0.1	0.5	0.06	<1
43	PW 1-3	<0.02	4	1.47	0.2	<0.1	0.4	0.04	<1

Appendix G: Source Samples Raw Data

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
44	PW 1-4	0.03	0.36	0.36	10.8	<0.1	1.1	0.14	5
45	PW 1-5	0.04	0.29	0.21	12.7	0.1	1.5	0.17	8
46	SC 1-1	0.38	0.26	13.6	0.8	<0.1	26.7	1.54	<1
47	SC 1-2	0.1	0.22	9.52	1.4	<0.1	5	0.36	<1
48	SC 1-3	0.39	0.26	14.5	1.1	<0.1	22.8	1.38	9
49	SC 2-1	0.76	0.41	12	1.2	0.1	48.2	2.65	1
50	SC 2-2	0.36	0.26	10.4	1.2	0.1	23.7	1.42	<1
51	SC 2-3	0.12	0.21	9.56	0.7	<0.1	6	0.41	<1
52	SC 2-4	0.09	0.26	10.6	1.9	0.1	4.2	0.35	20
53	Souris 1-1	<0.02	0.15	3.18	1.2	<0.1	0.2	0.02	<1
54	Souris 1-2	<0.02	0.21	2.97	0.8	<0.1	0.2	0.03	<1
55	Souris 1-3	<0.02	0.15	2.87	1.1	<0.1	0.3	0.04	<1
56	Souris 1-4	0.02	0.26	4.69	1	<0.1	0.3	0.04	3
57	Souris 1-5	<0.02	0.19	3.41	1.1	<0.1	0.2	0.02	<1
58	Souris 2-1	<0.02	0.11	2.36	1.3	<0.1	0.2	0.02	<1
59	Souris 2-2	<0.02	0.15	2.51	3.7	<0.1	0.3	0.04	2
60	Souris 2-3	<0.02	0.15	2.77	2.8	0.1	0.3	0.03	1
61	Souris 2-4	<0.02	0.12	2.61	1.7	<0.1	0.3	0.03	<1

Appendix G: Source Samples Raw Data

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
62	Souris 2-5	0.02	0.15	5.04	1.5	<0.1	0.5	0.04	<1
63	Souris 3-1	<0.02	0.19	2.58	0.9	<0.1	0.2	0.03	<1
64	Souris 3-2	<0.02	0.16	2.88	0.7	<0.1	0.2	0.03	<1
65	Souris 3-3	<0.02	0.25	2.47	0.7	<0.1	0.2	0.03	<1
66	Souris 3-4	<0.02	0.14	2.76	0.8	<0.1	0.2	0.04	<1
67	Souris 3-5	<0.02	0.1	2.93	1.2	<0.1	0.2	0.03	<1
68	Souris 4-1	<0.02	0.08	2.89	0.8	<0.1	0.1	<0.02	<1
69	Souris 4-2	<0.02	0.2	2.69	1	<0.1	0.2	<0.02	3
70	Souris 3-2 R	<0.02	0.17	2.89	0.6	<0.1	0.2	0.02	<1
71	Souris 4-3	<0.02	0.26	3.42	1.5	0.2	0.3	0.03	3
72	Souris 4-4	<0.02	0.38	3.69	1	<0.1	0.3	0.04	<1
73	SSKR 1-2	0.03	0.1	1.87	1.5	<0.1	0.7	0.05	1
74	SSKR 1-3	0.04	0.09	1.99	4.7	0.2	1	0.08	2
75	WHC 1-1	0.03	0.19	7.09	5	0.2	1	0.12	1
76	WHC 1-2	<0.02	0.14	8.31	4.1	0.1	0.9	0.12	1
77	WHC 1-3	0.02	0.16	9.7	4.7	0.2	1.1	0.14	8
78	WHC 1-4	0.03	0.21	7.8	5.4	0.2	0.8	0.12	2
79	WHC 10-1	0.03	0.12	12	3.6	<0.1	1.3	0.19	<1
80	WHC 10-2	0.03	0.15	10.4	4.4	<0.1	1.5	0.22	<1

Appendix G: Source Samples Raw Data

#	Sample Name	Tb ICP MS Total Digestion	Th ICP MS Total Digestion	U ICP MS Total Digestion	V ICP MS Total Digestion	W ICP MS Total Digestion	Y ICP MS Total Digestion	Yb ICP MS Total Digestion	Zn ICP MS Total Digestion
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
81	WHC 10-3	0.02	0.09	12.9	3	<0.1	1.2	0.17	<1
82	WHC 10-4	0.03	0.11	12.2	4.2	<0.1	1.3	0.19	<1
83	WHC 2	<0.02	0.04	35.2	20.9	<0.1	0.2	<0.02	<1
84	WHC 2-2	<0.02	0.06	35.6	21.2	<0.1	0.2	0.03	<1
85	WHC 2-3	<0.02	0.11	36.8	17.2	0.1	1	0.11	3
86	WHC 3-1	<0.02	0.16	12.2	15.9	0.1	0.4	0.04	1
87	WHC 3-2	<0.02	0.16	10	17.8	<0.1	0.5	0.07	1
88	WHC 3-3	<0.02	0.17	11.8	20.5	<0.1	0.4	0.05	2
89	WHC 4-1	<0.02	0.11	11.9	16.6	<0.1	0.3	0.03	<1
90	WHC 4-2	<0.02	0.14	11.7	16.6	<0.1	0.3	0.04	<1
91	WHC 8-1	<0.02	0.08	11.1	19.9	<0.1	0.3	0.02	<1
92	WHC 8-2	<0.02	0.06	12.8	20.9	<0.1	0.2	<0.02	<1
93	WM 1-2	0.02	0.08	19.6	6.1	0.7	1.5	0.17	7
94	WM 1-3	0.04	0.07	22	8.5	1.1	1.7	0.22	4
95	WM 1-4	0.18	0.02	19.8	28.6	2.6	7.6	0.87	11
96	WM 1-5	0.09	0.03	20	9.9	1.8	3.5	0.36	5
97	WM 1-6	0.16	0.04	21.6	43.3	4.2	8.6	0.94	24
98	WHC 8-1 R	<0.02	0.07	10.8	20	<0.1	0.3	0.02	1

Appendix H: Archaeological Samples Raw Data

** Negative values indicate the elemental concentration of the sample is less than the standard. All values in parts per million (ppm), "Int2SE" refers to the Standard Deviation, and "LOD" refers to the machine's limit of detection for each element.*

Table H.1: Fincastle (DlOx-5) Artifact 1 Cat #843

Pt #	**Na23**	Int2SE	LOD	**Mg25**	Int2SE	LOD	**Al27**	Int2SE	LOD	**Si29**	Int2SE	LOD
1	**154**	21	0.016	**250**	120	0.016	**335**	56	0.0071	**466140**	260	
2	**112**	15	0.017	**109**	43	0.016	**266**	48	0.0075	**466510**	140	
3	**140**	16	0.016	**167**	70	0.017	**393**	66	0.0086	**466030**	260	
4	**217**	22	0.013	**250**	110	0.013	**325**	46	0.0075	**465700**	330	
5	**190**	26	0.014	**156**	54	0.014	**376**	21	0.0079	**465810**	440	
Average	***162.6***	***20***		***186.4***	***79.4***		***339***	***47.4***		***466038***	***286***	
Pt #	**P31**	Int2SE	LOD	**K39**	Int2SE	LOD	**Ca43**	Int2SE	LOD	**Sc45**	Int2SE	LOD
1	**28.4**	6.6	0.018	**314**	38	0.0067	**159**	62	0.42	**5.3**	1	0.0026
2	**16**	3.1	0.021	**308**	28	0.0069	**226**	52	0.48	**3.58**	0.56	0.0028
3	**19.4**	2.6	0.012	**316**	25	0.0063	**239**	57	0.38	**3.81**	0.61	0.0021
4	**26.4**	2.6	0.011	**463**	66	0.0051	**167**	52	0.31	**5.3**	1.1	0.0017
5	**24.9**	5	0.012	**358**	30	0.0058	**185**	38	0.35	**3.28**	0.65	0.0021
Average	***23.02***	***3.98***		***351.8***	***37.4***		***195.2***	***52.2***		***4.254***	***0.784***	
Pt #	**Ti49**	Int2SE	LOD	**V51**	Int2SE	LOD	**Cr52**	Int2SE	LOD	**Cr53**	Int2SE	LOD
1	**-3.5**	3.5	0.023	**1.44**	0.31	0.00038	**1.9**	1.3	0.0048	**1.06**	0.82	0.0045
2	**-5.2**	3.9	0.024	**1.7**	0.2	0.0004	**0.54**	0.66	0.0051	**0.7**	0.73	0.0047
3	**-6.8**	5.6	0.034	**1.27**	0.14	0.00051	**1.25**	0.71	0.0043	**3.5**	3.4	0.0043
4	**-3**	3.3	0.025	**1.24**	0.13	0.00037	**2.4**	1.6	0.0034	**4.2**	2.1	0.0034
5	**-3.9**	2.5	0.027	**1.323**	0.084	0.00038	**1.04**	0.67	0.0039	**2**	1.1	0.0039
Average	***-4.48***	***3.76***		***1.3946***	***0.1728***		***1.426***	***0.988***		***2.292***	***1.63***	
Pt #	**Mn55**	Int2SE	LOD	**Fe57**	Int2SE	LOD	**Co59**	Int2SE	LOD	**Ni60**	Int2SE	LOD
1	**2.27**	0.44	0.00078	**310**	100	0.048	**1**	1.3	0.00014	**10**	13	0.0034
2	**1.64**	0.43	0.00097	**380**	280	0.05	**0.06**	0.089	0.00013	**2.05**	0.62	0.0035
3	**2.76**	0.88	0.00058	**540**	270	0.039	**0.38**	0.39	0.00018	**4.6**	3.4	0.004
4	**2.12**	0.29	0.00044	**1040**	620	0.031	**0.146**	0.082	0.00013	**15**	20	0.0029
5	**1.79**	0.2	0.00057	**780**	540	0.037	**0.28**	0.18	0.00018	**4.5**	2.3	0.0034
Average	***2.116***	***0.448***		***610***	***362***		***0.3732***	***0.4082***		***7.23***	***7.864***	

Table H.1: Fincastle (DlOx-5) Artifact 1 Cat #843 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**9.3**	6.1	0.018	**50**	18	0.0012	**0.318**	0.094	0.00032	**0.245**	0.053	0.00014
2	**5.8**	2.7	0.023	**41**	26	0.0012	**0.65**	0.23	0.00041	**0.262**	0.043	0.00016
3	**5.7**	2	0.022	**51**	33	0.0018	**0.44**	0.16	0.00036	**0.294**	0.041	0.00015
4	**4.9**	2.3	0.018	**75**	28	0.0013	**0.26**	0.11	0.0003	**0.375**	0.06	0.00014
5	**5.8**	2.1	0.022	**52**	24	0.0014	**0.291**	0.074	0.00032	**0.29**	0.034	0.00014
Average	***6.3***	***3.04***		***53.8***	***25.8***		***0.3918***	***0.1336***		***0.2932***	***0.0462***	
Pt #	**Sr88**	Int2SE	LOD	**Y89**	Int2SE	LOD	**Zr90**	Int2SE	LOD	**Nb93**	Int2SE	LOD
1	**1.18**	0.14	0.00014	**0.684**	0.09	0.0001	**6.08**	0.69	0.0014	**0.011**	0.015	7.60E-05
2	**1.18**	0.24	0.00017	**0.54**	0.1	7.00E-05	**8.3**	4.8	0.0014	**-0.0034**	0.0096	6.10E-05
3	**1.21**	0.17	0.00016	**0.628**	0.081	5.30E-05	**7.8**	1.6	0.0019	**0.038**	0.018	0.00012
4	**1.08**	0.13	0.00012	**1.1**	0.12	4.00E-05	**5.97**	0.77	0.0014	**0.014**	0.01	8.60E-05
5	**1.07**	0.12	0.00013	**0.663**	0.098	5.40E-05	**8.4**	1.2	0.0016	**0.0131**	0.0083	0.00011
Average	***1.144***	***0.16***		***0.723***	***0.0978***		***7.31***	***1.812***		***0.01454***	***0.01218***	
Pt #	**Mo95**	Int2SE	LOD	**Mo98**	Int2SE	LOD	**Ag107**	Int2SE	LOD	**Cd111**	Int2SE	LOD
1	**0.042**	0.028	4.00E-05	**0.083**	0.092	2.50E-05	**-0.05**	0.14	0.00086	**0.27**	0.17	0.00069
2	**0.04**	0.027	0.0002	**0.025**	0.024	2.00E-05	**-0.088**	0.099	0.00098	**0.069**	0.078	0.00055
3	**0.024**	0.017	3.50E-05	**0.045**	0.022	2.20E-05	**0.015**	0.085	0.0012	**0.14**	0.16	0.00085
4	**0.11**	0.14	0.00017	**0.131**	0.082	0.00019	**0.105**	0.064	0.00093	**0.27**	0.11	0.0007
5	**0.055**	0.031	3.30E-05	**0.041**	0.019	0.00013	**-0.007**	0.067	0.001	**0.09**	0.1	0.00076
Average	***0.0542***	***0.0486***		***0.065***	***0.0478***		***-0.005***	***0.091***		***0.1678***	***0.1236***	
Pt #	**Cd114**	Int2SE	LOD	**Sn122**	Int2SE	LOD	**Cs133**	Int2SE	LOD	**Ba137**	Int2SE	LOD
1	**0.31**	0.16	0.00018	**0.01**	0.18	0.0017	**0.0057**	0.0068	6.30E-05	**4.98**	0.68	5.70E-05
2	**0.075**	0.044	3.00E-05	**0.06**	0.16	0.0018	**0.0071**	0.008	7.10E-05	**13.7**	6.2	4.60E-05
3	**0.141**	0.049	0.00018	**0.12**	0.2	0.0026	**0.0011**	0.0057	6.10E-05	**9.9**	4.3	5.10E-05
4	**0.33**	0.12	0.00018	**-0.09**	0.15	0.0018	**0.0026**	0.0042	5.10E-05	**4.26**	0.68	6.30E-05
5	**0.146**	0.067	0.00026	**0.09**	0.11	0.002	**0.0025**	0.006	6.50E-05	**5.01**	0.58	4.70E-05
Average	***0.2004***	***0.088***		***0.038***	***0.16***		***0.0038***	***0.00614***		***7.57***	***2.488***	

Table H.1: Fincastle (DlOx-5) Artifact 1 Cat #843 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.523**	0.068	7.40E-06	**1.69**	0.21	6.00E-06	**0.252**	0.03	5.90E-06	**0.99**	0.22	0.00011
2	**0.455**	0.086	6.00E-06	**1.36**	0.29	4.90E-06	**0.228**	0.054	4.80E-06	**0.82**	0.18	0.00011
3	**0.495**	0.068	6.60E-06	**1.37**	0.16	5.40E-06	**0.213**	0.036	5.20E-06	**0.84**	0.13	2.60E-05
4	**0.97**	0.11	8.10E-06	**2.84**	0.31	6.60E-06	**0.458**	0.07	6.50E-06	**1.84**	0.22	3.20E-05
5	**0.505**	0.068	6.10E-06	**1.43**	0.15	5.00E-06	**0.233**	0.034	4.80E-06	**0.89**	0.17	0.00016
Average	***0.5896***	***0.08***		***1.738***	***0.224***		***0.2768***	***0.0448***		***1.076***	***0.184***	
Pt #	**Sm147**	Int2SE	LOD	**Eu153**	Int2SE	LOD	**Gd157**	Int2SE	LOD	**Tb159**	Int2SE	LOD
1	**0.313**	0.073	3.70E-05	**0.044**	0.014	1.00E-05	**0.176**	0.045	3.70E-05	**0.0228**	0.0072	2.80E-05
2	**0.194**	0.059	3.00E-05	**0.047**	0.014	8.10E-06	**0.22**	0.06	3.00E-05	**0.0292**	0.0086	4.70E-06
3	**0.219**	0.072	3.30E-05	**0.052**	0.014	8.90E-06	**0.166**	0.058	3.30E-05	**0.023**	0.0054	5.20E-06
4	**0.427**	0.073	4.10E-05	**0.092**	0.02	1.10E-05	**0.427**	0.069	4.10E-05	**0.067**	0.012	6.50E-06
5	**0.212**	0.048	3.10E-05	**0.065**	0.022	8.20E-06	**0.191**	0.044	3.10E-05	**0.0314**	0.0074	4.90E-06
Average	***0.273***	***0.065***		***0.06***	***0.0168***		***0.236***	***0.0552***		***0.03468***	***0.00812***	
Pt #	**Dy163**	Int2SE	LOD	**Ho165**	Int2SE	LOD	**Er166**	Int2SE	LOD	**Yb172**	Int2SE	LOD
1	**0.202**	0.053	2.40E-05	**0.0415**	0.0092	6.20E-06	**0.126**	0.033	1.80E-05	**0.089**	0.025	2.90E-05
2	**0.154**	0.03	1.90E-05	**0.0298**	0.0074	5.00E-06	**0.065**	0.02	1.50E-05	**0.069**	0.022	2.30E-05
3	**0.179**	0.035	2.20E-05	**0.0209**	0.0062	5.60E-06	**0.091**	0.025	1.60E-05	**0.131**	0.044	2.60E-05
4	**0.332**	0.094	2.70E-05	**0.056**	0.012	6.90E-06	**0.157**	0.032	2.00E-05	**0.168**	0.047	3.20E-05
5	**0.179**	0.042	2.00E-05	**0.041**	0.011	5.20E-06	**0.071**	0.017	1.50E-05	**0.147**	0.053	2.40E-05
Average	***0.2092***	***0.0508***		***0.03784***	***0.00916***		***0.102***	***0.0254***		***0.1208***	***0.0382***	
Pt #	**Hf178**	Int2SE	LOD	**Ta181**	Int2SE	LOD	**W182**	Int2SE	LOD	**W184**	Int2SE	LOD
1	**0.121**	0.032	2.40E-05	**-0.0013**	0.0011	3.30E-05	**0.0083**	0.0065	1.90E-05	**0.0146**	0.0095	1.60E-05
2	**0.095**	0.025	1.90E-05	**0.0023**	0.0029	5.40E-06	**0.0105**	0.0071	1.60E-05	**0.0125**	0.007	1.30E-05
3	**0.142**	0.042	2.10E-05	**0.0039**	0.0035	6.00E-06	**0.0062**	0.0053	1.70E-05	**0.014**	0.012	1.50E-05
4	**0.12**	0.031	2.70E-05	**0.0048**	0.003	2.80E-05	**0.014**	0.01	2.10E-05	**0.018**	0.018	1.80E-05
5	**0.198**	0.035	2.00E-05	**0.0037**	0.0027	2.90E-05	**0.0057**	0.0041	1.60E-05	**0.0071**	0.0053	1.40E-05
Average	***0.1352***	***0.033***		***0.00268***	***0.00264***		***0.00894***	***0.0066***		***0.01324***	***0.01036***	

Table H.1: Fincastle (DlOx-5) Artifact 1 Cat #843 Continued

Pt #	**Pb204**	Int2SE	LOD	**Pb206**	Int2SE	LOD	**Pb207**	Int2SE	LOD	**Pb208**	Int2SE	LOD
1	**1.36**	0.52	0.0026	**1.04**	0.16	7.80E-05	**0.76**	0.13	1.80E-05	**0.766**	0.093	6.60E-05
2	**1.44**	0.33	0.002	**0.491**	0.067	9.80E-05	**0.293**	0.05	7.00E-05	**0.347**	0.057	5.10E-05
3	**1.47**	0.4	0.0019	**0.75**	0.087	7.60E-05	**0.52**	0.051	1.60E-05	**0.56**	0.083	4.80E-05
4	**1.02**	0.27	0.0024	**0.957**	0.089	9.70E-05	**0.655**	0.099	0.0001	**0.79**	0.13	4.70E-05
5	**2.18**	0.69	0.0021	**0.736**	0.089	0.00011	**0.512**	0.052	1.50E-05	**0.61**	0.067	6.30E-06
Average	***1.494***	***0.442***		***0.7948***	***0.0984***		***0.548***	***0.0764***		***0.6146***	***0.086***	

Pt #	**Bi209**	Int2SE	LOD	**Th232**	Int2SE	LOD	**U238**	Int2SE	LOD
1	**0.028**	0.012	4.00E-05	**0**	1	5.90E-06	**8.01**	0.72	3.70E-06
2	**0.0116**	0.0069	5.20E-05	**0**	1	4.80E-06	**11.27**	0.78	3.00E-06
3	**0.024**	0.011	2.40E-05	**0.51**	0.5	5.30E-06	**8.7**	0.95	3.30E-06
4	**0.058**	0.03	5.80E-05	**1.7**	1.7	6.60E-06	**8.26**	0.57	4.00E-06
5	**0.054**	0.018	5.00E-05	**0**	1	4.90E-06	**9.16**	0.72	3.00E-06
Average	***0.03512***	***0.01558***		***0.442***	***1.04***		***9.08***	***0.748***	

Table H.2: Fincastle (DlOx-5) Artifact 2 Cat #900

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**189**	10	0.011	**84**	24	0.012	**479**	45	0.0051	**466446**	53	
2	**287**	12	0.012	**120**	57	0.012	**877**	71	0.0061	**465904**	70	
3	**290**	14	0.013	**80**	25	0.012	**981**	98	0.0069	**465830**	110	
4	**169**	11	0.011	**75**	36	0.01	**468**	51	0.0054	**466460**	110	
5	**365**	21	0.014	**60.8**	9.2	0.013	**970**	110	0.0062	**465750**	120	
Average	***260***	***13.6***		***83.96***	***30.24***		***755***	***75***		***466078***	***92.6***	

Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	**12.8**	2.1	0.014	**269**	12	0.005	**273**	25	0.29	**2.6**	0.38	0.0017
2	**0.6**	1.7	0.016	**423**	13	0.0049	**288**	48	0.34	**2.53**	0.45	0.0018
3	**10.8**	2	0.015	**451**	23	0.0054	**261**	34	0.34	**2.76**	0.45	0.002
4	**13.9**	2	0.014	**282**	16	0.0046	**259**	43	0.31	**2.9**	0.47	0.0018
5	**7.3**	3.5	0.015	**501**	27	0.0056	**314**	48	0.37	**3.5**	0.51	0.0022
Average	***9.08***	***2.26***		***385.2***	***18.2***		***279***	***39.6***		***2.858***	***0.452***	

Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	**-0.83**	0.91	0.019	**0.504**	0.036	0.00032	**0.18**	0.3	0.0038	**0.31**	0.2	0.0038
2	**-1.5**	1.1	0.019	**0.326**	0.032	0.0003	**-1.29**	0.39	0.0036	**0.15**	0.2	0.0034
3	**-2**	1.2	0.019	**0.337**	0.03	0.00032	**-0.61**	0.36	0.0039	**-0.1**	0.23	0.0035
4	**-0.4**	1.4	0.017	**0.422**	0.039	0.00025	**-0.1**	0.35	0.0035	**0.19**	0.24	0.0032
5	**1.4**	7.7	0.02	**0.448**	0.053	0.00032	**-1.4**	1	0.0041	**0.31**	0.34	0.004
Average	***-0.666***	***2.462***		***0.4074***	***0.038***		***-0.644***	***0.48***		***0.172***	***0.242***	

Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	**1.112**	0.067	0.00058	**45**	14	0.036	**0.021**	0.018	9.20E-05	**0.67**	0.37	0.0026
2	**1.07**	0.14	0.00071	**27**	13	0.031	**0.032**	0.011	0.0001	**0.86**	0.35	0.0025
3	**1.218**	0.085	0.00062	**22**	11	0.037	**0.014**	0.01	0.00012	**0.11**	0.38	0.0026
4	**1.3**	0.1	0.00063	**69**	45	0.035	**0.02**	0.018	0.0001	**1.43**	0.67	0.0023
5	**1.27**	0.22	0.00067	**106**	46	0.042	**0.043**	0.022	0.00011	**1.46**	0.42	0.003
Average	***1.194***	***0.1224***		***53.8***	***25.8***		***0.026***	***0.0158***		***0.906***	***0.438***	

Table H.2: Fincastle (DlOx-5) Artifact 2 Cat #900 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**6.2**	1.2	0.013	**8.1**	4.4	0.001	**0.586**	0.035	0.00024	**0.398**	0.032	8.70E-05
2	**4.8**	1.4	0.014	**5**	2.5	0.00094	**0.573**	0.051	0.00026	**0.647**	0.033	0.00011
3	**5.8**	1.5	0.013	**2.8**	1.1	0.00099	**0.618**	0.056	0.00027	**0.707**	0.052	0.00014
4	**6.5**	1.5	0.015	**6.7**	6.3	0.0008	**0.508**	0.048	0.00021	**0.374**	0.036	0.00012
5	**4.6**	1.8	0.017	**16.6**	9.8	0.00097	**0.449**	0.066	0.00028	**0.743**	0.048	0.00014
Average	***5.58***	***1.48***		***7.84***	***4.82***		***0.5468***	***0.0512***		***0.5738***	***0.0402***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**1.72**	0.095	8.60E-05	**0.144**	0.022	2.50E-05	**1.96**	0.15	0.0011	**0.076**	0.01	5.70E-05
2	**2.53**	0.21	9.00E-05	**0.165**	0.026	2.40E-05	**6**	1.9	0.0011	**0.081**	0.0096	7.00E-05
3	**2.1**	0.17	0.0001	**0.088**	0.016	5.20E-05	**2.67**	0.21	0.0011	**0.112**	0.015	6.90E-05
4	**1.65**	0.51	7.80E-05	**0.053**	0.01	4.60E-05	**1.71**	0.27	0.001	**0.09**	0.012	6.80E-05
5	**1.91**	0.18	0.00014	**0.053**	0.011	5.60E-05	**2.45**	0.3	0.0011	**0.124**	0.018	5.70E-05
Average	***1.982***	***0.233***		***0.1006***	***0.017***		***2.958***	***0.566***		***0.0966***	***0.01292***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.011**	0.01	1.90E-05	**0.0157**	0.0069	1.20E-05	**-0.057**	0.037	0.00068	**0.066**	0.039	4.40E-05
2	**0.0116**	0.0092	0.0002	**0.0212**	0.0082	1.20E-05	**-0.011**	0.038	0.00067	**0.019**	0.036	0.00051
3	**-0.0039**	0.006	0.00015	**0.009**	0.0049	1.30E-05	**-0.029**	0.038	0.00073	**0.011**	0.045	0.00051
4	**0.007**	0.0054	0.00013	**0.0189**	0.0095	1.10E-05	**0.002**	0.039	0.0006	**0.056**	0.038	0.00047
5	**0.008**	0.012	0.00019	**0.028**	0.015	1.30E-05	**-0.12**	0.048	0.00071	**0.157**	0.074	0.00069
Average	***0.00674***	***0.00852***		***0.01856***	***0.0089***		***-0.043***	***0.04***		***0.0618***	***0.0464***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.035**	0.018	1.80E-05	**-0.095**	0.068	0.0015	**-0.0031**	0.0027	3.30E-05	**7.13**	0.35	0.00031
2	**0.04**	0.019	0.00017	**-0.073**	0.074	0.0012	**0.0089**	0.0038	5.50E-05	**10.91**	0.79	2.80E-05
3	**0.03**	0.018	0.00017	**-0.066**	0.072	0.0015	**-0.0013**	0.0031	6.50E-05	**9.65**	0.74	3.10E-05
4	**0.028**	0.016	0.00012	**0.017**	0.087	0.0013	**0.0023**	0.004	4.20E-05	**7.09**	0.55	2.60E-05
5	**0.062**	0.022	0.00015	**-0.03**	0.11	0.0015	**-0.0031**	0.0038	5.20E-05	**7.61**	0.62	3.10E-05
Average	***0.039***	***0.0186***		***-0.0494***	***0.0822***		***0.00074***	***0.00348***		***8.478***	***0.61***	

Table H.2: Fincastle (DlOx-5) Artifact 2 Cat #900 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.0358**	0.0068	3.60E-06	**0.147**	0.054	3.00E-06	**0.0117**	0.0043	2.90E-06	**0.068**	0.022	7.50E-05
2	**0.0428**	0.0083	3.50E-06	**0.127**	0.023	2.90E-06	**0.0135**	0.0041	1.50E-05	**0.083**	0.027	1.30E-05
3	**0.0216**	0.0054	3.80E-06	**0.0515**	0.0093	3.30E-06	**0.007**	0.0028	3.10E-06	**0.027**	0.012	1.50E-05
4	**0.0146**	0.0044	3.20E-06	**0.043**	0.012	2.70E-06	**0.0061**	0.0028	2.60E-06	**0.022**	0.012	1.30E-05
5	**0.0102**	0.0039	3.90E-06	**0.044**	0.012	3.30E-06	**0.004**	0.0015	3.10E-06	**0.009**	0.0069	1.50E-05
Average	***0.025***	***0.00576***		***0.0825***	***0.02206***		***0.00846***	***0.0031***		***0.0418***	***0.01598***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.019**	0.012	9.60E-05	**0.0071**	0.0029	4.70E-06	**0.03**	0.013	0.00012	**0.0053**	0.0021	2.70E-06
2	**0.0183**	0.009	9.50E-05	**0.0086**	0.0032	4.60E-06	**0.028**	0.012	1.70E-05	**0.0046**	0.0018	2.60E-06
3	**-0.0012**	0.0064	0.00014	**0.0019**	0.0014	5.10E-06	**0.0087**	0.0073	1.90E-05	**0.0014**	0.001	2.90E-06
4	**0.0061**	0.0049	1.60E-05	**0.0046**	0.003	4.30E-06	**0.017**	0.011	1.60E-05	**0.0024**	0.0016	2.50E-06
5	**0.0066**	0.0059	0.00015	**0.003**	0.0016	5.10E-06	**0.0106**	0.0079	1.90E-05	**0.00072**	0.00054	3.00E-06
Average	***0.00976***	***0.00764***		***0.00504***	***0.00242***		***0.01886***	***0.01024***		***0.002884***	***0.001408***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.042**	0.012	1.10E-05	**0.006**	0.0024	2.90E-06	**0.023**	0.0074	8.60E-06	**0.0206**	0.0082	1.30E-05
2	**0.026**	0.0086	1.10E-05	**0.0096**	0.0031	2.80E-06	**0.0141**	0.006	8.30E-06	**0.065**	0.03	1.30E-05
3	**0.0104**	0.0054	1.20E-05	**0.0058**	0.0023	3.10E-06	**0.0083**	0.0045	9.20E-06	**0.027**	0.014	1.40E-05
4	**0.0166**	0.0097	1.00E-05	**0.0045**	0.0022	2.60E-06	**0.0053**	0.0034	7.70E-06	**0.0073**	0.0042	1.20E-05
5	**0.0059**	0.0044	1.20E-05	**0.0015**	0.0011	3.10E-06	**0.0085**	0.0046	9.30E-06	**0.0069**	0.0046	1.40E-05
Average	***0.02018***	***0.00802***		***0.00548***	***0.00222***		***0.01184***	***0.00518***		***0.02536***	***0.0122***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.037**	0.011	1.10E-05	**-0.00059**	0.00079	1.70E-05	**0.0013**	0.0016	9.40E-06	**0.001**	0.001	8.10E-06
2	**0.35**	0.17	1.10E-05	**0.00151**	0.00099	2.20E-05	**0.0043**	0.0057	9.10E-06	**0.0055**	0.003	7.80E-06
3	**0.079**	0.018	1.20E-05	**0.0017**	0.0011	2.90E-05	**0.0009**	0.0015	1.00E-05	**0**	1	8.70E-06
4	**0.045**	0.015	1.00E-05	**0.0014**	0.0013	2.80E-06	**0.0033**	0.0033	8.50E-06	**0.0029**	0.0027	7.30E-06
5	**0.075**	0.017	1.20E-05	**0.0016**	0.0013	3.40E-06	**0.0062**	0.0043	1.00E-05	**0.0011**	0.0012	8.80E-06
Average	***0.1172***	***0.0462***		***0.001124***	***0.001096***		***0.0032***	***0.00328***		***0.0021***	***0.20158***	

Table H.2: Fincastle (DlOx-5) Artifact 2 Cat #900 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**0.77**	0.22	0.0017	**0.164**	0.031	0.00011	**0.06**	0.016	7.40E-05	**0.086**	0.017	4.50E-05
2	**0.94**	0.2	0.0018	**0.099**	0.021	7.70E-05	**0.07**	0.021	6.30E-05	**0.061**	0.014	4.80E-05
3	**0.77**	0.24	0.0024	**0.093**	0.015	6.00E-05	**0.067**	0.015	0.00012	**0.061**	0.015	4.50E-05
4	**0.84**	0.2	0.0021	**0.121**	0.036	7.30E-05	**0.095**	0.037	7.80E-06	**0.078**	0.03	5.70E-05
5	**1.12**	0.31	0.0022	**0.136**	0.027	8.50E-06	**0.077**	0.025	9.30E-06	**0.078**	0.017	5.40E-05
Average	***0.888***	***0.234***		***0.1226***	***0.026***		***0.0738***	***0.0228***		***0.0728***	***0.0186***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.035**	0.0094	1.50E-05	**0.041**	0.082	2.80E-06	**3.65**	0.14	1.80E-06
2	**0.0067**	0.0053	5.50E-05	**0**	1	2.70E-06	**1.411**	0.073	1.80E-06
3	**0.0105**	0.0044	6.70E-05	**0**	1	3.00E-06	**1.87**	0.14	2.00E-06
4	**0.0147**	0.0063	5.10E-05	**0**	1	2.50E-06	**3.12**	0.17	1.70E-06
5	**0.027**	0.013	3.80E-05	**0**	1	3.00E-06	**2.92**	0.26	2.00E-06
Average	***0.01878***	***0.00768***		***0.0082***	***0.8164***		***2.5942***	***0.1566***	

Appendix H: Archaeological Samples Raw Data

Table H.3: Fincastle (DlOx-5) Artifact 3 Cat #13970

Pt #	**Na23**	Int2SE	LOD	**Mg25**	Int2SE	LOD	**Al27**	Int2SE	LOD	**Si29**	Int2SE	LOD
1	**324**	32	0.018	**132**	40	0.018	**910**	120	0.0098	**465490**	180	
2	**196**	17	0.015	**170**	110	0.015	**441**	49	0.0077	**465890**	140	
3	**199**	19	0.015	**63**	27	0.015	**581**	57	0.0078	**466110**	210	
4	**278**	15	0.019	**45**	4.8	0.021	**908**	93	0.0097	**465860**	170	
5	**412**	45	0.017	**610**	200	0.016	**550**	60	0.0082	**464460**	380	
Average	***281.8***	***25.6***		***204***	***76.36***		***678***	***75.8***		***465562***	***216***	
Pt #	**P31**	Int2SE	LOD	**K39**	Int2SE	LOD	**Ca43**	Int2SE	LOD	**Sc45**	Int2SE	LOD
1	**23**	4.5	0.015	**544**	41	0.0073	**276**	78	0.45	**3.12**	0.78	0.0026
2	**122**	18	0.012	**321**	25	0.0058	**307**	54	0.36	**3.44**	0.73	0.0021
3	**11.9**	1.6	0.011	**368**	17	0.006	**193**	47	0.38	**2.72**	0.64	0.0022
4	**11.9**	2.5	0.015	**527**	26	0.0077	**246**	52	0.42	**2.2**	0.49	0.0028
5	**41.2**	7.7	0.012	**543**	50	0.0066	**391**	96	0.37	**4.75**	0.88	0.0024
Average	***42***	***6.86***		***460.6***	***31.8***		***282.6***	***65.4***		***3.246***	***0.704***	
Pt #	**Ti49**	Int2SE	LOD	**V51**	Int2SE	LOD	**Cr52**	Int2SE	LOD	**Cr53**	Int2SE	LOD
1	**36**	44	0.033	**0.88**	0.12	0.00051	**1.2**	0.64	0.0049	**2.4**	1.1	0.0047
2	**2.7**	1.8	0.027	**1.54**	0.13	0.00039	**0.93**	0.37	0.0039	**1.03**	0.63	0.0037
3	**-1.3**	5.1	0.027	**1.55**	0.25	0.00039	**85**	81	0.0041	**37**	22	0.0038
4	**-4.3**	2.6	0.033	**0.663**	0.064	0.00048	**0.23**	0.45	0.0052	**0.32**	0.47	0.0044
5	**5.3**	2.1	0.026	**1.8**	1.4	0.00041	**8.6**	4.1	0.0045	**27**	29	0.0045
Average	***7.68***	***11.12***		***1.2866***	***0.3928***		***19.192***	***17.312***		***13.55***	***10.64***	
Pt #	**Mn55**	Int2SE	LOD	**Fe57**	Int2SE	LOD	**Co59**	Int2SE	LOD	**Ni60**	Int2SE	LOD
1	**1.45**	0.22	0.00073	**256**	85	0.045	**0.094**	0.045	0.00019	**2.8**	1.8	0.0043
2	**1.04**	0.11	0.00054	**208**	76	0.036	**0.073**	0.028	0.00012	**2.23**	0.79	0.0035
3	**24**	38	0.00054	**270**	230	0.037	**0.69**	0.56	0.00013	**11.2**	8.9	0.0036
4	**0.938**	0.085	0.00067	**120**	180	0.047	**0.005**	0.013	0.00019	**0.68**	0.49	0.0047
5	**3.59**	0.93	0.00061	**1240**	330	0.04	**2.2**	3.3	0.00018	**4.9**	1.4	0.0039
Average	***6.2036***	***7.869***		***418.8***	***180.2***		***0.6124***	***0.7892***		***4.362***	***2.676***	

Table H.3: Fincastle (DlOx-5) Artifact 3 Cat #13970 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**7.3**	5	0.024	**45**	16	0.0017	**0.447**	0.088	0.00039	**0.476**	0.052	0.00015
2	**8.2**	2.5	0.025	**26**	11	0.0014	**0.626**	0.074	0.00035	**0.279**	0.045	0.00011
3	**16**	10	0.019	**9.2**	7.4	0.0013	**0.314**	0.066	0.00038	**0.296**	0.032	0.00016
4	**4**	2.4	0.027	**4.1**	1.8	0.0017	**0.278**	0.052	0.00047	**0.416**	0.037	0.00016
5	**12**	5	0.022	**243**	61	0.0014	**1.3**	0.23	0.00041	**0.367**	0.056	0.00017
Average	***9.5***	***4.98***		***65.46***	***19.44***		***0.593***	***0.102***		***0.3668***	***0.0444***	

Pt #	Sr88	Int2SE	LOD	Y89	Int2SE	LOD	Zr90	Int2SE	LOD	Nb93	Int2SE	LOD
1	**2.03**	0.22	0.00016	**1.69**	0.51	8.20E-05	**10**	13	0.002	**0.139**	0.033	0.0001
2	**5.5**	0.66	0.00012	**111**	14	3.30E-05	**1.94**	0.21	0.0016	**0.085**	0.02	0.00011
3	**1.28**	0.11	0.00016	**0.321**	0.045	4.10E-05	**2.47**	0.39	0.0015	**0.133**	0.025	9.30E-05
4	**1.9**	0.17	0.00016	**0.501**	0.085	5.10E-05	**2.18**	0.26	0.002	**0.113**	0.015	0.00012
5	**1.63**	0.21	0.00015	**1.28**	0.45	5.40E-05	**33**	24	0.0016	**0.119**	0.028	9.40E-05
Average	***2.468***	***0.274***		***22.9584***	***3.018***		***9.918***	***7.572***		***0.1178***	***0.0242***	

Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	**0.038**	0.029	4.60E-05	**0.055**	0.029	2.90E-05	**-0.017**	0.079	0.0013	**0.18**	0.12	0.0011
2	**0.02**	0.011	0.00022	**0.018**	0.017	2.60E-05	**0.014**	0.061	0.00099	**0.19**	0.14	0.001
3	**0.16**	0.12	3.00E-05	**1**	1	1.90E-05	**0.037**	0.051	0.001	**0.31**	0.11	0.0012
4	**0.0009**	0.0019	3.40E-05	**0.0049**	0.0052	2.10E-05	**-0.195**	0.085	0.0013	**0.19**	0.1	0.0011
5	**0.225**	0.059	4.90E-05	**0.156**	0.045	3.10E-05	**0.113**	0.094	0.0011	**0.47**	0.21	0.00087
Average	***0.08878***	***0.04418***		***0.24678***	***0.21924***		***-0.0096***	***0.074***		***0.268***	***0.136***	

Pt #	Cd114	Int2SE	LOD	Sn122	Int2SE	LOD	Cs133	Int2SE	LOD	Ba137	Int2SE	LOD
1	**0.122**	0.058	0.00021	**-0.21**	0.18	0.0024	**0.0034**	0.0052	8.30E-05	**9.2**	1.2	6.50E-05
2	**0.105**	0.047	0.00027	**0.03**	0.13	0.002	**0.007**	0.0054	6.00E-05	**16.1**	1	5.90E-05
3	**0.281**	0.072	0.00017	**0.29**	0.38	0.002	**0.0021**	0.0047	7.00E-05	**4.98**	0.47	4.20E-05
4	**0.125**	0.038	0.00021	**-0.14**	0.12	0.0028	**-0.0064**	0.0048	6.80E-05	**6.37**	0.67	4.80E-05
5	**0.48**	0.15	0.00037	**0.02**	0.13	0.0021	**0.0147**	0.0083	5.50E-05	**32.1**	7.5	6.90E-05
Average	***0.2226***	***0.073***		***-0.002***	***0.188***		***0.00416***	***0.00568***		***13.75***	***2.168***	

Table H.3: Fincastle (DlOx-5) Artifact 3 Cat #13970 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	0.48	0.17	8.40E-06	1.08	0.41	6.90E-06	0.222	0.087	6.70E-06	0.95	0.36	0.00013
2	22.8	4.2	3.90E-05	69	15	6.30E-06	9	1.8	6.10E-06	41.9	7.6	0.00013
3	0.093	0.026	5.40E-06	0.198	0.052	4.50E-06	0.033	0.011	4.30E-06	0.172	0.047	2.20E-05
4	0.072	0.017	6.10E-06	0.127	0.033	5.10E-06	0.0208	0.0074	4.90E-06	0.115	0.033	2.40E-05
5	0.55	0.2	8.60E-06	1.41	0.51	7.30E-06	0.233	0.085	7.00E-06	1.06	0.49	0.00015
Average	4.799	0.9226		14.363	3.201		1.90176	0.39808		8.8394	1.706	

Pt #	Sm147	Int2SE	LOD	Eu153	Int2SE	LOD	Gd157	Int2SE	LOD	Tb159	Int2SE	LOD
1	0.26	0.13	0.00016	0.055	0.017	1.10E-05	0.38	0.16	4.30E-05	0.058	0.021	6.80E-06
2	11.7	2.1	3.90E-05	2.85	0.5	1.00E-05	16.5	2.6	3.90E-05	2.77	0.41	6.10E-06
3	0.042	0.02	2.70E-05	0.0082	0.0039	7.30E-06	0.058	0.026	2.70E-05	0.0065	0.0026	4.30E-06
4	0.044	0.024	3.10E-05	0.0085	0.0048	8.20E-06	0.043	0.017	3.10E-05	0.0063	0.003	4.80E-06
5	0.31	0.12	4.40E-05	0.058	0.022	1.20E-05	0.34	0.16	4.40E-05	0.052	0.018	6.80E-06
Average	2.4712	0.4788		0.59594	0.10954		3.4642	0.5926		0.57856	0.09092	

Pt #	Dy163	Int2SE	LOD	Ho165	Int2SE	LOD	Er166	Int2SE	LOD	Yb172	Int2SE	LOD
1	0.3	0.11	2.80E-05	0.058	0.019	7.20E-06	0.17	0.052	2.10E-05	0.179	0.076	3.40E-05
2	17.2	2.4	2.50E-05	3.71	0.48	6.50E-06	10.3	1.3	1.90E-05	7.51	0.95	3.00E-05
3	0.035	0.013	1.80E-05	0.0151	0.0056	4.60E-06	0.029	0.01	8.10E-05	0.06	0.017	2.10E-05
4	0.055	0.019	2.00E-05	0.0153	0.0046	5.10E-06	0.039	0.013	1.50E-05	0.072	0.031	2.40E-05
5	0.28	0.11	2.80E-05	0.052	0.023	7.20E-06	0.145	0.056	2.10E-05	0.239	0.092	3.40E-05
Average	3.574	0.5304		0.77008	0.10644		2.1366	0.2862		1.612	0.2332	

Pt #	Hf178	Int2SE	LOD	Ta181	Int2SE	LOD	W182	Int2SE	LOD	W184	Int2SE	LOD
1	0.047	0.028	2.80E-05	0.0021	0.0052	3.80E-05	0.0079	0.0059	2.20E-05	0.0049	0.0048	1.90E-05
2	0.02	0.011	2.50E-05	0.0023	0.003	6.90E-06	0.014	0.011	2.00E-05	0.003	0.0029	1.70E-05
3	0.02	0.01	1.80E-05	0.0016	0.0013	4.90E-06	0.026	0.017	1.40E-05	0.022	0.015	1.20E-05
4	0.029	0.013	2.00E-05	0.0014	0.0014	5.90E-05	0.00033	0.00065	1.70E-05	0.002	0.0022	1.40E-05
5	1.75	0.94	2.80E-05	0.0055	0.0049	7.80E-06	0.029	0.013	2.40E-05	0.057	0.021	2.00E-05
Average	0.3732	0.2004		0.00258	0.00316		0.015446	0.00951		0.01778	0.00918	

Table H.3: Fincastle (DlOx-5) Artifact 3 Cat #13970 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**2.25**	0.71	0.0016	**0.416**	0.057	1.80E-05	**0.153**	0.04	2.10E-05	**0.266**	0.062	8.10E-05
2	**3.89**	0.67	0.0021	**2.8**	0.65	5.80E-05	**2.11**	0.45	1.90E-05	**2.2**	0.48	6.20E-05
3	**1.49**	0.37	0.0002	**0.315**	0.057	5.50E-05	**0.097**	0.047	8.10E-05	**0.103**	0.037	5.00E-05
4	**1.43**	0.34	0.0027	**0.26**	0.041	1.40E-05	**0.056**	0.019	1.50E-05	**0.063**	0.012	3.30E-05
5	**2.32**	0.52	0.0017	**0.6**	0.13	0.00012	**0.317**	0.065	9.50E-05	**0.72**	0.17	9.10E-06
Average	***2.276***	***0.522***		***0.8782***	***0.187***		***0.5466***	***0.1242***		***0.6704***	***0.1522***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.44**	0.13	5.50E-05	**0**	1	6.80E-06	**7.9**	0.72	4.20E-06
2	**0.05**	0.013	3.20E-05	**0**	1	6.10E-06	**10.89**	0.86	3.80E-06
3	**0.134**	0.067	3.00E-05	**0**	1	4.30E-06	**10.38**	0.8	2.70E-06
4	**0.0221**	0.0073	2.40E-05	**0**	1	4.90E-06	**8**	0.56	3.10E-06
5	**0.158**	0.033	3.90E-05	**0**	1	6.90E-06	**6.54**	0.48	4.50E-06
Average	***0.16082***	***0.05006***		***0***	***1***		***8.742***	***0.684***	

Table H.4: Smith-Swainson (FeOw-1, 2, and 3) Artifact 1 Cat #H72.7.799

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**225**	35	0.015	**300**	140	0.012	**361**	54	0.008	**465270**	610	
2	**178**	21	0.013	**88**	49	0.0095	**516**	55	0.0075	**466410**	110	
3	**105.5**	6.5	0.012	**29.1**	7.8	0.0079	**383**	31	0.0066	**466717**	52	
4	**95.9**	9.8	0.01	**25.9**	6.7	0.0073	**283**	22	0.0057	**466766**	56	
5	**101**	12	0.01	**64**	49	0.0069	**180**	12	0.0053	**466852**	80	
Average	***141.08***	***16.86***		***101.4***	***50.5***		***344.6***	***34.8***		***466403***	***181.6***	
Pt #	**P31**	Int2SE	LOD	**K39**	Int2SE	LOD	**Ca43**	Int2SE	LOD	**Sc45**	Int2SE	LOD
1	**44**	12	0.023	**289**	28	0.0064	**185**	76	0.38	**3.5**	1.1	0.0025
2	**3.2**	2.4	0.019	**291**	20	0.0053	**135**	26	0.32	**2.52**	0.47	0.0021
3	**12.3**	2.2	0.017	**192.2**	8.3	0.0046	**182**	24	0.25	**1.49**	0.26	0.0018
4	**15.4**	3.8	0.015	**181**	13	0.0041	**154**	23	0.23	**1.86**	0.4	0.0016
5	**9.8**	1.8	0.016	**168**	13	0.0039	**116**	31	0.24	**3.12**	0.51	0.0016
Average	***16.94***	***4.44***		***224.24***	***16.46***		***154.4***	***36***		***2.498***	***0.548***	
Pt #	**Ti49**	Int2SE	LOD	**V51**	Int2SE	LOD	**Cr52**	Int2SE	LOD	**Cr53**	Int2SE	LOD
1	**2.4**	1.5	0.018	**0.75**	0.11	0.00027	**-1.3**	1.8	0.0075	**4.3**	3.6	0.0064
2	**0.7**	1.3	0.013	**0.618**	0.059	0.00022	**-4.9**	1.5	0.0061	**-0.2**	0.48	0.0053
3	**0.37**	0.61	0.011	**0.648**	0.054	0.00019	**-1.66**	0.52	0.0052	**-0.05**	0.23	0.0044
4	**0.75**	0.53	0.01	**0.658**	0.058	0.00016	**-2.29**	0.44	0.0047	**0.07**	0.32	0.004
5	**1.12**	0.82	0.0095	**0.623**	0.053	0.00017	**-1.73**	0.46	0.0047	**0.4**	0.65	0.0041
Average	***1.068***	***0.952***		***0.6594***	***0.0668***		***-2.376***	***0.944***		***0.904***	***1.056***	
Pt #	**Mn55**	Int2SE	LOD	**Fe57**	Int2SE	LOD	**Co59**	Int2SE	LOD	**Ni60**	Int2SE	LOD
1	**2.9**	1	0.001	**1250**	630	0.046	**0.59**	0.37	0.00013	**9.3**	3.9	0.0025
2	**1.4**	0.27	0.00081	**101**	34	0.035	**0.037**	0.028	0.00012	**1.4**	0.48	0.0022
3	**1.24**	0.11	0.00072	**62**	20	0.03	**0.0019**	0.0071	0.0001	**0.82**	0.28	0.0018
4	**1.32**	0.15	0.00067	**68**	23	0.029	**0.026**	0.013	9.30E-05	**1.11**	0.33	0.0016
5	**1.33**	0.29	0.00079	**149**	48	0.026	**0.076**	0.043	9.50E-05	**2.7**	1	0.0016
Average	***1.638***	***0.364***		***326***	***151***		***0.14618***	***0.09222***		***3.066***	***1.198***	

Table H.4: Smith-Swainson (FeOw-1, 2, and 3) Artifact 1 Cat #H72.7.799 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**17.8**	5	0.02	**150**	48	0.001	**2.9**	1.6	0.00026	**0.253**	0.039	0.00011
2	**10**	2.1	0.016	**23**	12	0.00073	**1.07**	0.13	0.00021	**0.218**	0.025	0.00012
3	**4.3**	1.1	0.013	**3**	1.8	0.00057	**0.933**	0.069	0.00019	**0.144**	0.017	0.00011
4	**4.6**	1	0.0095	**6.4**	5	0.00054	**2.47**	0.97	0.00015	**0.132**	0.014	9.00E-05
5	**7.2**	1.4	0.012	**18**	8	0.00049	**0.871**	0.093	0.00017	**0.147**	0.018	9.00E-05
Average	***8.78***	***2.12***		***40.08***	***14.96***		***1.6488***	***0.5724***		***0.1788***	***0.0226***	
Pt #	**Sr88**	Int2SE	LOD	**Y89**	Int2SE	LOD	**Zr90**	Int2SE	LOD	**Nb93**	Int2SE	LOD
1	**2.02**	0.69	0.00014	**0.47**	0.11	8.20E-05	**4.3**	2.6	0.0012	**0.054**	0.018	9.00E-05
2	**1.52**	0.13	0.00012	**0.378**	0.046	4.60E-05	**1.87**	0.39	0.00095	**0.053**	0.012	6.40E-05
3	**1.38**	0.088	8.10E-05	**0.128**	0.016	6.10E-05	**1.16**	0.1	0.00081	**0.0297**	0.0061	4.00E-05
4	**1.8**	0.33	7.70E-05	**0.194**	0.053	4.00E-05	**1.42**	0.12	0.00067	**0.0358**	0.0094	3.90E-05
5	**1.14**	0.1	7.50E-05	**0.125**	0.057	5.20E-05	**0.7**	0.18	0.00073	**0.026**	0.0075	4.10E-05
Average	***1.572***	***0.2676***		***0.259***	***0.0564***		***1.89***	***0.678***		***0.0397***	***0.0106***	
Pt #	**Mo95**	Int2SE	LOD	**Mo98**	Int2SE	LOD	**Ag107**	Int2SE	LOD	**Cd111**	Int2SE	LOD
1	**0.163**	0.083	0.00024	**0.111**	0.08	0.00012	**0.19**	0.1	0.00069	**0.77**	0.3	0.00063
2	**0.018**	0.011	0.00013	**0.0177**	0.0087	0.00011	**0.042**	0.033	0.00054	**0.076**	0.047	0.00066
3	**0.0015**	0.0022	2.20E-05	**0.0056**	0.0038	7.00E-05	**0.021**	0.031	0.00042	**0.023**	0.024	0.00045
4	**0.0048**	0.005	0.00018	**0.006**	0.0043	0.0001	**0.033**	0.031	0.00037	**0.086**	0.044	0.00033
5	**0.022**	0.017	3.10E-05	**0.017**	0.011	2.00E-05	**0.053**	0.029	0.00039	**0.083**	0.05	0.00041
Average	***0.04186***	***0.02364***		***0.03146***	***0.02156***		***0.0678***	***0.0448***		***0.2076***	***0.093***	
Pt #	**Cd114**	Int2SE	LOD	**Sn122**	Int2SE	LOD	**Cs133**	Int2SE	LOD	**Ba137**	Int2SE	LOD
1	**0.76**	0.3	0.00018	**0.16**	0.16	0.0014	**0.0053**	0.0082	6.20E-05	**44**	26	9.50E-05
2	**0.058**	0.024	0.00013	**-0.037**	0.061	0.0011	**0.0034**	0.0045	4.90E-05	**14.3**	1.7	0.00018
3	**0.046**	0.021	0.00014	**-0.028**	0.03	0.0007	**0.0002**	0.0017	5.20E-05	**11.26**	0.68	3.00E-05
4	**0.16**	0.096	0.00017	**-0.009**	0.039	0.00077	**0.0002**	0.0022	4.40E-05	**31.5**	6.4	0.00014
5	**0.056**	0.03	0.00011	**-0.002**	0.041	0.00069	**0.0012**	0.0021	4.60E-05	**13.2**	1.5	0.00015
Average	***0.216***	***0.0942***		***0.0168***	***0.0662***		***0.00206***	***0.00374***		***22.852***	***7.256***	

Table H.4: Smith-Swainson (FeOw-1, 2, and 3) Artifact 1 Cat #H72.7.799 Continued

Pt #	**La139**	Int2SE	LOD	**Ce140**	Int2SE	LOD	**Pr141**	Int2SE	LOD	**Nd146**	Int2SE	LOD
1	**0.147**	0.045	4.20E-05	**0.4**	0.064	1.00E-05	**0.081**	0.028	9.80E-06	**0.311**	0.072	4.50E-05
2	**0.107**	0.018	4.10E-05	**0.25**	0.032	4.00E-06	**0.041**	0.0075	3.90E-06	**0.175**	0.029	8.30E-05
3	**0.0295**	0.0054	1.90E-05	**0.081**	0.012	1.60E-05	**0.01**	0.0023	3.10E-06	**0.044**	0.014	0.00011
4	**0.087**	0.046	4.40E-06	**0.219**	0.089	3.70E-06	**0.035**	0.016	3.50E-06	**0.141**	0.084	1.60E-05
5	**0.0211**	0.0054	5.40E-06	**0.0739**	0.0097	4.60E-06	**0.016**	0.0048	4.40E-06	**0.035**	0.0097	2.00E-05
Average	***0.07832***	***0.02396***		***0.20478***	***0.04134***		***0.0366***	***0.01172***		***0.1412***	***0.04174***	
Pt #	**Sm147**	Int2SE	LOD	**Eu153**	Int2SE	LOD	**Gd157**	Int2SE	LOD	**Tb159**	Int2SE	LOD
1	**0.121**	0.037	5.60E-05	**0.029**	0.011	4.10E-05	**0.093**	0.047	0.00016	**0.0214**	0.0055	9.00E-06
2	**0.052**	0.018	2.20E-05	**0.0082**	0.0037	6.00E-06	**0.072**	0.02	0.00011	**0.011**	0.0039	1.70E-05
3	**0.0145**	0.0095	1.80E-05	**0.0049**	0.0024	2.40E-05	**0.0109**	0.0057	0.00015	**0.0023**	0.0012	1.40E-05
4	**0.051**	0.025	2.00E-05	**0.0108**	0.0048	5.50E-06	**0.041**	0.02	8.60E-05	**0.0054**	0.0027	1.30E-05
5	**0.0074**	0.0055	2.50E-05	**0.0039**	0.002	6.80E-06	**0.019**	0.012	9.20E-05	**0.0036**	0.0021	4.00E-06
Average	***0.04918***	***0.019***		***0.01136***	***0.00478***		***0.04718***	***0.02094***		***0.00874***	***0.00308***	
Pt #	**Dy163**	Int2SE	LOD	**Ho165**	Int2SE	LOD	**Er166**	Int2SE	LOD	**Yb172**	Int2SE	LOD
1	**0.112**	0.042	3.70E-05	**0.0254**	0.0096	9.60E-06	**0.063**	0.024	2.80E-05	**0.053**	0.022	4.40E-05
2	**0.061**	0.018	1.50E-05	**0.0203**	0.0051	3.80E-06	**0.053**	0.014	1.10E-05	**0.073**	0.022	8.20E-05
3	**0.019**	0.0074	1.20E-05	**0.0039**	0.0017	1.50E-05	**0.021**	0.0088	9.00E-06	**0.056**	0.015	1.40E-05
4	**0.041**	0.02	5.40E-05	**0.0123**	0.0053	1.40E-05	**0.0163**	0.0057	1.00E-05	**0.038**	0.014	6.50E-05
5	**0.0146**	0.0083	1.70E-05	**0.0039**	0.0023	1.90E-05	**0.009**	0.0054	1.30E-05	**0.0189**	0.0084	2.00E-05
Average	***0.04952***	***0.01914***		***0.01316***	***0.0048***		***0.03246***	***0.01158***		***0.04778***	***0.01628***	
Pt #	**Hf178**	Int2SE	LOD	**Ta181**	Int2SE	LOD	**W182**	Int2SE	LOD	**W184**	Int2SE	LOD
1	**0.034**	0.015	3.80E-05	**0.0018**	0.0021	1.10E-05	**0.052**	0.024	3.30E-05	**0.033**	0.012	2.80E-05
2	**0.082**	0.031	1.50E-05	**0.00094**	0.0009	2.00E-05	**0.008**	0.0049	1.30E-05	**0.0096**	0.0051	1.10E-05
3	**0.0238**	0.0073	1.20E-05	**0.0014**	0.001	3.40E-06	**0.00025**	0.0005	1.00E-05	**-1.59E-06**	2.40E-07	8.80E-06
4	**0.0252**	0.0079	1.40E-05	**0.00091**	0.00097	3.90E-06	**0.0013**	0.0018	1.20E-05	**0.0041**	0.0034	1.00E-05
5	**0.076**	0.065	1.70E-05	**0.0017**	0.0017	2.90E-05	**0.0057**	0.0056	1.50E-05	**0.0058**	0.004	1.20E-05
Average	***0.0482***	***0.02524***		***0.00135***	***0.001334***		***0.01345***	***0.00736***		***0.010499682***	***0.004900048***	

Table H.4: Smith-Swainson (FeOw-1, 2, and 3) Artifact 1 Cat #H72.7.799 Continued

Pt #	**Pb204**	Int2SE	LOD	**Pb206**	Int2SE	LOD	**Pb207**	Int2SE	LOD	**Pb208**	Int2SE	LOD
1	**2.2**	0.64	0.0032	**0.82**	0.17	0.00011	**0.407**	0.076	7.40E-05	**0.436**	0.071	3.10E-05
2	**2.38**	0.69	0.0027	**0.364**	0.049	8.20E-05	**0.21**	0.029	5.10E-05	**0.256**	0.034	6.70E-05
3	**1.73**	0.37	0.0029	**0.248**	0.025	3.90E-05	**0.129**	0.017	5.70E-05	**0.135**	0.011	3.20E-05
4	**2**	0.34	0.0023	**0.335**	0.035	9.90E-05	**0.16**	0.025	5.20E-05	**0.16**	0.025	5.60E-05
5	**1.9**	0.42	0.0021	**0.318**	0.041	6.50E-05	**0.162**	0.021	4.20E-05	**0.175**	0.023	3.80E-05
Average	***2.042***	***0.492***		***0.417***	***0.064***		***0.2136***	***0.0336***		***0.2324***	***0.0328***	

Pt #	**Bi209**	Int2SE	LOD	**Th232**	Int2SE	LOD	**U238**	Int2SE	LOD
1	**0.107**	0.036	4.00E-05	**-0.006**	0.0037	9.30E-06	**6.19**	0.72	5.90E-06
2	**0.023**	0.013	6.80E-05	**-0.012**	0.0053	3.70E-06	**5.54**	0.37	2.30E-06
3	**0.004**	0.0026	5.40E-05	**-0.0053**	0.0015	1.50E-05	**6.61**	0.34	1.90E-06
4	**0.0074**	0.0043	4.50E-05	**-0.00298**	0.00089	3.30E-06	**6.96**	0.3	2.10E-06
5	**0.0146**	0.0083	4.30E-05	**-0.00155**	0.00035	4.10E-06	**6.34**	0.34	2.60E-06
Average	***0.0312***	***0.01284***		***-0.005566***	***0.002348***		***6.328***	***0.414***	

Table H.5: Smith-Swainson (FeOw-1, 2, and 3) Artifact 2 Cat #H72.7.800

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**224**	17	0.008	**103**	38	0.0058	**620**	140	0.004	**465980**	240	
2	**242**	24	0.0073	**290**	120	0.0051	**510**	170	0.0034	**465640**	350	
3	**170**	21	0.0077	**71**	32	0.0057	**352**	48	0.0036	**466530**	98	
4	**168**	27	0.0086	**164**	78	0.0055	**271**	36	0.0046	**466350**	250	
5	**288**	32	0.0086	**430**	140	0.006	**488**	88	0.0043	**464950**	520	
Average	*218.4*	*24.2*		*211.6*	*81.6*		*448.2*	*96.4*		*465890*	*291.6*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**25.1**	9	0.012	**344**	31	0.003	**291**	52	0.18	**3.44**	0.43	0.0012
2	**39**	16	0.0089	**321**	30	0.0028	**266**	79	0.15	**4.12**	0.52	0.0012
3	**15.2**	3	0.009	**256**	32	0.003	**243**	24	0.17	**3.63**	0.39	0.0012
4	**17.9**	7.5	0.011	**228**	35	0.0032	**199**	27	0.2	**3.52**	0.53	0.0013
5	**28.8**	9.1	0.012	**413**	39	0.0033	**315**	65	0.2	**3.49**	0.57	0.0014
Average	*25.2*	*8.92*		*312.4*	*33.4*		*262.8*	*49.4*		*3.64*	*0.488*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**9**	14	0.0074	**1.34**	0.16	0.00013	**-1.92**	0.83	0.0035	**0.34**	0.38	0.0031
2	**4.2**	2.9	0.0068	**1.17**	0.12	0.00011	**-0.4**	1	0.0033	**1.44**	0.7	0.0027
3	**1.5**	1.4	0.0076	**1.237**	0.072	0.00012	**-0.9**	0.34	0.0035	**0.31**	0.59	0.0031
4	**2.9**	2.5	0.0071	**1.2**	0.12	0.00011	**-1.55**	0.97	0.0038	**1.14**	0.54	0.0031
5	**5.1**	2.3	0.0075	**1.53**	0.43	0.00011	**1.6**	2.1	0.0039	**4.6**	2.5	0.0032
Average	*4.54*	*4.62*		*1.2954*	*0.1804*		*-0.634*	*1.048*		*1.566*	*0.942*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**2.49**	0.87	0.00056	**215**	90	0.02	**0.19**	0.11	7.40E-05	**3.5**	1	0.0012
2	**2.68**	0.68	0.00039	**650**	220	0.02	**0.286**	0.083	6.20E-05	**5.8**	2.3	0.0012
3	**1.85**	0.34	0.0004	**77**	34	0.021	**0.093**	0.063	5.80E-05	**3.1**	1.4	0.0012
4	**1.5**	0.36	0.00051	**300**	170	0.019	**0.071**	0.038	7.30E-05	**3.8**	1.6	0.0013
5	**2.94**	0.69	0.00052	**860**	250	0.023	**0.245**	0.086	6.70E-05	**9.4**	4.6	0.0013
Average	*2.292*	*0.588*		*420.4*	*152.8*		*0.177*	*0.076*		*5.12*	*2.18*	

Table H.5: Smith-Swainson (FeOw-1, 2, and 3) Artifact 2 Cat #H72.7.800 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**7.4**	1.6	0.0096	**66**	34	0.0004	**2.92**	0.76	0.00013	**0.277**	0.078	6.90E-05
2	**10.9**	3	0.0086	**92**	30	0.00036	**1.26**	0.11	0.00013	**0.216**	0.037	6.20E-05
3	**6.06**	0.98	0.0092	**41**	25	0.00037	**1.6**	0.13	0.00012	**0.192**	0.044	6.10E-05
4	**5.8**	1.3	0.01	**36**	16	0.00042	**1.39**	0.19	0.00014	**0.171**	0.031	6.50E-05
5	**9.2**	2.5	0.0081	**121**	33	0.00043	**2.31**	0.4	0.00015	**0.236**	0.033	7.80E-05
Average	***7.872***	***1.876***		***71.2***	***27.6***		***1.896***	***0.318***		***0.2184***	***0.0446***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**2.35**	0.38	5.60E-05	**0.416**	0.07	2.90E-05	**32.8**	3	0.00056	**0.25**	0.02	4.10E-05
2	**1.6**	0.19	6.50E-05	**0.337**	0.046	3.30E-05	**27.3**	5.3	0.00049	**0.248**	0.04	3.40E-05
3	**1.69**	0.11	6.00E-05	**0.273**	0.033	3.70E-05	**53.4**	6.2	0.00052	**0.319**	0.034	2.00E-05
4	**1.44**	0.13	7.30E-05	**0.169**	0.023	2.40E-05	**11.32**	0.9	0.00058	**0.249**	0.029	2.60E-05
5	**1.82**	0.21	6.10E-05	**0.264**	0.04	4.60E-05	**19.3**	3.3	0.00058	**0.232**	0.029	3.50E-05
Average	***1.78***	***0.204***		***0.2918***	***0.0424***		***28.824***	***3.74***		***0.2596***	***0.0304***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.051**	0.019	1.80E-05	**0.041**	0.014	4.70E-05	**0.099**	0.046	0.00031	**0.217**	0.078	0.00022
2	**0.053**	0.02	7.20E-05	**0.069**	0.023	1.20E-05	**0.099**	0.029	0.00028	**0.51**	0.15	0.00024
3	**0.034**	0.02	1.90E-05	**0.02**	0.01	4.80E-05	**0.089**	0.039	0.00027	**0.056**	0.04	0.00022
4	**0.028**	0.015	0.00013	**0.036**	0.013	1.20E-05	**0.074**	0.043	0.00029	**0.191**	0.057	0.00033
5	**0.074**	0.034	0.00012	**0.071**	0.03	1.60E-05	**0.139**	0.048	0.00032	**0.37**	0.11	0.00032
Average	***0.048***	***0.0216***		***0.0474***	***0.018***		***0.1***	***0.041***		***0.2688***	***0.087***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.237**	0.083	5.80E-05	**0.074**	0.077	0.0005	**0.0053**	0.005	3.10E-05	**44**	15	0.0001
2	**0.57**	0.19	7.40E-05	**0.18**	0.1	0.0006	**0.007**	0.0034	3.00E-05	**12.2**	2.2	9.90E-05
3	**0.149**	0.082	9.20E-05	**0.071**	0.057	0.00051	**0.005**	0.0049	2.70E-05	**12.2**	1.5	2.60E-05
4	**0.155**	0.068	8.60E-05	**0.046**	0.062	0.00049	**0.0032**	0.0032	4.10E-05	**14.1**	3.2	0.00011
5	**0.42**	0.15	7.10E-05	**0.12**	0.1	0.00071	**0.0095**	0.0057	4.20E-05	**26.1**	6.3	3.50E-05
Average	***0.3062***	***0.1146***		***0.0982***	***0.0792***		***0.006***	***0.00444***		***21.72***	***5.64***	

Table H.5: Smith-Swainson (FeOw-1, 2, and 3) Artifact 2 Cat #H72.7.800 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.092**	0.023	1.30E-05	**0.169**	0.033	1.10E-05	**0.0398**	0.0061	1.10E-05	**0.148**	0.038	1.20E-05
2	**0.069**	0.0097	3.40E-06	**0.176**	0.03	2.80E-06	**0.031**	0.0041	2.70E-06	**0.133**	0.021	1.30E-05
3	**0.075**	0.035	3.30E-06	**0.123**	0.028	2.80E-06	**0.0238**	0.0054	2.60E-06	**0.097**	0.016	1.20E-05
4	**0.05**	0.017	2.30E-05	**0.121**	0.042	1.60E-05	**0.0176**	0.0049	1.20E-05	**0.074**	0.022	1.30E-05
5	**0.083**	0.034	2.10E-05	**0.258**	0.077	3.80E-06	**0.0366**	0.0076	1.30E-05	**0.14**	0.031	1.70E-05
Average	*0.0738*	*0.02374*		*0.1694*	*0.042*		*0.02976*	*0.00562*		*0.1184*	*0.0256*	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.06**	0.023	1.50E-05	**0.0121**	0.0037	4.00E-06	**0.046**	0.011	6.40E-05	**0.0079**	0.0031	9.70E-06
2	**0.049**	0.015	1.60E-05	**0.0091**	0.0028	2.10E-05	**0.057**	0.023	6.20E-05	**0.0114**	0.0043	2.50E-06
3	**0.0193**	0.0083	1.50E-05	**0.0088**	0.0027	4.10E-06	**0.044**	0.015	1.60E-05	**0.0099**	0.0026	1.30E-05
4	**0.0214**	0.0095	1.60E-05	**0.0064**	0.0025	4.30E-06	**0.0178**	0.0088	7.10E-05	**0.0039**	0.0018	1.10E-05
5	**0.043**	0.013	2.10E-05	**0.0118**	0.0049	5.60E-06	**0.061**	0.022	2.20E-05	**0.0082**	0.0029	1.50E-05
Average	*0.03854*	*0.01376*		*0.00964*	*0.00332*		*0.04516*	*0.01596*		*0.00826*	*0.00294*	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.073**	0.018	9.90E-06	**0.0111**	0.0032	2.50E-06	**0.048**	0.011	7.50E-06	**0.047**	0.019	1.20E-05
2	**0.067**	0.012	1.00E-05	**0.0114**	0.0032	2.60E-06	**0.0342**	0.0087	7.80E-06	**0.046**	0.012	1.20E-05
3	**0.043**	0.012	1.00E-05	**0.0103**	0.0029	2.60E-06	**0.0301**	0.0076	7.60E-06	**0.035**	0.011	1.20E-05
4	**0.0273**	0.0094	4.50E-05	**0.0059**	0.0021	2.70E-06	**0.0172**	0.0057	4.40E-05	**0.0174**	0.0095	1.20E-05
5	**0.057**	0.022	1.40E-05	**0.0089**	0.0041	3.50E-06	**0.03**	0.012	1.00E-05	**0.135**	0.069	1.60E-05
Average	*0.05346*	*0.01468*		*0.00952*	*0.0031*		*0.0319*	*0.009*		*0.05608*	*0.0241*	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.369**	0.064	4.10E-05	**0.00184**	0.00097	2.90E-06	**0.0112**	0.0057	8.80E-06	**0.0081**	0.005	7.40E-06
2	**0.34**	0.12	1.10E-05	**0.0035**	0.0019	2.20E-05	**0.022**	0.011	9.10E-06	**0.0189**	0.0068	7.80E-06
3	**0.257**	0.035	1.00E-05	**0.002**	0.0015	1.20E-05	**0.0106**	0.0085	3.60E-05	**0.0084**	0.006	3.10E-05
4	**0.118**	0.025	1.10E-05	**0.001**	0.00069	1.30E-05	**0.0082**	0.0078	9.20E-06	**0.0068**	0.0049	7.90E-06
5	**0.59**	0.32	1.40E-05	**0.0026**	0.0018	1.40E-05	**0.034**	0.011	1.20E-05	**0.0159**	0.0073	1.00E-05
Average	*0.3348*	*0.1128*		*0.002188*	*0.001372*		*0.0172*	*0.0088*		*0.01162*	*0.006*	

Table H.5: Smith-Swainson (FeOw-1, 2, and 3) Artifact 2 Cat #H72.7.800 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**12.4**	1.8	0.0012	**0.41**	0.14	6.60E-06	**0.31**	0.11	3.80E-05	**0.34**	0.12	2.40E-05
2	**14.7**	2.3	0.0012	**0.59**	0.16	6.90E-06	**0.35**	0.14	3.70E-05	**0.41**	0.13	2.80E-05
3	**17**	2.5	0.0018	**0.38**	0.18	3.50E-05	**0.3**	0.16	7.30E-06	**0.3**	0.14	2.40E-05
4	**14.8**	2.1	0.0024	**0.3**	0.1	5.80E-05	**0.209**	0.097	3.30E-05	**0.3**	0.11	3.60E-05
5	**5.6**	1	0.0023	**0.64**	0.18	9.10E-06	**0.37**	0.15	6.10E-05	**0.7**	0.21	2.30E-05
Average	***12.9***	***1.94***		***0.464***	***0.152***		***0.3078***	***0.1314***		***0.41***	***0.142***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.06**	0.021	2.80E-05	**0.16**	0.33	2.50E-06	**4.61**	0.21	1.60E-06
2	**0.082**	0.024	2.60E-05	**-0.00094**	0.00036	2.60E-06	**4.63**	0.27	1.60E-06
3	**0.0242**	0.0084	2.50E-05	**-0.00103**	0.00033	2.50E-06	**5.48**	0.29	1.60E-06
4	**0.097**	0.02	4.10E-05	**-0.00154**	0.00054	1.50E-05	**6.12**	0.59	1.60E-06
5	**0.078**	0.017	3.70E-05	**-0.00084**	0.00037	3.40E-06	**4.23**	0.25	1.00E-05
Average	***0.06824***	***0.01808***		***0.03113***	***0.06632***		***5.014***	***0.322***	

Table H.6: Smith-Swainson (FeOw-1, 2, and 3) Artifact 3 Cat #H72.7.837

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**232**	33	0.01	**143**	79	0.0077	**560**	59	0.0049	**466020**	200	
2	**218**	17	0.0075	**95**	54	0.0056	**517**	68	0.0036	**466070**	190	
3	**330**	130	0.0087	**220**	160	0.0063	**1200**	1100	0.004	**464900**	2000	
4	**205**	18	0.0092	**43.1**	5.7	0.0069	**494**	67	0.0043	**466330**	97	
5	**165**	15	0.0072	**74**	34	0.0061	**338**	37	0.0034	**466490**	82	
Average	***230***	***42.6***		***115.02***	***66.54***		***621.8***	***266.2***		***465962***	***513.8***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**32.6**	4.5	0.014	**464**	46	0.0039	**147**	25	0.23	**2.93**	0.66	0.0017
2	**43.6**	7.9	0.012	**495**	39	0.0028	**175**	27	0.19	**3.31**	0.63	0.0012
3	**70**	64	0.011	**610**	250	0.0033	**270**	170	0.2	**3.72**	0.58	0.0015
4	**23.2**	3.3	0.011	**412**	26	0.0035	**144**	36	0.19	**3.43**	0.55	0.0016
5	**23.6**	2.9	0.0088	**358**	29	0.0028	**124**	22	0.15	**3.19**	0.51	0.0013
Average	***38.6***	***16.52***		***467.8***	***78***		***172***	***56***		***3.316***	***0.586***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**1.9**	1.1	0.0091	**0.671**	0.056	0.00013	**-2.19**	0.92	0.0047	**0.24**	0.57	0.0041
2	**2.9**	4	0.0064	**0.749**	0.072	9.00E-05	**-1.14**	0.54	0.0034	**0.11**	0.25	0.0031
3	**26**	35	0.0074	**1.6**	1.1	0.00011	**-1.6**	1.5	0.004	**1.6**	1.5	0.0034
4	**1.34**	0.67	0.0078	**2.1**	0.5	0.00013	**-2.4**	0.39	0.0043	**0.14**	0.31	0.0039
5	**1.24**	0.73	0.006	**0.782**	0.06	0.0001	**-1.09**	0.44	0.0035	**-0.03**	0.2	0.003
Average	***6.676***	***8.3***		***1.1804***	***0.3576***		***-1.684***	***0.758***		***0.412***	***0.566***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**1.42**	0.18	0.00065	**290**	150	0.028	**0.119**	0.047	9.50E-05	**3**	1.1	0.0015
2	**1.33**	0.15	0.00057	**111**	28	0.018	**0.044**	0.023	7.00E-05	**3.2**	1.5	0.0012
3	**5.5**	6.4	0.00049	**820**	870	0.023	**0.17**	0.16	6.40E-05	**5.4**	3.3	0.0013
4	**1.41**	0.17	0.0005	**152**	39	0.025	**0.13**	0.17	7.70E-05	**2.55**	0.83	0.0014
5	**1.29**	0.19	0.0004	**195**	52	0.019	**0.065**	0.028	7.00E-05	**1.99**	0.42	0.0011
Average	***2.19***	***1.418***		***313.6***	***227.8***		***0.1056***	***0.0856***		***3.228***	***1.43***	

Table H.6: Smith-Swainson (FeOw-1, 2, and 3) Artifact 3 Cat #H72.7.837 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**8.1**	3.4	0.012	**26**	13	0.00047	**0.6**	0.11	0.00014	**0.313**	0.033	8.90E-05
2	**5.3**	1.1	0.009	**23**	11	0.00035	**0.6**	0.11	0.00014	**0.318**	0.044	6.10E-05
3	**7.8**	1.9	0.0097	**27**	13	0.0004	**0.97**	0.63	0.00014	**1**	1	7.60E-05
4	**5.9**	1.2	0.013	**26**	11	0.00041	**1.17**	0.36	0.00015	**0.309**	0.024	8.30E-05
5	**4.9**	1.3	0.008	**22**	13	0.00032	**0.625**	0.092	0.0001	**0.217**	0.023	4.90E-05
Average	***6.4***	***1.78***		***24.8***	***12.2***		***0.793***	***0.2604***		***0.4314***	***0.2248***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**1.323**	0.099	9.40E-05	**0.87**	0.16	4.70E-05	**5.17**	0.79	0.00069	**0.099**	0.015	3.20E-05
2	**3.86**	0.8	7.00E-05	**3.5**	1	3.40E-05	**3.71**	0.38	0.00052	**0.078**	0.012	4.20E-05
3	**2.1**	1.3	6.70E-05	**0.82**	0.22	4.80E-05	**4.96**	0.84	0.00059	**0.26**	0.23	4.20E-05
4	**1.76**	0.28	8.50E-05	**1.28**	0.17	3.20E-05	**4.91**	0.37	0.00062	**0.159**	0.021	3.30E-05
5	**0.981**	0.065	5.50E-05	**0.444**	0.029	3.00E-05	**6.48**	0.9	0.00051	**0.216**	0.02	2.00E-05
Average	***2.0048***	***0.5088***		***1.3828***	***0.3158***		***5.046***	***0.656***		***0.1624***	***0.0596***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.02**	0.013	2.50E-05	**0.023**	0.01	1.60E-05	**0.009**	0.031	0.00035	**0.122**	0.054	0.00025
2	**0.0058**	0.0061	9.80E-05	**0.0115**	0.0063	1.40E-05	**0.043**	0.033	0.00029	**0.072**	0.034	0.00025
3	**0.034**	0.026	0.00011	**0.064**	0.068	1.40E-05	**0.038**	0.031	0.00034	**0.46**	0.46	0.00017
4	**0.0097**	0.0066	9.20E-05	**0.02**	0.021	1.40E-05	**0.05**	0.024	0.00035	**0.099**	0.06	0.00031
5	**0.0041**	0.0034	2.10E-05	**0.0047**	0.0043	1.30E-05	**0.029**	0.023	0.00026	**0.096**	0.058	0.00023
Average	***0.01472***	***0.01102***		***0.02464***	***0.02192***		***0.0338***	***0.0284***		***0.1698***	***0.1332***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.093**	0.041	0.00019	**0.009**	0.041	0.00076	**0.0014**	0.0027	3.90E-05	**6.97**	0.74	3.40E-05
2	**0.115**	0.064	6.00E-05	**0.037**	0.038	0.00051	**0.0028**	0.0022	2.30E-05	**6.23**	0.84	2.90E-05
3	**0.38**	0.29	0.00012	**0.08**	0.11	0.00064	**0.022**	0.031	3.80E-05	**11.4**	8.2	3.10E-05
4	**0.089**	0.037	0.00013	**0.068**	0.061	0.00057	**0.0012**	0.0019	2.70E-05	**14.9**	4.1	3.10E-05
5	**0.132**	0.039	1.70E-05	**0.055**	0.039	0.00046	**0.0001**	0.0016	2.30E-05	**7.2**	1.2	2.90E-05
Average	***0.1618***	***0.0942***		***0.0498***	***0.0578***		***0.0055***	***0.00788***		***9.34***	***3.016***	

Table H.6: Smith-Swainson (FeOw-1, 2, and 3) Artifact 3 Cat #H72.7.837 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.503**	0.082	4.40E-06	**2.1**	1.2	2.60E-05	**0.244**	0.081	1.40E-05	**0.82**	0.17	1.60E-05
2	**9.3**	3	3.80E-06	**30.7**	9.8	3.20E-06	**4.8**	1.5	3.00E-06	**16.7**	5.4	1.40E-05
3	**0.4**	0.21	1.50E-05	**1.19**	0.35	1.70E-05	**0.166**	0.047	3.20E-06	**0.62**	0.17	1.50E-05
4	**0.83**	0.21	1.60E-05	**2.63**	0.93	3.40E-06	**0.39**	0.15	2.00E-05	**1.59**	0.48	1.50E-05
5	**0.206**	0.018	1.40E-05	**0.752**	0.066	1.10E-05	**0.113**	0.012	3.00E-06	**0.348**	0.034	1.40E-05
Average	***2.2478***	***0.704***		***7.4744***	***2.4692***		***1.1426***	***0.358***		***4.0156***	***1.2508***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.178**	0.041	2.00E-05	**0.0458**	0.0094	5.40E-06	**0.227**	0.048	8.80E-05	**0.04**	0.012	3.20E-06
2	**3.2**	1	1.80E-05	**0.57**	0.18	4.70E-06	**1.9**	0.59	1.80E-05	**0.262**	0.079	1.30E-05
3	**0.159**	0.055	1.90E-05	**0.0428**	0.0092	5.00E-06	**0.182**	0.05	2.00E-05	**0.027**	0.0055	3.00E-06
4	**0.315**	0.069	1.90E-05	**0.067**	0.019	5.00E-06	**0.336**	0.059	2.00E-05	**0.0547**	0.0091	1.20E-05
5	**0.077**	0.017	6.40E-05	**0.0249**	0.0048	4.70E-06	**0.126**	0.021	1.80E-05	**0.0146**	0.003	2.80E-06
Average	***0.7858***	***0.2364***		***0.1501***	***0.04448***		***0.5542***	***0.1536***		***0.07966***	***0.02172***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.237**	0.044	1.30E-05	**0.042**	0.011	3.40E-06	**0.134**	0.03	4.10E-05	**0.152**	0.033	1.60E-05
2	**1.36**	0.41	1.20E-05	**0.215**	0.067	2.90E-06	**0.51**	0.15	8.70E-06	**0.41**	0.1	1.40E-05
3	**0.184**	0.033	1.20E-05	**0.0397**	0.0068	3.10E-06	**0.113**	0.022	9.30E-06	**0.178**	0.033	1.50E-05
4	**0.339**	0.056	1.20E-05	**0.086**	0.017	3.10E-06	**0.235**	0.039	9.30E-06	**0.227**	0.041	1.50E-05
5	**0.107**	0.014	1.10E-05	**0.0239**	0.0045	2.90E-06	**0.073**	0.011	3.20E-05	**0.096**	0.03	1.40E-05
Average	***0.4454***	***0.1114***		***0.08132***	***0.02126***		***0.213***	***0.0504***		***0.2126***	***0.0474***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.062**	0.022	1.40E-05	**0.0026**	0.0015	2.80E-05	**0.0121**	0.0056	1.20E-05	**0.008**	0.0049	1.00E-05
2	**0.043**	0.013	1.20E-05	**0.00106**	0.00086	3.40E-06	**0.0023**	0.0019	1.00E-05	**0.0021**	0.0017	3.10E-05
3	**0.059**	0.021	1.30E-05	**0.0057**	0.0043	2.10E-05	**0.0122**	0.0089	1.10E-05	**0.017**	0.015	9.30E-06
4	**0.038**	0.012	1.30E-05	**0.0042**	0.0022	3.60E-06	**0.0021**	0.0019	1.10E-05	**0.0065**	0.0041	3.80E-05
5	**0.0255**	0.0072	1.20E-05	**0.0013**	0.001	1.20E-05	**0.0029**	0.0025	1.00E-05	**0.0032**	0.0027	8.70E-06
Average	***0.0455***	***0.01504***		***0.002972***	***0.001972***		***0.00632***	***0.00416***		***0.00736***	***0.00568***	

Table H.6: Smith-Swainson (FeOw-1, 2, and 3) Artifact 3 Cat #H72.7.837 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**4.4**	0.82	0.0028	**0.477**	0.088	4.80E-05	**0.34**	0.13	6.20E-05	**0.319**	0.077	3.80E-05
2	**3.08**	0.43	0.0024	**0.56**	0.11	3.50E-05	**0.39**	0.08	5.10E-05	**0.398**	0.074	2.20E-05
3	**7.2**	2.2	0.0027	**0.93**	0.59	8.10E-06	**0.71**	0.57	4.50E-05	**0.81**	0.62	2.20E-05
4	**3.93**	0.61	0.0023	**0.538**	0.077	5.10E-05	**0.365**	0.052	4.70E-05	**0.4**	0.048	2.40E-05
5	**2.03**	0.3	0.002	**0.406**	0.047	4.20E-05	**0.261**	0.045	8.30E-06	**0.308**	0.061	2.20E-05
Average	***4.128***	***0.872***		***0.5822***	***0.1824***		***0.4132***	***0.1754***		***0.447***	***0.176***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.026**	0.01	3.10E-05	**0.07**	0.15	3.30E-06	**6.61**	0.43	2.10E-06
2	**0.023**	0.013	2.30E-05	**0.69**	0.71	2.90E-06	**6.06**	0.28	1.80E-06
3	**0.036**	0.014	3.20E-05	**-0.00038**	0.00014	1.20E-05	**5.66**	0.26	1.90E-06
4	**0.0195**	0.0075	3.00E-05	**0.16**	0.33	3.10E-06	**6.25**	0.46	1.90E-06
5	**0.0139**	0.0056	2.00E-05	**-8.15E-06**	7.30E-07	2.80E-06	**5.76**	0.3	1.80E-06
Average	***0.02368***	***0.01002***		***0.18392237***	***0.238028146***		***6.068***	***0.346***	

Appendix H: Archaeological Samples Raw Data

Table H.7: Muhlbach (FbPf-1) Artifact 1 Cat #28

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	284	19	0.0082	243	87	0.0055	483	60	0.004	465640	270	
2	309	22	0.0074	55	18	0.0048	391	62	0.004	466330	100	
3	294	39	0.011	710	330	0.0072	280	110	0.0061	463700	1300	
4	343	48	0.0079	160	73	0.0048	362	58	0.0044	465750	300	
5	141	19	0.006	63	34	0.004	125	17	0.0029	466801	75	
Average	*274.2*	*29.4*		*246.2*	*108.4*		*328.2*	*61.4*		*465644.2*	*409*	
Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	45.9	4.9	0.003	471	55	0.0032	170	42	0.16	3.69	0.49	0.0014
2	25.9	7.5	0.0027	493	43	0.0027	146	45	0.15	3.86	0.51	0.0013
3	77	25	0.0038	580	110	0.0039	240	110	0.23	4.59	0.75	0.0018
4	48.2	5.6	0.0027	649	66	0.0027	162	58	0.16	3.75	0.57	0.0013
5	23	4.4	0.002	199	23	0.0021	119	23	0.11	3.56	0.6	0.00099
Average	*44*	*9.48*		*478.4*	*59.4*		*167.4*	*55.6*		*3.89*	*0.584*	
Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	5.1	1.2	0.0047	1.89	0.4	8.30E-05	-0.1	2.6	0.0045	1.5	1.1	0.004
2	2.93	0.7	0.0041	1.19	0.16	8.60E-05	-1.39	0.9	0.0038	0.54	0.5	0.0033
3	9.4	6.6	0.0053	1.28	0.36	0.00016	2	2.3	0.0054	6.8	4.8	0.0048
4	3.57	0.75	0.0039	0.83	0.15	9.50E-05	0.9	3.3	0.0039	0.4	0.46	0.0034
5	1.91	0.76	0.0029	1.05	0.38	7.00E-05	-1.32	0.75	0.003	1.12	0.64	0.0025
Average	*4.582*	*2.002*		*1.248*	*0.29*		*0.018*	*1.97*		*2.072*	*1.5*	
Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	2.36	0.45	0.0004	590	180	0.029	0.282	0.099	8.10E-05	5	1.5	0.0012
2	1.38	0.22	0.00035	224	80	0.023	0.106	0.079	7.80E-05	3.9	2.1	0.001
3	5.1	2.2	0.00051	2080	830	0.033	0.63	0.37	0.00012	10.4	5.3	0.0014
4	2.04	0.71	0.00037	750	420	0.023	0.122	0.079	9.10E-05	6.9	2.7	0.001
5	1.35	0.29	0.00026	240	120	0.019	0.145	0.064	7.80E-05	2.44	0.58	0.00075
Average	*2.446*	*0.774*		*776.8*	*326*		*0.257*	*0.1382*		*5.728*	*2.436*	

Table H.7: Muhlbach (FbPf-1) Artifact 1 Cat #28 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**11.6**	3.3	0.01	**113**	30	0.00035	**2.07**	0.41	0.00013	**0.329**	0.036	6.10E-05
2	**8.4**	2.1	0.0085	**26**	11	0.00038	**0.97**	0.14	9.40E-05	**0.367**	0.039	6.50E-05
3	**21**	13	0.014	**209**	73	0.00052	**1.24**	0.42	0.00014	**0.31**	0.098	9.70E-05
4	**7.4**	1.8	0.0096	**82**	47	0.00037	**0.48**	0.13	0.00011	**0.387**	0.047	7.20E-05
5	**4.9**	1	0.008	**39**	17	0.00022	**1.87**	0.22	8.70E-05	**0.194**	0.027	4.60E-05
Average	***10.66***	***4.24***		***93.8***	***35.6***		***1.326***	***0.264***		***0.3174***	***0.0494***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**2.68**	0.26	6.60E-05	**3.33**	0.65	2.30E-05	**5.8**	1.4	0.00037	**0.059**	0.016	3.20E-05
2	**1.66**	0.16	7.60E-05	**0.829**	0.085	3.20E-05	**3.76**	0.58	0.00031	**0.0312**	0.0085	3.50E-05
3	**1.07**	0.35	0.0001	**0.487**	0.054	5.90E-05	**6.5**	3.2	0.00044	**0.054**	0.027	3.00E-05
4	**0.97**	0.11	6.70E-05	**1.48**	0.26	3.70E-05	**5.9**	2.8	0.00031	**0.0353**	0.0098	3.40E-05
5	**2.47**	0.37	5.20E-05	**2.66**	0.97	2.00E-05	**1.73**	0.22	0.00023	**0.0221**	0.0057	2.90E-05
Average	***1.77***	***0.25***		***1.7572***	***0.4038***		***4.738***	***1.64***		***0.04032***	***0.0134***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.139**	0.051	2.20E-05	**0.134**	0.056	1.40E-05	**0.172**	0.04	0.00022	**0.37**	0.12	0.00036
2	**0.022**	0.011	2.50E-05	**0.031**	0.015	4.90E-05	**0.177**	0.05	0.0002	**0.128**	0.067	0.0002
3	**0.223**	0.069	4.40E-05	**0.198**	0.087	7.80E-05	**0.27**	0.15	0.0003	**0.38**	0.13	0.00031
4	**0.026**	0.014	8.80E-05	**0.055**	0.02	2.10E-05	**0.109**	0.025	0.00016	**0.26**	0.16	0.00034
5	**0.055**	0.037	2.30E-05	**0.035**	0.021	1.50E-05	**0.089**	0.018	0.00013	**0.135**	0.07	0.00019
Average	***0.093***	***0.0364***		***0.0906***	***0.0398***		***0.1634***	***0.0566***		***0.2546***	***0.1094***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.268**	0.078	6.80E-05	**0.116**	0.073	0.00047	**0.0091**	0.0048	3.00E-05	**37.1**	8.4	0.00011
2	**0.21**	0.1	8.20E-05	**0.14**	0.084	0.00045	**0.0052**	0.0045	3.60E-05	**14.4**	1.9	3.20E-05
3	**0.45**	0.15	0.0001	**0.27**	0.18	0.0006	**0.012**	0.012	5.90E-05	**16.3**	4.7	5.70E-05
4	**0.142**	0.059	0.00011	**0.049**	0.07	0.00042	**0.0017**	0.0027	3.60E-05	**7.2**	2.6	0.00014
5	**0.062**	0.03	8.00E-05	**0.076**	0.044	0.00023	**0.0026**	0.0023	2.70E-05	**32.4**	4.2	8.50E-05
Average	***0.2264***	***0.0834***		***0.1302***	***0.0902***		***0.00612***	***0.00526***		***21.48***	***4.36***	

Table H.7: Muhlbach (FbPf-1) Artifact 1 Cat #28 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**3.8**	0.78	3.70E-06	**9.4**	1.6	1.80E-05	**1.8**	0.32	3.00E-06	**7.4**	1.5	1.40E-05
2	**0.663**	0.05	1.60E-05	**2.6**	0.33	1.40E-05	**0.407**	0.054	1.00E-05	**1.42**	0.15	6.10E-05
3	**0.438**	0.098	3.70E-05	**1.84**	0.33	6.20E-06	**0.264**	0.049	2.40E-05	**0.86**	0.14	2.70E-05
4	**1.66**	0.37	2.10E-05	**6.1**	1.4	1.20E-05	**1.04**	0.28	1.50E-05	**3.49**	0.88	6.80E-05
5	**3**	1.1	3.90E-06	**8.4**	2.3	1.20E-05	**1.56**	0.47	1.10E-05	**6**	2.1	1.40E-05
Average	***1.9122***	***0.4796***		***5.668***	***1.192***		***1.0142***	***0.2346***		***3.834***	***0.954***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**1.67**	0.35	1.70E-05	**0.397**	0.093	2.20E-05	**1.44**	0.3	1.80E-05	**0.2**	0.041	2.70E-06
2	**0.356**	0.06	1.90E-05	**0.074**	0.011	5.10E-06	**0.265**	0.045	9.30E-05	**0.0397**	0.0066	1.20E-05
3	**0.212**	0.062	3.40E-05	**0.061**	0.023	2.50E-05	**0.166**	0.034	0.00015	**0.0278**	0.0081	5.40E-06
4	**0.76**	0.15	6.80E-05	**0.177**	0.037	6.90E-06	**0.57**	0.16	2.70E-05	**0.1**	0.023	4.10E-06
5	**1.42**	0.57	1.80E-05	**0.29**	0.11	4.80E-06	**1.16**	0.43	6.70E-05	**0.173**	0.062	8.00E-06
Average	***0.8836***	***0.2384***		***0.1998***	***0.0548***		***0.7202***	***0.1938***		***0.1081***	***0.02814***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**1.15**	0.26	1.10E-05	**0.192**	0.041	2.90E-06	**0.482**	0.092	3.10E-05	**0.414**	0.099	1.30E-05
2	**0.225**	0.029	1.20E-05	**0.046**	0.0071	3.20E-06	**0.135**	0.02	3.00E-05	**0.11**	0.015	1.50E-05
3	**0.138**	0.039	2.20E-05	**0.0229**	0.0057	5.70E-06	**0.084**	0.027	4.70E-05	**0.117**	0.048	2.60E-05
4	**0.55**	0.11	1.70E-05	**0.091**	0.02	4.30E-06	**0.214**	0.05	3.40E-05	**0.181**	0.044	2.00E-05
5	**0.92**	0.33	4.20E-05	**0.149**	0.059	3.00E-06	**0.38**	0.15	9.00E-06	**0.33**	0.12	1.40E-05
Average	***0.5966***	***0.1536***		***0.10018***	***0.02656***		***0.259***	***0.0678***		***0.2304***	***0.0652***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.067**	0.04	1.20E-05	**-0.0003**	0.0014	3.30E-06	**0.047**	0.023	1.10E-05	**0.044**	0.011	4.40E-05
2	**0.052**	0.027	1.30E-05	**0.0031**	0.0029	1.50E-05	**0.0189**	0.0086	1.20E-05	**0.042**	0.037	4.10E-05
3	**0.121**	0.08	2.30E-05	**0.01**	0.0081	6.50E-06	**0.05**	0.019	5.90E-05	**0.07**	0.033	5.10E-05
4	**0.063**	0.065	1.70E-05	**0.00082**	0.0008	2.10E-05	**0.021**	0.012	1.60E-05	**0.036**	0.02	1.40E-05
5	**0.0058**	0.0033	1.20E-05	**0.0022**	0.0021	1.20E-05	**0.0148**	0.0066	1.10E-05	**0.0142**	0.0065	2.70E-05
Average	***0.06176***	***0.04306***		***0.003164***	***0.00306***		***0.03034***	***0.01384***		***0.04124***	***0.0215***	

Table H.7: Muhlbach (FbPf-1) Artifact 1 Cat #28 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**6.7**	1.4	0.0025	**0.89**	0.12	3.90E-05	**0.617**	0.072	5.60E-05	**0.94**	0.15	2.10E-05
2	**4.88**	0.55	0.0022	**0.96**	0.12	2.80E-05	**0.85**	0.12	9.90E-06	**0.89**	0.15	2.60E-05
3	**5.2**	1.8	0.0026	**1.25**	0.86	1.60E-05	**0.98**	0.58	4.90E-05	**1.25**	0.65	4.50E-05
4	**2.92**	0.49	0.0022	**0.55**	0.11	4.60E-05	**0.41**	0.091	1.30E-05	**0.51**	0.12	2.40E-05
5	**2.6**	0.34	0.0018	**1.08**	0.14	3.90E-05	**0.873**	0.054	2.60E-05	**0.917**	0.091	1.60E-05
Average	***4.46***	***0.916***		***0.946***	***0.27***		***0.746***	***0.1834***		***0.9014***	***0.2322***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.129**	0.027	2.40E-05	**0.73**	0.93	2.80E-06	**2.16**	0.16	1.90E-06
2	**0.068**	0.032	3.60E-05	**0.1**	0.2	3.10E-06	**2.1**	0.12	2.10E-06
3	**0.31**	0.19	6.90E-05	**-0.54**	0.65	5.50E-06	**4.42**	0.41	1.00E-05
4	**0.045**	0.022	3.40E-05	**0.76**	0.73	4.10E-06	**3.05**	0.27	2.80E-06
5	**0.036**	0.013	2.40E-05	**0.85**	0.66	2.90E-06	**1.651**	0.094	2.00E-06
Average	***0.1176***	***0.0568***		***0.38***	***0.634***		***2.6762***	***0.2108***	

Table H.8: Muhlbach (FbPf-1) Artifact 2 Cat #30

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**264**	22	0.012	**101**	39	0.0068	**273**	26	0.0057	**466220**	110	
2	**347**	53	0.012	**164**	96	0.0081	**358**	46	0.0057	**465930**	240	
3	**114**	19	0.01	**41**	39	0.0065	**78.3**	5.6	0.0048	**465700**	2200	
4	**204**	19	0.013	**42**	27	0.008	**400**	100	0.0057	**466390**	250	
5	**420**	120	0.014	**300**	170	0.0084	**289**	50	0.0073	**464800**	1400	
Average	***269.8***	***46.6***		***129.6***	***74.2***		***279.66***	***45.52***		***465808***	***840***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**19.3**	3.9	0.004	**543**	47	0.0044	**127**	34	0.23	**3.09**	0.49	0.002
2	**17.4**	2.9	0.0039	**579**	59	0.0043	**134**	53	0.22	**3.32**	0.49	0.002
3	**10.2**	1.1	0.0033	**212**	31	0.0037	**72**	29	0.2	**3.29**	0.55	0.0018
4	**21.5**	2.4	0.004	**439**	31	0.0047	**97**	33	0.22	**1.62**	0.48	0.0022
5	**40**	20	0.0044	**750**	160	0.0048	**104**	95	0.25	**5.2**	1.7	0.0022
Average	***21.68***	***6.06***		***504.6***	***65.6***		***106.8***	***48.8***		***3.304***	***0.742***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**0.52**	0.53	0.0059	**0.853**	0.083	0.00011	**-1**	1.7	0.0061	**0.58**	0.59	0.0053
2	**0.96**	0.67	0.0059	**0.855**	0.087	8.60E-05	**0.3**	1.7	0.006	**1.1**	1.2	0.0051
3	**1**	1.4	0.0051	**0.653**	0.06	0.00011	**-2.21**	0.9	0.0052	**0.66**	0.62	0.0043
4	**1.11**	0.96	0.0066	**1.36**	0.1	0.00012	**-6.4**	1.9	0.0064	**1.5**	3.2	0.0054
5	**4**	2.5	0.0064	**1**	0.26	0.00015	**-2**	11	0.0064	**-0.7**	1.6	0.0057
Average	***1.518***	***1.212***		***0.9442***	***0.118***		***-2.262***	***3.44***		***0.628***	***1.442***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**1.92**	0.75	0.00054	**460**	100	0.038	**0.21**	0.12	0.00013	**5.3**	2.3	0.0015
2	**1.46**	0.43	0.00054	**420**	300	0.037	**0.26**	0.23	0.00011	**2.97**	0.77	0.0016
3	**0.77**	0.4	0.00045	**2300**	3600	0.031	**0.069**	0.096	0.0001	**1.89**	0.58	0.0014
4	**1.46**	0.96	0.00054	**139**	52	0.039	**0.042**	0.047	0.00013	**1.9**	1.2	0.0018
5	**2.3**	1.1	0.00059	**730**	460	0.035	**0.36**	0.24	0.00016	**14.6**	8.9	0.0018
Average	***1.582***	***0.728***		***809.8***	***902.4***		***0.1882***	***0.1466***		***5.332***	***2.75***	

Table H.8: Muhlbach (FbPf-1) Artifact 2 Cat #30 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**7.2**	2.4	0.015	**48**	19	0.00044	**0.329**	0.055	0.00017	**0.294**	0.028	9.30E-05
2	**9.5**	2.8	0.017	**84**	86	0.00044	**0.33**	0.12	0.00018	**0.348**	0.057	9.90E-05
3	**6.4**	1.9	0.014	**25**	29	0.0004	**0.318**	0.061	0.00018	**0.114**	0.033	9.10E-05
4	**7.3**	3	0.015	**4.9**	4.1	0.00049	**0.63**	0.14	0.0002	**0.323**	0.051	0.00011
5	**19**	14	0.017	**115**	81	0.00056	**0.55**	0.21	0.00021	**0.57**	0.17	0.00014
Average	***9.88***	***4.82***		***55.38***	***43.82***		***0.4314***	***0.1172***		***0.3298***	***0.0678***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**0.511**	0.053	0.00011	**0.394**	0.055	6.10E-05	**4.82**	0.8	0.00049	**0.0389**	0.0084	3.50E-05
2	**0.579**	0.063	0.00012	**0.427**	0.058	6.30E-05	**4.18**	0.71	0.00053	**0.036**	0.011	4.10E-05
3	**0.396**	0.067	9.50E-05	**0.196**	0.029	4.20E-05	**3.9**	2.7	0.0005	**0.071**	0.086	2.50E-05
4	**0.91**	0.12	9.70E-05	**1.07**	0.2	3.90E-05	**4.32**	0.5	0.00056	**0.046**	0.012	4.80E-05
5	**0.65**	0.1	0.00012	**0.9**	0.13	6.10E-05	**6.2**	6.2	0.00057	**0.036**	0.018	2.90E-05
Average	***0.6092***	***0.0806***		***0.5974***	***0.0944***		***4.684***	***2.182***		***0.04558***	***0.02708***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.105**	0.074	3.50E-05	**0.048**	0.032	2.30E-05	**0.081**	0.03	0.00032	**0.147**	0.059	0.00024
2	**0.044**	0.023	0.00013	**0.071**	0.074	2.80E-05	**0.08**	0.031	0.00031	**0.39**	0.22	0.00033
3	**0.016**	0.022	0.00013	**0.026**	0.031	3.70E-05	**0.052**	0.017	0.00028	**0.049**	0.062	0.00044
4	**0.042**	0.03	3.20E-05	**0.036**	0.038	7.80E-05	**0.031**	0.05	0.00031	**0.058**	0.068	0.00043
5	**0.35**	0.36	5.60E-05	**0.14**	0.11	3.60E-05	**0.079**	0.041	0.00034	**0.25**	0.15	0.00063
Average	***0.1114***	***0.1018***		***0.0642***	***0.057***		***0.0646***	***0.0338***		***0.1788***	***0.1118***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.163**	0.075	0.00017	**0.081**	0.063	0.00065	**-0.0035**	0.0016	5.40E-05	**5.5**	1.4	4.60E-05
2	**0.094**	0.052	0.00018	**0.115**	0.064	0.0005	**0.0079**	0.0087	5.20E-05	**3.74**	0.85	0.00021
3	**0.018**	0.015	0.00013	**0.067**	0.046	0.00031	**0.0019**	0.0031	4.60E-05	**3.73**	0.48	7.40E-05
4	**0.02**	0.021	0.00016	**0.3**	0.44	0.0006	**0.0024**	0.0039	4.80E-05	**9.7**	3.4	4.10E-05
5	**0.38**	0.18	0.00013	**0.1**	0.12	0.00065	**0.0094**	0.0064	7.10E-05	**6.2**	2.5	0.00025
Average	***0.135***	***0.0686***		***0.1326***	***0.1466***		***0.00362***	***0.00474***		***5.774***	***1.726***	

Table H.8: Muhlbach (FbPf-1) Artifact 2 Cat #30 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.237**	0.03	2.00E-05	**0.932**	0.086	5.00E-06	**0.139**	0.016	1.60E-05	**0.617**	0.073	2.20E-05
2	**0.237**	0.037	2.10E-05	**1.16**	0.22	6.10E-06	**0.158**	0.033	5.80E-06	**0.502**	0.074	7.90E-05
3	**0.119**	0.02	9.50E-06	**0.79**	0.44	2.20E-05	**0.082**	0.022	7.60E-06	**0.319**	0.075	3.50E-05
4	**0.96**	0.19	5.20E-06	**3.11**	0.4	2.20E-05	**0.424**	0.076	4.20E-06	**2.01**	0.4	7.50E-05
5	**0.597**	0.088	2.50E-05	**3.23**	0.75	2.70E-05	**0.425**	0.098	3.30E-05	**1.42**	0.34	3.50E-05
Average	***0.43***	***0.073***		***1.8444***	***0.3792***		***0.2456***	***0.049***		***0.9736***	***0.1924***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.142**	0.027	2.70E-05	**0.0384**	0.0098	7.30E-06	**0.114**	0.038	0.00012	**0.026**	0.0054	4.30E-06
2	**0.139**	0.047	9.90E-05	**0.031**	0.013	9.00E-06	**0.153**	0.042	3.50E-05	**0.0266**	0.0062	5.30E-06
3	**0.071**	0.038	4.40E-05	**0.0201**	0.0077	1.20E-05	**0.092**	0.045	0.0001	**0.0124**	0.0038	7.00E-06
4	**0.459**	0.087	2.40E-05	**0.095**	0.025	6.60E-06	**0.51**	0.12	0.00013	**0.063**	0.018	3.90E-06
5	**0.319**	0.06	4.30E-05	**0.069**	0.023	1.20E-05	**0.37**	0.073	4.50E-05	**0.038**	0.011	6.90E-06
Average	***0.226***	***0.0518***		***0.0507***	***0.0157***		***0.2478***	***0.0636***		***0.0332***	***0.00888***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.141**	0.031	1.80E-05	**0.0315**	0.007	2.00E-05	**0.073**	0.018	1.40E-05	**0.076**	0.027	2.10E-05
2	**0.127**	0.041	2.20E-05	**0.0252**	0.0059	5.60E-06	**0.062**	0.02	1.70E-05	**0.065**	0.022	2.60E-05
3	**0.046**	0.022	2.90E-05	**0.011**	0.0034	2.00E-05	**0.025**	0.011	2.20E-05	**0.047**	0.018	3.40E-05
4	**0.316**	0.062	1.60E-05	**0.062**	0.014	2.10E-05	**0.193**	0.05	1.20E-05	**0.151**	0.044	1.90E-05
5	**0.306**	0.052	2.80E-05	**0.053**	0.012	2.00E-05	**0.117**	0.036	2.10E-05	**0.135**	0.037	3.30E-05
Average	***0.1872***	***0.0416***		***0.03654***	***0.00846***		***0.094***	***0.027***		***0.0948***	***0.0296***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.074**	0.024	1.80E-05	**-0.00031**	0.00063	1.80E-05	**0.0085**	0.0077	1.70E-05	**0.0048**	0.0037	1.50E-05
2	**0.107**	0.068	2.20E-05	**0.0009**	0.001	6.40E-06	**0.0053**	0.0042	2.10E-05	**0.022**	0.023	5.30E-05
3	**0.037**	0.038	2.90E-05	**-0.00079**	0.00012	1.90E-05	**0.0053**	0.0067	2.70E-05	**0.013**	0.018	2.40E-05
4	**0.038**	0.016	1.60E-05	**-0.00076**	0.00073	2.80E-05	**-0.0033**	0.0023	1.50E-05	**0.0047**	0.0059	5.00E-05
5	**0.048**	0.026	2.90E-05	**0.0014**	0.0018	8.20E-06	**0.073**	0.045	2.70E-05	**0.025**	0.025	2.30E-05
Average	***0.0608***	***0.0344***		***0.000088***	***0.000856***		***0.01776***	***0.01318***		***0.0139***	***0.01512***	

Table H.8: Muhlbach (FbPf-1) Artifact 2 Cat #30 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**7.52**	0.93	0.0039	**0.304**	0.097	6.60E-05	**0.119**	0.033	1.40E-05	**0.18**	0.061	4.10E-05
2	**6.8**	1	0.0034	**0.39**	0.12	6.00E-05	**0.169**	0.055	7.60E-05	**0.254**	0.079	3.20E-05
3	**4.2**	1	0.0038	**0.136**	0.069	7.30E-05	**0.2**	0.21	8.10E-05	**0.077**	0.049	3.10E-05
4	**10.9**	2.6	0.0034	**0.3**	0.12	8.50E-05	**0.157**	0.086	1.30E-05	**0.198**	0.08	2.00E-05
5	**9.4**	2.8	0.0032	**0.49**	0.23	7.00E-05	**0.13**	0.04	6.10E-05	**0.32**	0.12	4.20E-05
Average	***7.764***	***1.666***		***0.324***	***0.1272***		***0.155***	***0.0848***		***0.2058***	***0.0778***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.097**	0.035	4.40E-05	**0**	1	4.40E-06	**5.26**	0.39	3.00E-06
2	**0.078**	0.019	3.50E-05	**0**	1	5.40E-06	**3.24**	0.18	3.70E-06
3	**0.014**	0.015	3.40E-05	**0**	1	7.10E-06	**2.96**	0.3	4.90E-06
4	**0.024**	0.013	5.10E-05	**0**	1	3.90E-06	**5.07**	0.45	1.40E-05
5	**0.112**	0.077	8.10E-05	**0**	1	6.90E-06	**4.3**	1.3	1.60E-05
Average	***0.065***	***0.0318***		***0***	***1***		***4.166***	***0.524***	

Table H.9: Muhlbach (FbPf-1) Artifact 3 Cat #264

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**285**	27	0.0068	**32.4**	4.4	0.004	**446**	49	0.0037	**466268**	69	
2	**611**	35	0.0052	**88.5**	6.2	0.0029	**486**	21	0.0026	**465631**	60	
3	**189.8**	8.7	0.0085	**31.8**	7.7	0.0057	**259**	27	0.0041	**466635**	63	
4	**343**	60	0.008	**139**	56	0.005	**400**	130	0.0038	**465750**	400	
Average	*357.2*	*32.675*		*72.925*	*18.575*		*397.75*	*56.75*		*466071*	*148*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**35.1**	4	0.0023	**419**	35	0.0023	**200**	23	0.13	**2.48**	0.44	0.0011
2	**99.2**	4.1	0.0016	**874**	39	0.0018	**379**	23	0.093	**2.57**	0.19	0.00087
3	**37.5**	3	0.0026	**281**	10	0.0029	**135**	19	0.14	**1.82**	0.44	0.0014
4	**77**	14	0.0024	**485**	75	0.0028	**236**	47	0.14	**2.97**	0.42	0.0014
Average	*62.2*	*6.275*		*514.75*	*39.75*		*237.5*	*28*		*2.46*	*0.3725*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**1.54**	0.45	0.0032	**0.332**	0.027	5.20E-05	**-6.6**	1.5	0.0032	**-0.36**	0.28	0.0029
2	**1.85**	0.26	0.0024	**0.362**	0.018	5.00E-05	**-0.15**	0.35	0.0024	**0.89**	0.2	0.0021
3	**9.2**	6.8	0.0038	**0.413**	0.03	8.30E-05	**-2.4**	0.54	0.004	**-0.05**	0.19	0.0034
4	**80**	52	0.0039	**1.72**	0.53	7.80E-05	**-2.4**	1.7	0.0039	**0.38**	0.49	0.0035
Average	*23.1475*	*14.8775*		*0.70675*	*0.15125*		*-2.8875*	*1.0225*		*0.215*	*0.29*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**1.57**	0.11	0.00028	**257**	31	0.018	**0.019**	0.01	6.70E-05	**1.63**	0.44	0.00076
2	**2.82**	0.1	0.00022	**109.5**	3.7	0.014	**0.293**	0.02	4.90E-05	**12.73**	0.6	0.00066
3	**1.551**	0.089	0.00035	**188**	34	0.024	**0.0147**	0.0078	8.70E-05	**1.47**	0.47	0.0011
4	**2.42**	0.44	0.00034	**470**	130	0.023	**0.2**	0.1	8.70E-05	**8.4**	4.9	0.00098
Average	*2.09025*	*0.18475*		*256.125*	*49.675*		*0.131675*	*0.03445*		*6.0575*	*1.6025*	

Table H.9: Muhlbach (FbPf-1) Artifact 3 Cat #264 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**5.7**	1.4	0.0075	**9**	3.9	0.00028	**0.509**	0.035	9.40E-05	**0.297**	0.028	4.80E-05
2	**14.8**	1.1	0.0069	**11.5**	1.3	0.00018	**0.473**	0.029	7.20E-05	**0.546**	0.053	4.60E-05
3	**3.4**	1.2	0.0094	**8.7**	4	0.00032	**0.465**	0.055	0.00014	**0.195**	0.018	7.80E-05
4	**7.7**	2.4	0.0097	**20.8**	6.7	0.00027	**0.635**	0.071	0.00013	**0.42**	0.12	6.30E-05
Average	***7.9***	***1.525***		***12.5***	***3.975***		***0.5205***	***0.0475***		***0.3645***	***0.05475***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**1.67**	0.13	6.80E-05	**0.323**	0.044	1.70E-05	**2.99**	0.29	0.00026	**0.126**	0.012	2.10E-05
2	**1.85**	0.11	3.20E-05	**0.19**	0.011	1.70E-05	**1.94**	0.12	0.00023	**0.1195**	0.0074	1.90E-05
3	**1.2**	0.11	8.10E-05	**0.386**	0.046	3.70E-05	**2.68**	0.26	0.00035	**0.147**	0.013	2.50E-05
4	**1.44**	0.13	6.70E-05	**0.635**	0.058	2.80E-05	**3.9**	1.4	0.00033	**0.28**	0.11	3.00E-05
Average	***1.54***	***0.12***		***0.3835***	***0.03975***		***2.8775***	***0.5175***		***0.168125***	***0.0356***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.0053**	0.0046	1.30E-05	**-0.0008**	0.0012	8.20E-06	**0.069**	0.021	0.00015	**0.004**	0.024	0.00019
2	**0.065**	0.012	4.50E-05	**0.074**	0.01	5.80E-06	**0.45**	0.092	0.00013	**4.13**	0.26	1.80E-05
3	**0.0014**	0.0016	1.50E-05	**0.0029**	0.0025	9.40E-06	**0.017**	0.02	0.00019	**0.022**	0.017	0.0002
4	**0.027**	0.014	1.50E-05	**0.026**	0.012	5.90E-05	**0.183**	0.068	0.0002	**0.53**	0.2	0.00025
Average	***0.024675***	***0.00805***		***0.025525***	***0.006425***		***0.17975***	***0.05025***		***1.1715***	***0.12525***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.029**	0.017	6.70E-05	**0.044**	0.023	0.00031	**0.0034**	0.0022	2.90E-05	**5.98**	0.3	1.70E-05
2	**3.87**	0.18	6.70E-05	**0.9**	0.22	0.00017	**-0.0005**	0.001	1.70E-05	**6.18**	0.29	1.20E-05
3	**0.046**	0.017	8.10E-05	**0.002**	0.019	0.00031	**-0.0007**	0.0024	3.40E-05	**5.79**	0.51	1.90E-05
4	**0.49**	0.21	7.70E-05	**0.51**	0.23	0.00033	**0.0094**	0.0046	3.00E-05	**9.28**	0.82	1.90E-05
Average	***1.10875***	***0.106***		***0.364***	***0.123***		***0.0029***	***0.00255***		***6.8075***	***0.48***	

Table H.9: Muhlbach (FbPf-1) Artifact 3 Cat #264 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.0598**	0.0078	2.10E-06	**0.148**	0.018	1.10E-05	**0.0243**	0.0037	1.70E-06	**0.098**	0.016	7.90E-06
2	**0.0581**	0.0058	1.50E-06	**0.1483**	0.0096	1.30E-06	**0.0218**	0.0029	9.40E-06	**0.077**	0.011	5.60E-06
3	**0.077**	0.0093	1.60E-05	**0.174**	0.02	2.00E-06	**0.0332**	0.0043	9.70E-06	**0.129**	0.018	9.00E-06
4	**0.127**	0.019	2.40E-06	**0.323**	0.044	9.70E-06	**0.073**	0.014	1.60E-05	**0.257**	0.035	9.10E-06
Average	***0.080475***	***0.010475***		***0.198325***	***0.0229***		***0.038075***	***0.006225***		***0.14025***	***0.02***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.032**	0.015	4.60E-05	**0.0089**	0.0025	2.60E-06	**0.044**	0.016	1.00E-05	**0.0072**	0.0022	7.40E-06
2	**0.0108**	0.0044	7.00E-06	**0.0054**	0.0014	1.90E-06	**0.0284**	0.0072	7.30E-06	**0.0043**	0.001	1.10E-06
3	**0.043**	0.011	1.10E-05	**0.0122**	0.0033	3.00E-06	**0.066**	0.019	1.20E-05	**0.0084**	0.0024	1.80E-06
4	**0.07**	0.015	1.10E-05	**0.0183**	0.0044	3.10E-06	**0.073**	0.016	1.20E-05	**0.0172**	0.0033	1.80E-06
Average	***0.03895***	***0.01135***		***0.0112***	***0.0029***		***0.05285***	***0.01455***		***0.009275***	***0.002225***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.045**	0.011	3.00E-05	**0.01**	0.0025	1.60E-06	**0.038**	0.01	4.90E-06	**0.0274**	0.0091	7.60E-06
2	**0.0319**	0.0063	4.50E-06	**0.0078**	0.0014	1.20E-06	**0.0205**	0.0034	3.50E-06	**0.0207**	0.005	5.40E-06
3	**0.074**	0.017	7.30E-06	**0.0184**	0.0043	1.90E-06	**0.043**	0.01	5.50E-06	**0.051**	0.016	8.70E-06
4	**0.127**	0.024	7.40E-06	**0.025**	0.004	1.20E-05	**0.08**	0.013	5.60E-06	**0.09**	0.014	4.10E-05
Average	***0.069475***	***0.014575***		***0.0153***	***0.00305***		***0.045375***	***0.0091***		***0.047275***	***0.011025***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.0311**	0.0077	6.50E-06	**-0.00095**	0.00067	1.20E-05	**0**	1	6.10E-06	**0.00013**	0.00026	5.30E-06
2	**0.0287**	0.0066	4.60E-06	**0.00277**	0.00093	1.30E-06	**0.0038**	0.0019	4.30E-06	**0.004**	0.0021	3.80E-06
3	**0.031**	0.012	7.40E-06	**0.00024**	0.0003	1.70E-05	**0.00068**	0.00081	3.50E-05	**0.002**	0.0022	6.00E-06
4	**0.065**	0.02	7.50E-06	**0.008**	0.0049	1.30E-05	**0.0159**	0.0076	4.40E-05	**0.0151**	0.0084	6.10E-06
Average	***0.03895***	***0.011575***		***0.002515***	***0.0017***		***0.005095***	***0.2525775***		***0.0053075***	***0.00324***	

Table H.9: Muhlbach (FbPf-1) Artifact 3 Cat #264 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**6.7**	1.4	0.0018	**0.288**	0.033	2.20E-05	**0.175**	0.026	3.80E-05	**0.177**	0.019	1.60E-05
2	**9.45**	0.51	0.0012	**5.74**	0.32	3.00E-05	**5.61**	0.38	3.70E-06	**5.53**	0.36	1.60E-05
3	**5.77**	0.96	0.0021	**0.349**	0.057	5.40E-06	**0.158**	0.021	5.90E-06	**0.175**	0.025	2.50E-06
4	**7.5**	1.1	0.0026	**1.94**	0.59	4.00E-05	**1.71**	0.61	6.00E-06	**1.72**	0.59	2.10E-05
Average	***7.355***	***0.9925***		***2.07925***	***0.25***		***1.91325***	***0.25925***		***1.9005***	***0.2485***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.0091**	0.0032	2.00E-05	**0**	1	1.60E-06	**4.62**	0.3	1.10E-06
2	**0.075**	0.018	1.60E-05	**0**	1	5.50E-06	**5.15**	0.15	7.80E-07
3	**0.0226**	0.0063	2.70E-05	**0**	1	1.80E-06	**7.18**	0.33	1.30E-06
4	**0.41**	0.15	2.30E-05	**0**	1	8.50E-06	**7.98**	0.33	1.30E-06
Average	***0.129175***	***0.044375***		***0***	***1***		***6.2325***	***0.2775***	

Table H.10: Fitzgerald (ElNp-8) Artifact 1 Cat #Point

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	354	46	0.01	540	280	0.0069	570	270	0.0043	463500	1300	
2	242	14	0.0084	145	73	0.0057	570	110	0.0035	465830	220	
3	171	14	0.0091	218	79	0.0067	391	58	0.0048	466260	110	
4	178	16	0.0079	180	77	0.0049	520	54	0.0044	466149	81	
5	317	40	0.0099	330	140	0.0062	528	82	0.005	465230	280	
Average	252.4	26		282.6	129.8		515.8	114.8		465393.8	398.2	

Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	112	18	0.011	357	48	0.0039	282	47	0.2	3.47	0.71	0.0018
2	43	11	0.0086	422	35	0.0032	222	40	0.15	3.08	0.48	0.0016
3	13	2.5	0.0096	265	20	0.0033	189	28	0.19	2.81	0.55	0.0016
4	13.5	2.2	0.0086	301	22	0.0028	231	19	0.17	2.33	0.36	0.0013
5	27.4	4.2	0.01	400	38	0.0036	293	57	0.19	3.42	0.51	0.0017
Average	41.78	7.58		349	32.6		243.4	38.2		3.022	0.522	

Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	1.85	0.91	0.0065	2.39	0.17	0.0001	3.5	1.9	0.0046	8.9	5.2	0.0038
2	4	1.1	0.0049	2.06	0.15	7.90E-05	-0.87	0.49	0.0037	0.61	0.29	0.0034
3	1.92	0.52	0.0049	2.51	0.18	0.00011	-1.39	0.98	0.0038	-0.03	0.43	0.0034
4	2.69	0.4	0.0046	1.81	0.15	9.10E-05	-1.21	0.69	0.0032	1.16	0.85	0.0029
5	10.8	3.4	0.0054	2.35	0.18	0.0001	2.3	3	0.0042	11	17	0.0036
Average	4.252	1.266		2.224	0.166		0.466	1.412		4.328	4.754	

Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	5	1.1	0.00051	2300	1600	0.03	1.22	0.54	0.0001	16	6.9	0.0014
2	1.58	0.22	0.00039	229	83	0.025	0.12	0.1	4.90E-05	3.4	1.2	0.0012
3	2.09	0.39	0.00042	180	51	0.023	0.115	0.088	9.40E-05	2.03	0.82	0.0012
4	2.53	0.37	0.00038	115	33	0.019	0.076	0.03	7.80E-05	2.6	1.5	0.001
5	2.75	0.79	0.00048	770	180	0.03	0.6	0.45	7.20E-05	8.9	3.7	0.0013
Average	2.79	0.574		718.8	389.4		0.4262	0.2416		6.586	2.824	

Table H.10: Fitzgerald (ElNp-8) Artifact 1 Cat #Point Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**19.4**	5.5	0.01	**301**	79	0.00036	**6.9**	1.1	0.00017	**0.333**	0.062	9.20E-05
2	**8.6**	1.9	0.011	**69**	50	0.00032	**4.77**	0.3	0.00013	**0.334**	0.032	7.10E-05
3	**7.7**	1.5	0.0099	**51**	21	0.00036	**7.55**	0.35	0.00015	**0.213**	0.024	7.30E-05
4	**7.4**	1.6	0.01	**22**	9.2	0.00031	**13.95**	0.66	0.00012	**0.296**	0.033	6.30E-05
5	**13.1**	5.2	0.01	**186**	72	0.00036	**7.51**	0.89	0.00014	**0.289**	0.035	9.40E-05
Average	***11.24***	***3.14***		***125.8***	***46.24***		***8.136***	***0.66***		***0.293***	***0.0372***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**3.8**	0.54	7.00E-05	**3.58**	0.55	3.20E-05	**7.9**	2.1	0.00052	**0.0336**	0.0079	3.80E-05
2	**3.51**	0.37	8.10E-05	**0.82**	0.086	2.90E-05	**15.1**	1.1	0.00043	**0.07**	0.011	3.00E-05
3	**4.98**	0.28	8.30E-05	**0.765**	0.071	3.50E-05	**7.62**	0.78	0.00044	**0.064**	0.012	3.50E-05
4	**10.01**	0.4	6.80E-05	**1.35**	0.29	4.50E-05	**9.5**	1.9	0.00039	**0.0481**	0.0077	3.00E-05
5	**5.4**	0.49	9.00E-05	**1**	0.21	4.40E-05	**10.9**	3	0.00051	**0.091**	0.016	3.20E-05
Average	***5.54***	***0.416***		***1.503***	***0.2414***		***10.204***	***1.776***		***0.06134***	***0.01092***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.74**	0.41	3.40E-05	**0.204**	0.09	9.00E-05	**0.227**	0.063	0.00028	**1.2**	0.28	0.00021
2	**0.032**	0.02	0.00011	**0.031**	0.012	1.40E-05	**0.071**	0.024	0.00024	**0.177**	0.085	0.00036
3	**0.024**	0.014	2.20E-05	**0.03**	0.012	7.40E-05	**0.077**	0.025	0.00027	**0.148**	0.061	0.00017
4	**0.019**	0.01	1.80E-05	**0.024**	0.013	1.20E-05	**0.035**	0.03	0.00021	**0.045**	0.033	0.00032
5	**0.073**	0.034	0.0001	**0.122**	0.04	6.60E-05	**0.113**	0.036	0.00028	**0.43**	0.18	0.0002
Average	***0.1776***	***0.0976***		***0.0822***	***0.0334***		***0.1046***	***0.0356***		***0.4***	***0.1278***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**1.2**	0.25	0.00014	**0.214**	0.082	0.00033	**0.0052**	0.0033	3.30E-05	**126**	15	4.80E-05
2	**0.194**	0.091	9.20E-05	**0.077**	0.05	0.00038	**0.0047**	0.0034	2.90E-05	**87.9**	5.2	3.10E-05
3	**0.112**	0.051	0.00016	**-0.017**	0.028	0.0005	**0.0048**	0.0026	3.70E-05	**144**	5.8	3.00E-05
4	**0.082**	0.032	0.00012	**-0.011**	0.019	0.00037	**0.0014**	0.002	2.40E-05	**264**	12	2.60E-05
5	**0.31**	0.082	0.00021	**0.122**	0.093	0.00032	**0.0035**	0.0029	4.20E-05	**158**	18	4.50E-05
Average	***0.3796***	***0.1012***		***0.077***	***0.0544***		***0.00392***	***0.00284***		***155.98***	***11.2***	

Table H.10: Fitzgerald (ElNp-8) Artifact 1 Cat #Point Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	2.08	0.28	6.10E-06	6.59	0.85	5.10E-06	0.816	0.083	1.60E-05	3.08	0.37	7.20E-05
2	0.697	0.072	3.90E-06	2.05	0.19	1.30E-05	0.208	0.02	3.10E-06	0.756	0.076	1.40E-05
3	0.677	0.045	1.60E-05	1.75	0.19	1.30E-05	0.212	0.02	3.10E-06	0.788	0.062	1.40E-05
4	1.28	0.24	3.30E-06	3.13	0.56	2.80E-06	0.342	0.061	1.40E-05	1.4	0.3	5.00E-05
5	1.11	0.28	2.40E-05	3.3	1.2	2.00E-05	0.4	0.16	1.50E-05	1.19	0.29	2.10E-05
Average	1.1688	0.1834		3.364	0.598		0.3956	0.0688		1.4428	0.2196	
Pt #	Sm147	Int2SE	LOD	Eu153	Int2SE	LOD	Gd157	Int2SE	LOD	Tb159	Int2SE	LOD
1	0.82	0.11	2.80E-05	0.19	0.028	7.50E-06	0.83	0.15	2.90E-05	0.13	0.023	4.50E-06
2	0.161	0.028	1.80E-05	0.0486	0.0092	4.80E-06	0.178	0.036	1.90E-05	0.0205	0.0045	2.90E-06
3	0.156	0.034	7.30E-05	0.058	0.011	1.90E-05	0.171	0.03	0.0001	0.0213	0.0052	2.80E-06
4	0.321	0.08	8.20E-05	0.089	0.014	1.70E-05	0.346	0.097	8.60E-05	0.049	0.012	2.40E-06
5	0.235	0.082	8.60E-05	0.074	0.014	7.20E-06	0.225	0.07	2.80E-05	0.0347	0.0095	4.30E-06
Average	0.3386	0.0668		0.09192	0.01524		0.35	0.0766		0.0511	0.01084	
Pt #	Dy163	Int2SE	LOD	Ho165	Int2SE	LOD	Er166	Int2SE	LOD	Yb172	Int2SE	LOD
1	0.71	0.1	1.80E-05	0.152	0.025	4.70E-06	0.46	0.073	1.40E-05	0.437	0.089	2.20E-05
2	0.141	0.025	1.20E-05	0.0326	0.0065	1.20E-05	0.099	0.021	9.00E-06	0.094	0.023	1.40E-05
3	0.141	0.019	1.20E-05	0.0376	0.0059	1.60E-05	0.083	0.012	3.60E-05	0.123	0.025	1.40E-05
4	0.293	0.073	1.00E-05	0.062	0.017	2.60E-06	0.166	0.033	7.70E-06	0.197	0.06	1.20E-05
5	0.224	0.061	1.80E-05	0.042	0.0099	4.50E-06	0.118	0.033	1.30E-05	0.24	0.1	2.10E-05
Average	0.3018	0.0556		0.06524	0.01286		0.1852	0.0344		0.2182	0.0594	
Pt #	Hf178	Int2SE	LOD	Ta181	Int2SE	LOD	W182	Int2SE	LOD	W184	Int2SE	LOD
1	0.163	0.04	1.90E-05	0.0032	0.0025	2.60E-05	0.05	0.019	1.60E-05	0.042	0.014	1.40E-05
2	0.38	0.061	1.20E-05	0.00074	0.00059	1.30E-05	0.0104	0.0052	1.00E-05	0.0085	0.005	9.10E-06
3	0.211	0.043	1.20E-05	0.0016	0.0017	1.40E-05	0.0049	0.003	1.00E-05	0.0104	0.0084	9.00E-06
4	0.44	0.19	1.00E-05	0.0011	0.001	2.90E-06	0.0098	0.0046	8.90E-06	0.0082	0.0043	7.70E-06
5	0.89	0.44	1.80E-05	0.0037	0.0026	5.10E-06	0.041	0.012	1.60E-05	0.039	0.014	4.30E-05
Average	0.4168	0.1548		0.002068	0.001678		0.02322	0.00876		0.02162	0.00914	

Table H.10: Fitzgerald (ElNp-8) Artifact 1 Cat #Point Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**3.07**	0.57	0.0027	**1.09**	0.17	6.70E-05	**0.72**	0.1	5.70E-05	**0.84**	0.13	3.10E-05
2	**1.28**	0.22	0.0017	**0.518**	0.057	3.10E-05	**0.453**	0.056	3.40E-05	**0.467**	0.045	2.90E-05
3	**1.94**	0.4	0.0021	**0.488**	0.071	5.60E-05	**0.377**	0.051	8.10E-05	**0.456**	0.068	2.30E-05
4	**2.3**	0.32	0.0021	**0.586**	0.064	3.60E-05	**0.485**	0.047	3.10E-05	**0.55**	0.058	2.20E-05
5	**2.34**	0.5	0.0021	**0.76**	0.12	3.80E-05	**0.65**	0.12	4.20E-05	**0.78**	0.14	2.90E-05
Average	***2.186***	***0.402***		***0.6884***	***0.0964***		***0.537***	***0.0748***		***0.6186***	***0.0882***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.173**	0.042	3.80E-05	**0**	1	4.60E-06	**1.27**	0.1	3.00E-06
2	**0.029**	0.016	2.60E-05	**0**	1	2.90E-06	**1.225**	0.093	1.90E-06
3	**0.033**	0.015	5.50E-05	**0**	1	2.90E-06	**1.72**	0.13	1.90E-06
4	**0.0177**	0.0092	3.50E-05	**-0.91**	0.35	1.00E-05	**1.07**	0.11	1.70E-06
5	**0.101**	0.033	4.20E-05	**0.21**	0.41	4.30E-06	**1.205**	0.098	2.90E-06
Average	***0.07074***	***0.02304***		***-0.14***	***0.752***		***1.298***	***0.1062***	

Appendix H: Archaeological Samples Raw Data

Table H.11: Fitzgerald (ElNp-8) Artifact 2 Cat #346

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**399**	43	0.0067	**230**	100	0.0047	**570**	75	0.0032	**465200**	420	
2	**259**	23	0.0099	**156**	95	0.0074	**462**	57	0.0047	**465820**	460	
3	**180**	17	0.0071	**177**	88	0.0051	**348**	32	0.0032	**466200**	240	
4	**243**	15	0.0079	**81**	16	0.0055	**558**	80	0.0036	**466235**	95	
5	**215**	21	0.0092	**215**	90	0.0068	**610**	120	0.0041	**466050**	180	
Average	***259.2***	***23.8***		***171.8***	***77.8***		***509.6***	***72.8***		***465901***	***279***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**30.3**	8.2	0.0068	**571**	59	0.0024	**186**	25	0.13	**4.12**	0.86	0.0012
2	**61**	53	0.01	**442**	64	0.0036	**170**	100	0.2	**4.3**	1.1	0.0018
3	**23.2**	6.2	0.0071	**240**	18	0.0026	**169**	26	0.13	**3.12**	0.71	0.0013
4	**13**	2.7	0.0089	**353**	19	0.0028	**143**	23	0.16	**3.37**	0.72	0.0014
5	**22.6**	4.9	0.0099	**308**	27	0.0033	**193**	38	0.19	**2.43**	0.52	0.0017
Average	***30.02***	***15***		***382.8***	***37.4***		***172.2***	***42.4***		***3.468***	***0.782***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**0.84**	0.56	0.004	**0.402**	0.051	7.30E-05	**-0.71**	0.53	0.0028	**0.94**	0.67	0.0026
2	**2.7**	2	0.0062	**0.354**	0.082	0.00011	**-1.47**	0.62	0.0043	**1.1**	1.3	0.0038
3	**0.58**	0.39	0.0041	**0.235**	0.037	6.90E-05	**-0.31**	0.67	0.003	**0.64**	0.45	0.0026
4	**0.89**	0.4	0.0047	**0.24**	0.053	8.10E-05	**-1.41**	0.63	0.0034	**0.62**	0.49	0.0029
5	**1.16**	0.42	0.0055	**0.3**	0.053	8.60E-05	**-2.8**	1.2	0.0039	**1.1**	1	0.0034
Average	***1.234***	***0.754***		***0.3062***	***0.0552***		***-1.34***	***0.73***		***0.88***	***0.782***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**2.17**	0.52	0.00031	**710**	300	0.02	**0.34**	0.25	4.80E-05	**6**	1.8	0.00092
2	**1.96**	0.67	0.00047	**295**	80	0.029	**0.12**	0.057	9.30E-05	**5**	1.6	0.0013
3	**1.65**	0.37	0.00034	**540**	320	0.021	**0.074**	0.043	6.40E-05	**3.2**	1.2	0.00086
4	**1.08**	0.11	0.00042	**206**	75	0.022	**0.05**	0.024	5.40E-05	**2.28**	0.63	0.0011
5	**1.84**	0.26	0.00046	**273**	77	0.026	**0.19**	0.16	6.70E-05	**2.36**	0.62	0.0012
Average	***1.74***	***0.386***		***404.8***	***170.4***		***0.1548***	***0.1068***		***3.768***	***1.17***	

Table H.11: Fitzgerald (ElNp-8) Artifact 2 Cat #346 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**8.4**	2.8	0.0081	**100**	39	0.00025	**0.45**	0.099	7.90E-05	**0.493**	0.057	5.80E-05
2	**9.7**	3.1	0.011	**77**	51	0.00039	**0.58**	0.13	0.00014	**0.43**	0.032	7.80E-05
3	**5.8**	1.6	0.0076	**63**	30	0.00024	**0.365**	0.092	9.60E-05	**0.23**	0.024	6.80E-05
4	**6**	1.3	0.009	**53**	28	0.00031	**0.498**	0.093	0.00011	**0.332**	0.02	6.80E-05
5	**7**	2.6	0.0096	**52**	27	0.00034	**0.446**	0.089	0.00012	**0.285**	0.027	7.00E-05
Average	*7.38*	*2.28*		*69*	*35*		*0.4678*	*0.1006*		*0.354*	*0.032*	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**1.36**	0.19	4.70E-05	**0.41**	0.21	2.00E-05	**4.55**	0.55	0.00035	**0.017**	0.0038	1.80E-05
2	**1.28**	0.22	0.0001	**0.47**	0.23	4.70E-05	**4.17**	0.45	0.00051	**0.0175**	0.0069	3.00E-05
3	**0.975**	0.08	6.60E-05	**0.389**	0.05	2.80E-05	**3.87**	0.91	0.00037	**0.0134**	0.0038	2.30E-05
4	**1.36**	0.12	6.40E-05	**0.35**	0.044	3.70E-05	**5.31**	0.77	0.0004	**0.0156**	0.004	2.10E-05
5	**1.31**	0.2	8.00E-05	**0.471**	0.072	4.20E-05	**4.61**	0.79	0.00049	**0.0128**	0.0058	2.40E-05
Average	*1.257*	*0.162*		*0.418*	*0.1212*		*4.502*	*0.694*		*0.01526*	*0.00486*	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.043**	0.015	7.00E-05	**0.12**	0.1	4.50E-05	**0.103**	0.041	0.00018	**0.36**	0.11	0.00014
2	**0.057**	0.033	4.90E-05	**0.027**	0.014	3.10E-05	**0.045**	0.021	0.00034	**0.086**	0.06	0.00033
3	**0.039**	0.019	2.10E-05	**0.055**	0.033	1.30E-05	**0.05**	0.014	0.00021	**0.173**	0.078	0.00018
4	**0.037**	0.019	2.30E-05	**0.023**	0.012	1.50E-05	**0.034**	0.03	0.00025	**0.11**	0.047	0.0002
5	**0.041**	0.031	2.10E-05	**0.046**	0.021	5.60E-05	**0.045**	0.018	0.00027	**0.068**	0.043	0.00022
Average	*0.0434*	*0.0234*		*0.0542*	*0.036*		*0.0554*	*0.0248*		*0.1594*	*0.0676*	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.46**	0.2	7.60E-05	**0.105**	0.094	0.00039	**0.0041**	0.0017	1.70E-05	**5.91**	0.79	3.30E-05
2	**0.135**	0.09	4.10E-05	**0.07**	0.067	0.00056	**0.0025**	0.002	4.10E-05	**9.4**	4.8	6.90E-05
3	**0.187**	0.08	0.0001	**0.071**	0.049	0.00048	**0.0033**	0.0022	2.40E-05	**4.1**	0.4	3.00E-05
4	**0.173**	0.05	8.70E-05	**0.004**	0.02	0.00039	**0.0017**	0.0017	2.30E-05	**6.9**	1.4	3.20E-05
5	**0.156**	0.056	7.30E-05	**0.028**	0.032	0.00044	**0.0014**	0.0021	3.30E-05	**5.13**	0.5	3.00E-05
Average	*0.2222*	*0.0952*		*0.0556*	*0.0524*		*0.0026*	*0.00194*		*6.288*	*1.578*	

Table H.11: Fitzgerald (ElNp-8) Artifact 2 Cat #346 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.25**	0.13	1.60E-05	**1.03**	0.45	1.10E-05	**0.107**	0.05	1.30E-05	**0.45**	0.21	1.60E-05
2	**0.32**	0.15	8.80E-06	**1.1**	0.46	7.40E-06	**0.156**	0.07	2.10E-05	**0.55**	0.27	3.30E-05
3	**0.282**	0.034	1.30E-05	**0.982**	0.094	3.20E-06	**0.136**	0.012	3.00E-06	**0.481**	0.053	1.40E-05
4	**0.209**	0.025	1.40E-05	**0.81**	0.11	1.50E-05	**0.102**	0.013	1.10E-05	**0.421**	0.069	1.50E-05
5	**0.36**	0.051	3.80E-06	**1.055**	0.088	3.20E-06	**0.138**	0.014	3.00E-06	**0.62**	0.11	1.40E-05
Average	***0.2842***	***0.078***		***0.9954***	***0.2404***		***0.1278***	***0.0318***		***0.5044***	***0.1424***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.166**	0.095	5.90E-05	**0.026**	0.016	5.20E-06	**0.102**	0.069	2.00E-05	**0.027**	0.017	3.10E-06
2	**0.163**	0.085	9.90E-05	**0.025**	0.011	1.10E-05	**0.092**	0.057	4.30E-05	**0.021**	0.011	6.50E-06
3	**0.125**	0.026	1.80E-05	**0.0272**	0.0069	4.70E-06	**0.128**	0.032	1.80E-05	**0.0177**	0.0037	9.60E-06
4	**0.097**	0.024	1.90E-05	**0.022**	0.0053	1.80E-05	**0.101**	0.025	2.00E-05	**0.0152**	0.0028	3.10E-06
5	**0.135**	0.038	1.80E-05	**0.0361**	0.0087	4.70E-06	**0.109**	0.032	1.80E-05	**0.0195**	0.0048	2.80E-06
Average	***0.1372***	***0.0536***		***0.02726***	***0.00958***		***0.1064***	***0.043***		***0.02008***	***0.00786***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.152**	0.083	1.30E-05	**0.033**	0.022	3.30E-06	**0.076**	0.043	2.90E-05	**0.044**	0.024	1.50E-05
2	**0.112**	0.058	2.70E-05	**0.022**	0.011	6.90E-06	**0.08**	0.05	2.00E-05	**0.046**	0.029	3.20E-05
3	**0.089**	0.019	1.10E-05	**0.0208**	0.0043	2.90E-06	**0.048**	0.011	8.70E-06	**0.032**	0.014	1.40E-05
4	**0.087**	0.019	1.30E-05	**0.0161**	0.0042	3.20E-06	**0.047**	0.011	9.60E-06	**0.04**	0.016	1.50E-05
5	**0.123**	0.023	1.10E-05	**0.0225**	0.0046	3.00E-06	**0.056**	0.015	8.80E-06	**0.039**	0.014	1.40E-05
Average	***0.1126***	***0.0404***		***0.02288***	***0.00922***		***0.0614***	***0.026***		***0.0402***	***0.0194***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.09**	0.018	1.30E-05	**0.00029**	0.00051	1.90E-05	**0.0135**	0.0067	1.10E-05	**0.017**	0.012	2.90E-05
2	**0.093**	0.019	2.70E-05	**0.0005**	0.0012	2.40E-05	**0.0085**	0.0055	2.40E-05	**0.007**	0.007	5.00E-05
3	**0.056**	0.015	1.20E-05	**0.0013**	0.0013	1.50E-05	**0.0076**	0.0053	1.00E-05	**0.0054**	0.0043	3.00E-05
4	**0.108**	0.046	1.30E-05	**0.00042**	0.00074	1.30E-05	**0.0041**	0.0026	1.10E-05	**0.0025**	0.0028	9.60E-06
5	**0.105**	0.055	1.20E-05	**0.0004**	0.00094	2.20E-05	**0.004**	0.003	1.00E-05	**0.0047**	0.0041	8.80E-06
Average	***0.0904***	***0.0306***		***0.000582***	***0.000938***		***0.00754***	***0.00462***		***0.00732***	***0.00604***	

Table H.11: Fitzgerald (ElNp-8) Artifact 2 Cat #346 Contined

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**1.2**	0.27	0.0018	**0.37**	0.049	3.80E-05	**0.29**	0.052	4.30E-05	**0.281**	0.045	1.80E-05
2	**2.32**	0.42	0.0026	**0.41**	0.16	6.90E-05	**0.38**	0.26	2.00E-05	**0.32**	0.1	3.20E-05
3	**1.7**	0.24	0.0019	**0.299**	0.06	4.00E-05	**0.15**	0.033	3.00E-05	**0.219**	0.043	1.60E-05
4	**1.83**	0.34	0.0018	**0.219**	0.03	5.00E-05	**0.135**	0.017	9.50E-06	**0.18**	0.032	2.30E-05
5	**2.03**	0.44	0.0018	**0.314**	0.054	7.70E-06	**0.2**	0.038	3.60E-05	**0.292**	0.056	3.90E-05
Average	***1.816***	***0.342***		***0.3224***	***0.0706***		***0.231***	***0.08***		***0.2584***	***0.0552***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.08**	0.031	2.00E-05	**1.9**	2.1	3.20E-06	**2.64**	0.22	2.10E-06
2	**0.039**	0.031	3.60E-05	**3.1**	2.1	6.60E-06	**3.68**	0.29	4.40E-06
3	**0.027**	0.013	2.00E-05	**0.53**	0.61	9.80E-06	**2.88**	0.19	1.90E-06
4	**0.04**	0.025	2.10E-05	**2.7**	2.9	3.10E-06	**2.83**	0.12	7.10E-06
5	**0.024**	0.012	2.80E-05	**1**	1.1	2.80E-06	**3.9**	0.34	1.90E-06
Average	***0.042***	***0.0224***		***1.846***	***1.762***		***3.186***	***0.232***	

Table H.12: Fitzgerald (ElNp-8) Artifact 3 Cat #16350

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**206**	11	0.0083	**58**	14	0.0054	**541**	68	0.0045	**466443**	74	
2	**159.3**	8	0.0076	**30.3**	3.1	0.0051	**419**	48	0.0042	**466648**	53	
3	**372**	18	0.0093	**63.8**	8.4	0.0052	**1050**	110	0.0051	**465640**	120	
4	**107.2**	7.2	0.0086	**25.7**	2.2	0.0056	**270**	25	0.0041	**466878**	37	
5	**161**	12	0.0079	**43.8**	6.7	0.0051	**409**	28	0.0035	**466548**	75	
Average	***201.1***	***11.24***		***44.32***	***6.88***		***537.8***	***55.8***		***466431.4***	***71.8***	

Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	**4.9**	1.1	0.01	**237**	16	0.0034	**182**	23	0.17	**2.94**	0.33	0.0014
2	**8**	1.6	0.0083	**186.2**	8	0.003	**176**	22	0.16	**2.69**	0.39	0.0013
3	**13.7**	3.1	0.011	**441**	18	0.0035	**246**	36	0.19	**2.48**	0.37	0.0015
4	**5.8**	1.1	0.0091	**117**	7.5	0.0033	**150**	20	0.16	**2.19**	0.37	0.0015
5	**11.4**	2.3	0.0084	**157.9**	7.5	0.003	**189**	15	0.15	**1.68**	0.31	0.0014
Average	***8.76***	***1.84***		***227.82***	***11.4***		***188.6***	***23.2***		***2.396***	***0.354***	

Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	**0.92**	0.51	0.006	**0.307**	0.029	9.50E-05	**-1.13**	0.36	0.0038	**0.19**	0.27	0.0034
2	**1.23**	0.34	0.0051	**0.77**	0.16	8.90E-05	**-2.4**	0.44	0.0033	**-0.28**	0.18	0.0027
3	**29.6**	3.5	0.0058	**1.12**	0.25	8.50E-05	**-3.1**	1.2	0.0039	**0.44**	0.44	0.0034
4	**4.23**	0.69	0.0052	**0.208**	0.021	8.90E-05	**-2.87**	0.49	0.0038	**-0.46**	0.25	0.0034
5	**4.86**	0.64	0.0047	**0.257**	0.026	9.10E-05	**-2.14**	0.5	0.0035	**0.4**	0.26	0.003
Average	***8.168***	***1.136***		***0.5324***	***0.0972***		***-2.328***	***0.598***		***0.058***	***0.28***	

Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	**0.93**	0.11	0.00042	**90**	17	0.022	**0.018**	0.016	7.90E-05	**1.88**	0.42	0.0011
2	**0.964**	0.086	0.00036	**81**	16	0.02	**0.014**	0.0095	5.10E-05	**1.56**	0.3	0.00098
3	**1.18**	0.13	0.00048	**179**	39	0.023	**0.017**	0.01	9.50E-05	**1.31**	0.31	0.0011
4	**0.636**	0.05	0.00039	**69**	11	0.024	**0.0129**	0.0053	7.40E-05	**1.56**	0.41	0.0011
5	**0.84**	0.13	0.00038	**176**	70	0.022	**0.039**	0.026	6.30E-05	**1.34**	0.48	0.001
Average	***0.91***	***0.1012***		***119***	***30.6***		***0.02018***	***0.01336***		***1.53***	***0.384***	

Table H.12: Fitzgerald (ElNp-8) Artifact 3 Cat #16350 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**7.7**	1.2	0.011	**10.8**	6.9	0.00039	**1.79**	0.17	0.00012	**0.195**	0.018	6.00E-05
2	**6.32**	0.96	0.0097	**3.6**	2.2	0.00034	**2.07**	0.16	7.90E-05	**0.157**	0.011	7.30E-05
3	**6.8**	1.2	0.0094	**9.6**	8.3	0.00035	**1.318**	0.088	0.00011	**0.632**	0.055	8.70E-05
4	**7.4**	1.7	0.01	**3.3**	1.9	0.0003	**2.07**	0.12	0.00012	**0.095**	0.011	7.70E-05
5	**6.06**	0.93	0.0087	**17.4**	6.4	0.0003	**1.77**	0.11	0.0001	**0.149**	0.012	5.80E-05
Average	***6.856***	***1.198***		***8.94***	***5.14***		***1.8036***	***0.1296***		***0.2456***	***0.0214***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**2.35**	0.24	7.20E-05	**0.145**	0.019	3.20E-05	**2.89**	0.33	0.00043	**0.0537**	0.0071	3.50E-05
2	**2.4**	0.2	6.50E-05	**0.145**	0.014	3.90E-05	**2.22**	0.25	0.00041	**0.0376**	0.0076	2.30E-05
3	**2.24**	0.19	6.40E-05	**0.282**	0.032	3.70E-05	**4.2**	0.43	0.00045	**0.214**	0.027	3.40E-05
4	**2.38**	0.17	6.50E-05	**0.136**	0.014	1.70E-05	**1.1**	0.11	0.00042	**0.0332**	0.0054	2.50E-05
5	**2.15**	0.12	6.00E-05	**0.16**	0.02	2.50E-05	**1.51**	0.13	0.00038	**0.0497**	0.008	3.20E-05
Average	***2.304***	***0.184***		***0.1736***	***0.0198***		***2.384***	***0.25***		***0.07764***	***0.01102***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.0111**	0.0058	1.40E-05	**0.009**	0.0042	9.10E-06	**0.105**	0.026	0.00027	**0.015**	0.019	0.00032
2	**0.0064**	0.0043	1.30E-05	**0.0051**	0.0035	7.10E-05	**0.184**	0.031	0.00026	**-0.013**	0.016	0.00027
3	**0.057**	0.022	1.50E-05	**0.08**	0.019	9.60E-06	**0.121**	0.027	0.00027	**0.03**	0.033	0.00028
4	**0.0086**	0.0047	1.40E-05	**0.0057**	0.0048	4.90E-05	**0.068**	0.018	0.00024	**0.024**	0.023	0.00042
5	**0.0161**	0.0063	9.40E-05	**0.0143**	0.0074	8.20E-06	**0.041**	0.011	0.00022	**0.061**	0.026	0.00027
Average	***0.01984***	***0.00862***		***0.02282***	***0.00778***		***0.1038***	***0.0226***		***0.0234***	***0.0234***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.015**	0.016	0.00013	**0.024**	0.035	0.00037	**-0.0002**	0.0021	4.20E-05	**26.8**	2.4	2.00E-05
2	**0.0078**	0.0073	0.00013	**0**	0.014	0.00039	**0.0013**	0.0021	3.50E-05	**32.5**	2.2	1.80E-05
3	**0.027**	0.016	0.00015	**0.04**	0.03	0.00045	**0.0419**	0.0071	3.60E-05	**20.5**	1.5	2.10E-05
4	**0.01**	0.012	0.00011	**0.033**	0.032	0.00036	**0.0011**	0.0016	3.70E-05	**34.7**	2.2	1.90E-05
5	**0.041**	0.019	7.80E-05	**0.036**	0.02	0.00027	**0.00045**	0.00099	2.30E-05	**29.3**	1.5	1.80E-05
Average	***0.02016***	***0.01406***		***0.0266***	***0.0262***		***0.00891***	***0.002778***		***28.76***	***1.96***	

Table H.12: Fitzgerald (ElNp-8) Artifact 3 Cat #16350 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.0446**	0.0062	1.40E-05	**0.109**	0.015	2.10E-06	**0.0145**	0.0031	1.80E-05	**0.057**	0.018	9.40E-06
2	**0.045**	0.0058	1.20E-05	**0.0867**	0.0087	1.90E-06	**0.015**	0.0034	1.30E-05	**0.05**	0.011	6.10E-05
3	**0.152**	0.023	2.00E-05	**0.282**	0.032	1.20E-05	**0.0435**	0.0078	2.10E-06	**0.178**	0.037	9.80E-06
4	**0.0376**	0.0098	2.50E-06	**0.089**	0.023	2.10E-06	**0.0124**	0.0037	1.10E-05	**0.062**	0.018	9.10E-06
5	**0.0631**	0.0098	2.30E-06	**0.083**	0.012	1.40E-05	**0.021**	0.0046	1.30E-05	**0.064**	0.014	8.50E-06
Average	***0.06846***	***0.01092***		***0.12994***	***0.01814***		***0.02128***	***0.00452***		***0.0822***	***0.0196***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.024**	0.01	1.20E-05	**0.0062**	0.0021	3.10E-06	**0.0256**	0.0082	1.20E-05	**0.003**	0.0012	1.90E-06
2	**0.0151**	0.0068	1.00E-05	**0.0094**	0.0026	2.80E-06	**0.0186**	0.0068	6.00E-05	**0.0046**	0.0013	9.10E-06
3	**0.037**	0.011	1.20E-05	**0.0109**	0.0031	3.30E-06	**0.056**	0.019	1.30E-05	**0.0075**	0.0023	1.10E-05
4	**0.0171**	0.0076	6.30E-05	**0.0084**	0.0023	3.10E-06	**0.0188**	0.0079	6.60E-05	**0.0028**	0.0011	1.80E-06
5	**0.0246**	0.0075	1.10E-05	**0.0078**	0.0021	2.80E-06	**0.029**	0.01	6.10E-05	**0.0042**	0.0012	1.70E-06
Average	***0.02356***	***0.00858***		***0.00854***	***0.00244***		***0.0296***	***0.01038***		***0.00442***	***0.00142***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.0278**	0.0093	7.70E-06	**0.0057**	0.0018	1.40E-05	**0.0215**	0.0057	5.90E-06	**0.0292**	0.0097	9.10E-06
2	**0.0283**	0.0071	6.80E-06	**0.0067**	0.002	9.60E-06	**0.0269**	0.0058	5.20E-06	**0.0247**	0.0069	8.10E-06
3	**0.058**	0.013	8.10E-06	**0.0117**	0.0031	2.10E-06	**0.0382**	0.008	6.20E-06	**0.045**	0.013	9.60E-06
4	**0.0299**	0.0077	7.40E-06	**0.0087**	0.0024	1.90E-06	**0.02**	0.0053	5.70E-06	**0.0258**	0.0079	8.90E-06
5	**0.0312**	0.0094	6.90E-06	**0.0077**	0.0022	1.80E-06	**0.0278**	0.0069	5.30E-06	**0.0294**	0.0087	8.30E-06
Average	***0.03504***	***0.0093***		***0.0081***	***0.0023***		***0.02688***	***0.00634***		***0.03082***	***0.00924***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.06**	0.012	7.90E-06	**0.0005**	0.0015	2.30E-06	**0.0022**	0.0017	6.80E-06	**0.00061**	0.00061	5.90E-06
2	**0.0394**	0.0094	7.10E-06	**1.00E-05**	0.00085	2.00E-06	**0.0028**	0.0021	6.10E-06	**0.0026**	0.002	2.90E-05
3	**0.116**	0.025	8.30E-06	**0.003**	0.0018	2.40E-05	**0.046**	0.012	7.20E-06	**0.055**	0.013	6.20E-06
4	**0.0198**	0.0069	4.30E-05	**0.00012**	0.00048	1.90E-05	**0.0045**	0.0023	6.60E-06	**0.0073**	0.0035	5.70E-06
5	**0.0361**	0.0081	7.20E-06	**0.00028**	0.00098	1.80E-05	**0.0123**	0.006	6.20E-06	**0.0148**	0.0062	5.30E-06
Average	***0.05426***	***0.01228***		***0.000782***	***0.001122***		***0.01356***	***0.00482***		***0.016062***	***0.005062***	

Table H.12: Fitzgerald (ElNp-8) Artifact 3 Cat #16350 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**3.27**	0.54	0.0019	**0.327**	0.028	5.10E-05	**0.185**	0.021	3.10E-05	**0.198**	0.019	3.30E-05
2	**2.57**	0.41	0.0017	**0.281**	0.023	6.30E-05	**0.213**	0.021	5.10E-05	**0.202**	0.018	3.10E-05
3	**4.83**	0.93	0.0017	**0.487**	0.065	5.40E-05	**0.363**	0.048	4.40E-05	**0.397**	0.046	2.20E-05
4	**2.81**	0.41	0.0023	**0.255**	0.03	5.10E-05	**0.18**	0.027	4.10E-05	**0.197**	0.028	3.00E-05
5	**1.75**	0.24	0.0019	**0.235**	0.028	2.60E-05	**0.15**	0.018	3.80E-05	**0.182**	0.02	1.60E-05
Average	***3.046***	***0.506***		***0.317***	***0.0348***		***0.2182***	***0.027***		***0.2352***	***0.0262***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.0077**	0.0037	5.70E-05	**0**	1	1.00E-05		0.29	1.20E-06
2	**0.0023**	0.0023	4.50E-05	**0**	1	1.70E-06	**4.45**	0.2	1.10E-06
3	**0.0099**	0.0049	4.10E-05	**0.13**	0.2	2.00E-06	**2.98**	0.15	1.30E-06
4	**0.0013**	0.0032	3.90E-05	**0**	1	1.80E-06	**3.2**	0.18	6.70E-06
5	**0.0078**	0.0034	3.10E-05	**0**	1	1.70E-06	**3.89**	0.16	1.10E-06
Average	***0.0058***	***0.0035***		***0.026***	***0.84***		***3.63***	***0.196***	

Table H.13: Melhagen (EgNn-1) Artifact 1 Cat #674

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	214	15	0.0073	143	42	0.0039	477	55	0.004	464990	190	
2	176	10	0.008	49.5	6	0.0042	457	60	0.0037	466110	150	
3	185	15	0.0072	35.2	2.1	0.0045	452	32	0.0034	466233	91	
4	117.6	7.4	0.0079	41.7	3.3	0.0046	333	26	0.0036	465470	140	
5	213	17	0.0073	39.5	3.1	0.0044	570	60	0.0033	465741	96	
Average	181.12	12.88		61.78	11.3		457.8	46.6		465708.8	133.4	
Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	154	18	0.0088	332	22	0.0027	359	30	0.15	2.31	0.47	0.00063
2	36	13	0.0088	326	18	0.003	337	45	0.15	2.36	0.46	0.00072
3	32.4	8.5	0.0074	297	24	0.0027	281	30	0.14	1.93	0.35	0.00066
4	115	11	0.0082	213.2	8.8	0.0029	338	29	0.15	2.1	0.33	0.00074
5	67.4	5.8	0.0071	347	17	0.0026	296	27	0.15	1.87	0.44	0.0007
Average	80.96	11.26		303.04	17.96		322.2	32.2		2.114	0.41	
Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	1.22	0.47	0.0027	1.75	0.25	6.20E-05	-2.9	1.1	0.0036	0.9	1.1	0.003
2	0.54	0.32	0.0032	0.67	0.11	7.20E-05	-3.06	0.85	0.0041	-0.62	0.54	0.0036
3	1.17	0.41	0.0026	0.81	0.16	7.00E-05	-4.26	0.89	0.0037	-0.32	0.3	0.0031
4	0.69	0.33	0.003	2.33	0.2	7.00E-05	-2.95	0.6	0.004	-0.11	0.2	0.0035
5	1.06	0.36	0.0031	1.36	0.11	8.60E-05	-4.4	1	0.0037	-0.32	0.28	0.0032
Average	0.936	0.378		1.384	0.166		-3.514	0.888		-0.094	0.484	
Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	2.57	0.57	0.00051	1660	220	0.021	0.57	0.24	9.00E-05	3.9	1.4	0.00088
2	2.45	0.2	0.00052	492	80	0.026	0.102	0.018	8.50E-05	1.62	0.33	0.00098
3	1.82	0.11	0.00043	456	93	0.023	0.306	0.056	7.70E-05	1.4	0.32	0.00094
4	2.23	0.12	0.00053	1790	170	0.024	0.174	0.069	9.70E-05	1.08	0.38	0.00097
5	1.61	0.1	0.00043	911	75	0.023	0.424	0.099	7.10E-05	1.28	0.34	0.00089
Average	2.136	0.22		1061.8	127.6		0.3152	0.0964		1.856	0.554	

Table H.13: Melhagen (EgNn-1) Artifact 1 Cat #674 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**9**	2.1	0.0085	**76**	31	0.00033	**2.66**	0.32	9.50E-05	**0.3**	0.024	5.30E-05
2	**7.1**	1.7	0.011	**1.3**	0.51	0.0006	**2.02**	0.34	0.00014	**0.28**	0.023	8.40E-05
3	**5.7**	1.2	0.0077	**0.97**	0.45	0.00036	**1.94**	0.27	0.00011	**0.26**	0.023	6.10E-05
4	**5.17**	0.83	0.0091	**1.56**	0.95	0.00026	**2.02**	0.12	9.10E-05	**0.157**	0.018	6.10E-05
5	**5.9**	1.4	0.0085	**0.21**	0.67	0.00025	**2.14**	0.17	8.70E-05	**0.27**	0.031	6.00E-05
Average	*6.574*	*1.446*		*16.008*	*6.716*		*2.156*	*0.244*		*0.2534*	*0.0238*	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**4.35**	0.33	5.90E-05	**10.2**	1.2	2.30E-05	**1.77**	0.2	0.00026	**0.0441**	0.0088	2.40E-05
2	**3.23**	0.61	0.00013	**2.1**	1.4	2.80E-05	**1.32**	0.14	0.00032	**0.0311**	0.0056	4.30E-05
3	**3.34**	0.44	0.00011	**0.78**	0.13	4.50E-05	**1.46**	0.092	0.00028	**0.0344**	0.0059	2.30E-05
4	**3.09**	0.12	6.90E-05	**4.01**	0.57	2.80E-05	**1.09**	0.089	0.00027	**0.03**	0.0043	1.40E-05
5	**3.83**	0.37	7.20E-05	**3.92**	0.75	2.00E-05	**1.62**	0.15	0.00023	**0.0356**	0.0079	2.10E-05
Average	*3.568*	*0.374*		*4.202*	*0.81*		*1.452*	*0.1342*		*0.03504*	*0.0065*	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.044**	0.016	1.30E-05	**0.044**	0.023	4.50E-05	**0.626**	0.082	0.00015	**0.233**	0.099	0.00023
2	**0.0105**	0.0065	7.60E-05	**0.0069**	0.0046	8.90E-05	**0.417**	0.053	0.0002	**0.06**	0.035	0.00014
3	**0.0082**	0.0049	6.80E-05	**-0.0001**	0.0041	7.00E-05	**0.577**	0.081	0.00018	**-0.041**	0.022	0.00022
4	**0.0012**	0.0014	1.50E-05	**0.0034**	0.0022	9.60E-06	**0.41**	0.068	0.00021	**0.032**	0.032	0.00018
5	**0.0027**	0.0032	1.50E-05	**0.005**	0.0047	6.10E-05	**1.02**	0.11	0.00019	**0.008**	0.022	0.00021
Average	*0.01332*	*0.0064*		*0.01184*	*0.00772*		*0.61*	*0.0788*		*0.0584*	*0.042*	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.265**	0.081	5.40E-05	**0.032**	0.051	0.00033	**0.0028**	0.002	3.00E-05	**30.9**	3.6	0.00012
2	**0.017**	0.011	0.00017	**-0.001**	0.028	0.00081	**0.0019**	0.0021	4.30E-05	**23.2**	3.7	0.0011
3	**0.015**	0.01	9.40E-05	**-0.05**	0.022	0.00049	**-0.0017**	0.0027	2.90E-05	**21.8**	3.1	0.0011
4	**0.0321**	0.0097	7.50E-05	**-0.025**	0.018	0.00017	**0.0002**	0.0014	3.00E-05	**26.5**	1.4	0.00022
5	**0.045**	0.014	5.40E-05	**-0.11**	0.035	0.00036	**-0.0026**	0.003	2.20E-05	**27.5**	2.2	0.00012
Average	*0.07482*	*0.02514*		*-0.0308*	*0.0308*		*0.00012*	*0.00224*		*25.98*	*2.8*	

Table H.13: Melhagen (EgNn-1) Artifact 1 Cat #674 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**12.1**	1.5	2.20E-06	**30**	3.7	1.30E-05	**4.18**	0.52	9.40E-06	**16**	2	7.30E-05
2	**3**	2	3.40E-05	**5.2**	3.6	5.40E-05	**0.72**	0.49	1.80E-05	**3.7**	2.5	0.00012
3	**0.61**	0.12	3.70E-05	**1.38**	0.34	5.00E-05	**0.206**	0.044	1.20E-05	**0.79**	0.19	0.00015
4	**4.27**	0.73	2.80E-05	**10.6**	2.2	2.10E-06	**1.42**	0.29	2.00E-06	**5.45**	0.96	8.70E-06
5	**3.78**	0.86	2.50E-06	**9.6**	2.9	1.60E-05	**1.24**	0.35	9.50E-06	**5.2**	1.5	8.80E-06
Average	***4.752***	***1.042***		***11.356***	***2.548***		***1.5532***	***0.3388***		***6.228***	***1.43***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**3.18**	0.39	8.00E-05	**0.611**	0.083	1.40E-05	**2.67**	0.33	1.00E-05	**0.363**	0.047	8.20E-06
2	**0.65**	0.46	5.50E-05	**0.103**	0.077	3.00E-06	**0.55**	0.36	5.80E-05	**0.075**	0.05	1.80E-06
3	**0.154**	0.043	9.80E-06	**0.0341**	0.0077	2.10E-05	**0.092**	0.034	5.20E-05	**0.0209**	0.0048	1.10E-05
4	**1.05**	0.2	1.10E-05	**0.23**	0.042	2.90E-06	**0.96**	0.18	1.10E-05	**0.135**	0.026	1.80E-06
5	**1**	0.26	1.10E-05	**0.203**	0.052	2.90E-06	**0.99**	0.26	5.50E-05	**0.125**	0.033	1.80E-06
Average	***1.2068***	***0.2706***		***0.23622***	***0.05234***		***1.0524***	***0.2328***		***0.14378***	***0.03216***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**1.97**	0.23	6.40E-06	**0.353**	0.045	1.60E-06	**0.84**	0.12	4.90E-06	**0.681**	0.097	4.00E-05
2	**0.49**	0.29	3.60E-05	**0.078**	0.048	1.90E-06	**0.23**	0.14	2.80E-05	**0.147**	0.097	8.80E-06
3	**0.109**	0.028	5.90E-05	**0.0197**	0.0055	8.50E-06	**0.042**	0.014	2.50E-05	**0.055**	0.019	7.10E-05
4	**0.7**	0.12	7.20E-06	**0.126**	0.023	1.80E-06	**0.331**	0.051	5.50E-06	**0.259**	0.046	8.60E-06
5	**0.65**	0.17	7.30E-06	**0.133**	0.036	1.90E-06	**0.294**	0.083	5.60E-06	**0.232**	0.056	8.70E-06
Average	***0.7838***	***0.1676***		***0.14194***	***0.0315***		***0.3474***	***0.0816***		***0.2748***	***0.063***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.04**	0.011	6.70E-06	**0.0026**	0.0014	1.90E-06	**0.0132**	0.0067	6.30E-06	**0.014**	0.0073	5.50E-06
2	**0.037**	0.011	8.30E-05	**-0.00016**	0.00083	2.20E-06	**-0.00171**	0.00056	5.70E-05	**0**	1	4.10E-05
3	**0.0278**	0.0081	6.90E-05	**-0.00066**	0.00087	2.00E-06	**-0.0014**	0.002	6.40E-06	**-0.00117**	0.00033	5.50E-06
4	**0.017**	0.0059	7.50E-06	**-0.00054**	0.00047	3.20E-05	**0.00051**	0.0005	5.50E-05	**-0.0008**	0.001	3.00E-05
5	**0.035**	0.013	7.60E-06	**-0.00133**	0.00068	1.40E-05	**0.00044**	0.00089	4.40E-05	**-0.0109**	0.0028	6.10E-06
Average	***0.03136***	***0.0098***		***-0.000018***	***0.00085***		***0.002208***	***0.00213***		***0.000226***	***0.202286***	

Table H.13: Melhagen (EgNn-1) Artifact 1 Cat #674 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**14.9**	2.9	0.002	**1.27**	0.14	3.30E-05	**1.06**	0.12	4.30E-05	**1.11**	0.13	2.10E-05
2	**14.7**	3	0.0043	**0.643**	0.097	0.00099	**0.465**	0.072	0.00095	**0.488**	0.079	0.00062
3	**16.5**	3	0.0028	**-0.23**	0.18	0.0004	**-0.32**	0.16	0.00034	**-0.49**	0.19	0.00025
4	**16**	2.8	0.0021	**0.5**	0.1	5.20E-06	**0.379**	0.084	4.60E-05	**0.403**	0.088	2.40E-05
5	**14.8**	2.8	0.0019	**-0.46**	0.37	2.50E-05	**-0.56**	0.36	3.70E-05	**-0.56**	0.36	2.10E-05
Average	***15.38***	***2.9***		***0.3446***	***0.1774***		***0.2048***	***0.1592***		***0.1902***	***0.1694***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.037**	0.015	3.20E-05	**0**	1	1.60E-06	**6**	0.32	1.10E-06
2	**0.0017**	0.0018	6.10E-05	**0**	1	3.80E-05	**4.13**	0.24	7.90E-05
3	**-0.087**	0.018	5.10E-05	**0**	1	2.50E-05	**3.56**	0.23	6.70E-05
4	**0.0036**	0.0021	2.40E-05	**0**	1	1.80E-06	**4.96**	0.25	1.30E-06
5	**-0.0058**	0.0029	2.20E-05	**0**	1	1.80E-06	**4.43**	0.24	1.30E-06
Average	***-0.0101***	***0.00796***		***0***	***1***		***4.616***	***0.256***	

Appendix H: Archaeological Samples Raw Data

Table H.14: Melhagen (EgNn-1) Artifact 2 Cat #4841

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	156.5	9.6	0.0092	71	8	0.0049	532	43	0.0041	464910	520	
2	337	15	0.011	57.2	3.9	0.0066	940	79	0.0045	465697	85	
3	270	15	0.011	61.2	7.7	0.0067	906	93	0.0046	465780	120	
4	336	28	0.0083	55.1	8.9	0.0051	712	92	0.0035	465820	210	
5	306	24	0.01	272	89	0.0055	810	110	0.0053	465020	400	
Average	*281.1*	*18.32*		*103.3*	*23.5*		*780*	*83.4*		*465445.4*	*267*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	7.9	2.4	0.011	412	30	0.0036	1180	190	0.17	2.7	0.22	0.00081
2	6.6	1.5	0.012	632	20	0.0041	272	34	0.2	2.38	0.29	0.00095
3	14.6	2.8	0.012	539	32	0.0043	267	37	0.18	2.34	0.4	0.001
4	7.3	1.9	0.011	617	66	0.0031	253	50	0.18	2.71	0.42	0.00076
5	17.2	4.7	0.012	527	51	0.0037	205	36	0.23	2.57	0.4	0.00088
Average	*10.72*	*2.66*		*545.4*	*39.8*		*435.4*	*69.4*		*2.54*	*0.346*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	1.95	0.71	0.0044	2.1	0.17	0.0001	-1.54	0.49	0.0049	0.43	0.26	0.0043
2	0.9	0.42	0.0051	0.961	0.077	0.00011	-2.59	0.4	0.0056	-0.32	0.21	0.0048
3	1.8	0.45	0.005	2	0.34	0.00012	-5.4	1.1	0.0059	-0.29	0.45	0.0054
4	1.58	0.52	0.0037	1.82	0.32	7.60E-05	-4.2	1.3	0.0044	0.05	0.53	0.0037
5	1.2	1.4	0.0047	1.43	0.19	0.00011	-3.5	2.3	0.005	1.6	1.2	0.0044
Average	*1.486*	*0.7*		*1.6622*	*0.2194*		*-3.446*	*1.118*		*0.294*	*0.53*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	11.5	2.4	0.00062	287	72	0.031	0.025	0.016	9.30E-05	1.59	0.35	0.0012
2	0.83	0.13	0.00069	129	26	0.036	0.036	0.038	8.00E-05	1.43	0.32	0.0014
3	1.87	0.27	0.00071	201	46	0.039	0.036	0.019	0.00011	1.27	0.46	0.0014
4	1.54	0.23	0.0007	189	96	0.027	0.01	0.022	7.20E-05	2.1	0.45	0.0011
5	1.61	0.33	0.0007	860	450	0.027	0.45	0.35	0.0001	4.6	1.9	0.0013
Average	*3.47*	*0.672*		*333.2*	*138*		*0.1114*	*0.089*		*2.198*	*0.696*	

Table H.14: Melhagen (EgNn-1) Artifact 2 Cat #4841 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**6.7**	1	0.01	**5**	4	0.00035	**122**	82	0.00011	**0.293**	0.026	9.10E-05
2	**4.45**	0.95	0.015	**1.9**	2.2	0.00037	**1.13**	0.075	0.00012	**0.59**	0.039	9.80E-05
3	**8.1**	1.9	0.013	**8.1**	4.3	0.00039	**1.325**	0.097	0.00018	**0.471**	0.039	9.80E-05
4	**7.6**	2	0.012	**11.2**	7.3	0.00029	**1.19**	0.13	9.50E-05	**0.529**	0.043	8.10E-05
5	**10.5**	2.6	0.013	**127**	53	0.00042	**1.22**	0.14	0.00011	**0.466**	0.037	9.10E-05
Average	***7.47***	***1.69***		***30.64***	***14.16***		***25.373***	***16.4884***		***0.4698***	***0.0368***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**36**	24	8.50E-05	**0.367**	0.079	2.80E-05	**3.03**	0.4	0.00033	**0.0201**	0.0064	1.70E-05
2	**1.92**	0.14	8.10E-05	**0.112**	0.015	4.20E-05	**11.29**	0.96	0.00035	**0.0278**	0.006	3.60E-06
3	**2.17**	0.25	8.40E-05	**0.278**	0.038	3.40E-05	**9.34**	0.81	0.00036	**0.044**	0.01	4.70E-05
4	**1.56**	0.15	6.60E-05	**0.118**	0.02	1.70E-05	**7.78**	0.9	0.00027	**0.0403**	0.008	2.60E-05
5	**1.74**	0.23	9.90E-05	**0.56**	0.11	4.90E-05	**6.9**	1.4	0.00033	**0.0282**	0.0087	1.90E-05
Average	***8.678***	***4.954***		***0.287***	***0.0524***		***7.668***	***0.894***		***0.03208***	***0.00782***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.011**	0.0064	1.60E-05	**0.0125**	0.0065	1.00E-05	**0.009**	0.012	0.00019	**0.04**	0.034	0.00022
2	**0.004**	0.0058	1.90E-05	**-0.0041**	0.0035	6.70E-05	**-0.02**	0.014	0.00024	**0.034**	0.021	0.00042
3	**0.0079**	0.0091	2.10E-05	**0.002**	0.0084	1.30E-05	**-0.014**	0.018	0.00023	**0.015**	0.031	0.0002
4	**0.0081**	0.006	1.90E-05	**0.0072**	0.0053	1.20E-05	**0.035**	0.024	0.00019	**0.098**	0.075	0.00031
5	**0.052**	0.03	2.10E-05	**0.063**	0.033	1.30E-05	**0.027**	0.06	0.00025	**0.252**	0.092	0.00024
Average	***0.0166***	***0.01146***		***0.01612***	***0.01134***		***0.0074***	***0.0256***		***0.0878***	***0.0506***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.023**	0.011	9.20E-05	**0.072**	0.037	0.00046	**0.0003**	0.002	3.80E-05	**1140**	790	0.00012
2	**-0.002**	0.014	8.00E-05	**-0.193**	0.036	0.00045	**-0.0034**	0.0027	3.60E-05	**11.16**	0.65	2.50E-05
3	**0.014**	0.018	0.00013	**-0.109**	0.049	0.00033	**0.0054**	0.0043	3.30E-05	**13.88**	0.8	2.70E-05
4	**0.0133**	0.0094	6.60E-05	**0.037**	0.029	0.0002	**0.0032**	0.0038	2.20E-05	**12.6**	1.3	2.40E-05
5	**0.27**	0.11	7.60E-05	**0.04**	0.059	0.00046	**0.0046**	0.0042	4.90E-05	**14.1**	1.6	2.70E-05
Average	***0.06366***	***0.03248***		***-0.0306***	***0.042***		***0.00202***	***0.0034***		***238.348***	***158.87***	

Table H.14: Melhagen (EgNn-1) Artifact 2 Cat #4841 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.408**	0.08	1.40E-05	**1.39**	0.21	1.30E-05	**0.196**	0.035	1.60E-05	**0.84**	0.14	6.70E-05
2	**0.114**	0.015	3.10E-06	**0.449**	0.048	2.70E-06	**0.0663**	0.0074	2.50E-06	**0.249**	0.034	9.50E-05
3	**0.257**	0.037	3.30E-06	**0.922**	0.084	3.00E-06	**0.126**	0.017	2.70E-06	**0.588**	0.098	1.20E-05
4	**0.105**	0.014	2.50E-05	**0.493**	0.045	1.20E-05	**0.065**	0.01	2.50E-06	**0.27**	0.036	6.50E-05
5	**0.57**	0.11	2.10E-05	**2.02**	0.23	3.00E-06	**0.304**	0.049	2.80E-06	**1.08**	0.17	5.70E-05
Average	***0.2908***	***0.0512***		***1.0548***	***0.1234***		***0.15146***	***0.02368***		***0.6054***	***0.0956***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.196**	0.052	1.10E-05	**0.041**	0.011	3.00E-06	**0.151**	0.038	8.80E-05	**0.0196**	0.0052	1.80E-06
2	**0.048**	0.01	0.00012	**0.013**	0.0034	3.60E-06	**0.04**	0.01	1.40E-05	**0.0069**	0.0019	2.10E-06
3	**0.142**	0.029	1.40E-05	**0.0178**	0.0046	3.90E-06	**0.118**	0.028	1.50E-05	**0.0159**	0.0044	2.30E-06
4	**0.052**	0.015	6.10E-05	**0.0144**	0.0036	3.60E-06	**0.049**	0.016	6.40E-05	**0.0052**	0.0019	2.10E-06
5	**0.208**	0.033	7.00E-05	**0.07**	0.02	4.00E-06	**0.25**	0.071	1.60E-05	**0.0275**	0.0059	2.40E-06
Average	***0.1292***	***0.0278***		***0.03124***	***0.00852***		***0.1216***	***0.0326***		***0.01502***	***0.00386***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.124**	0.038	7.30E-06	**0.0231**	0.0068	1.90E-06	**0.049**	0.014	5.60E-06	**0.04**	0.013	8.70E-06
2	**0.0295**	0.0097	8.70E-06	**0.0059**	0.0018	2.30E-06	**0.0122**	0.0038	6.70E-06	**0.0091**	0.0044	1.00E-05
3	**0.069**	0.02	9.60E-06	**0.0112**	0.0039	2.50E-06	**0.0261**	0.0093	7.30E-06	**0.0166**	0.0099	1.10E-05
4	**0.0279**	0.0089	8.70E-06	**0.0051**	0.0018	2.30E-06	**0.0124**	0.0067	6.70E-06	**0.0163**	0.0093	1.00E-05
5	**0.14**	0.031	9.80E-06	**0.0294**	0.0096	2.50E-06	**0.073**	0.02	7.50E-06	**0.069**	0.029	1.20E-05
Average	***0.07808***	***0.02152***		***0.01494***	***0.00478***		***0.03454***	***0.01076***		***0.0302***	***0.01312***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.09**	0.025	7.60E-06	**0.0011**	0.00075	2.20E-06	**0.004**	0.0025	7.40E-06	**0.0013**	0.0011	6.40E-06
2	**0.239**	0.033	9.20E-06	**0.00034**	0.0004	2.60E-05	**-0.003**	0.002	8.90E-06	**0.0023**	0.0042	5.70E-05
3	**0.16**	0.026	1.00E-05	**0.00058**	0.00054	2.00E-05	**0.0016**	0.0012	9.70E-06	**0.0016**	0.0015	8.40E-06
4	**0.168**	0.036	9.20E-06	**0.0003**	0.0028	2.60E-06	**-0.0026**	0.0043	8.80E-06	**0**	0.0016	7.60E-06
5	**0.206**	0.075	1.00E-05	**0.0009**	0.0021	2.90E-06	**0.0115**	0.0073	4.70E-05	**0.0172**	0.0074	8.50E-06
Average	***0.1726***	***0.039***		***0.000644***	***0.001318***		***0.0023***	***0.00346***		***0.00448***	***0.00316***	

Table H.14: Melhagen (EgNn-1) Artifact 2 Cat #4841 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**10.1**	1.1	0.0027	**0.14**	0.038	6.20E-05	**0.12**	0.031	3.40E-05	**0.123**	0.031	1.40E-05
2	**9.56**	0.87	0.0036	**-2.35**	0.33	4.80E-05	**-1.96**	0.27	7.30E-06	**-1.97**	0.28	3.40E-05
3	**15.5**	2.3	0.0034	**-0.61**	0.16	7.10E-06	**-0.43**	0.1	7.90E-06	**-0.54**	0.13	3.10E-05
4	**12.2**	3.6	0.0022	**0.174**	0.026	6.40E-06	**0.079**	0.019	7.20E-06	**0.1**	0.027	2.20E-05
5	**16.5**	5.1	0.0025	**0.316**	0.083	5.40E-05	**0.139**	0.035	9.90E-05	**0.246**	0.061	3.20E-05
Average	***12.772***	***2.594***		***-0.466***	***0.1274***		***-0.4104***	***0.091***		***-0.4082***	***0.1058***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.0004**	0.0028	3.30E-05	**0**	1	1.80E-06	**1.32**	0.1	1.40E-06
2	**-0.025**	0.0059	3.20E-05	**0**	1	2.20E-06	**3.38**	0.12	1.60E-06
3	**-0.033**	0.011	2.90E-05	**-2.8**	2.1	2.40E-06	**3.54**	0.21	1.80E-06
4	**0.008**	0.0051	2.50E-05	**0**	1	2.20E-06	**4.53**	0.26	1.60E-06
5	**0.044**	0.015	5.30E-05	**-5.4**	3.6	2.50E-06	**3.48**	0.3	8.40E-06
Average	***-0.00112***	***0.00796***		***-1.64***	***1.74***		***3.25***	***0.198***	

Table H.15: Melhagen (EgNn-1) Artifact 3 Cat #7205

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**185**	12	0.0078	**37.5**	3.2	0.0047	**550**	57	0.0049	**466221**	45	
2	**150.2**	7.9	0.0076	**32.9**	5	0.0046	**406**	38	0.0044	**466529**	44	
3	**96**	7.6	0.0069	**44.4**	8.9	0.004	**289**	31	0.004	**466564**	51	
4	**139**	10	0.008	**52**	20	0.0051	**425**	37	0.0044	**466272**	68	
5	**163**	7	0.0076	**41.5**	4.9	0.0045	**506**	60	0.0037	**466143**	91	
Average	***146.64***	***8.9***		***41.66***	***8.4***		***435.2***	***44.6***		***466345.8***	***59.8***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**14.9**	2.6	0.011	**282**	12	0.0032	**189**	28	0.18	**3.45**	0.43	0.00069
2	**8.6**	2.6	0.0092	**215.8**	9.7	0.003	**188**	23	0.16	**2.86**	0.32	0.00065
3	**16.1**	1.3	0.0081	**145.3**	9.3	0.0027	**184**	17	0.14	**2.18**	0.32	0.00057
4	**29.8**	4.1	0.0098	**216**	11	0.0031	**231**	28	0.18	**2.06**	0.35	0.00065
5	**42.7**	6.9	0.0095	**246**	12	0.0029	**287**	34	0.15	**1.97**	0.44	0.00065
Average	***22.42***	***3.5***		***221.02***	***10.8***		***215.8***	***26***		***2.504***	***0.372***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**1.33**	0.56	0.0057	**0.258**	0.035	8.40E-05	**-1.53**	0.4	0.0045	**0.26**	0.3	0.0037
2	**4.54**	0.82	0.0049	**0.286**	0.035	9.10E-05	**-3.3**	0.81	0.004	**-0.32**	0.36	0.0035
3	**2.65**	0.4	0.0036	**0.419**	0.033	6.60E-05	**-2.75**	0.51	0.0035	**0**	0.26	0.003
4	**1.27**	0.49	0.0039	**0.308**	0.031	8.70E-05	**-4.06**	0.9	0.0041	**0.51**	0.75	0.0036
5	**4.7**	1.2	0.0038	**0.42**	0.034	7.40E-05	**-4.6**	1.1	0.004	**-0.57**	0.48	0.0035
Average	***2.898***	***0.694***		***0.3382***	***0.0336***		***-3.248***	***0.744***		***-0.024***	***0.43***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**2.83**	0.24	0.00071	**477**	56	0.025	**0.008**	0.01	9.10E-05	**1.72**	0.52	0.0011
2	**2.15**	0.22	0.00057	**271**	47	0.024	**0.016**	0.014	7.80E-05	**1.78**	0.51	0.001
3	**3.11**	0.14	0.0005	**439**	30	0.021	**0.05**	0.017	7.40E-05	**1.41**	0.35	0.00094
4	**3.44**	0.17	0.00061	**473**	63	0.024	**0.035**	0.012	9.10E-05	**1.22**	0.37	0.00099
5	**3.82**	0.21	0.00056	**464**	34	0.024	**0.032**	0.012	7.70E-05	**0.98**	0.32	0.001
Average	***3.07***	***0.196***		***424.8***	***46***		***0.0282***	***0.013***		***1.422***	***0.414***	

Table H.15: Melhagen (EgNn-1) Artifact 3 Cat #7205 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**9**	1.9	0.0085	**2.5**	1.3	0.00036	**1.31**	0.11	0.00011	**0.241**	0.024	7.90E-05
2	**7.5**	1.3	0.0087	**7.7**	4.8	0.0004	**1.109**	0.098	0.00011	**0.227**	0.024	8.00E-05
3	**17**	20	0.0085	**6.1**	2.2	0.00041	**1.5**	0.27	7.70E-05	**0.149**	0.02	6.70E-05
4	**6**	1.7	0.0099	**5.2**	1.6	0.00042	**8.4**	4.8	0.0001	**0.204**	0.02	7.40E-05
5	**6.4**	1.3	0.011	**6.7**	3.6	0.00029	**1.35**	0.12	8.40E-05	**0.215**	0.023	7.30E-05
Average	*9.18*	*5.24*		*5.64*	*2.7*		*2.7338*	*1.0796*		*0.2072*	*0.0222*	

Pt #	Sr88	Int2SE	LOD	Y89	Int2SE	LOD	Zr90	Int2SE	LOD	Nb93	Int2SE	LOD
1	**1.29**	0.11	6.80E-05	**0.124**	0.017	3.80E-05	**9.54**	0.81	0.00036	**0.101**	0.011	3.40E-05
2	**1.18**	0.11	6.90E-05	**0.161**	0.029	3.50E-05	**7.53**	0.63	0.00028	**0.091**	0.012	3.30E-05
3	**1.066**	0.072	4.90E-05	**0.163**	0.016	1.80E-05	**5.27**	0.42	0.00027	**0.079**	0.0078	2.30E-05
4	**2.58**	0.95	6.90E-05	**0.402**	0.071	1.50E-05	**7.18**	0.57	0.00028	**0.1**	0.013	2.00E-05
5	**2.07**	0.37	5.90E-05	**2.16**	0.87	2.60E-05	**7.87**	0.93	0.00028	**0.097**	0.016	3.20E-05
Average	*1.6372*	*0.3224*		*0.602*	*0.2006*		*7.478*	*0.672*		*0.0936*	*0.01196*	

Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	**0.0016**	0.0042	1.50E-05	**0.001**	0.0045	9.50E-06	**0.044**	0.022	0.0002	**-0.018**	0.023	0.00035
2	**0.028**	0.013	1.40E-05	**0.0183**	0.0073	7.60E-05	**0.13**	0.025	0.00019	**0.014**	0.033	0.00041
3	**0.0124**	0.007	6.60E-05	**0.0212**	0.0077	5.70E-05	**0.133**	0.021	0.00017	**0.023**	0.016	0.00032
4	**0.0208**	0.0097	7.70E-05	**0.0141**	0.0076	6.60E-05	**0.085**	0.026	0.00018	**-0.02**	0.021	0.00031
5	**0.025**	0.01	1.30E-05	**0.0278**	0.0099	8.60E-06	**0.12**	0.026	0.00017	**0.025**	0.018	0.00027
Average	*0.01756*	*0.00878*		*0.01648*	*0.0074*		*0.1024*	*0.024*		*0.0048*	*0.0222*	

Pt #	Cd114	Int2SE	LOD	Sn122	Int2SE	LOD	Cs133	Int2SE	LOD	Ba137	Int2SE	LOD
1	**0.019**	0.013	6.30E-05	**-0.062**	0.031	0.00026	**-0.001**	0.0032	2.30E-05	**10.64**	0.6	2.00E-05
2	**0.018**	0.013	9.20E-05	**0.043**	0.028	0.00028	**-0.0012**	0.0037	3.50E-05	**9.76**	0.77	1.80E-05
3	**0.029**	0.013	0.00014	**0.029**	0.027	0.00025	**0.0043**	0.0024	2.90E-05	**14.3**	2.7	1.70E-05
4	**0.034**	0.016	8.00E-05	**0.021**	0.029	0.00048	**0.0015**	0.0031	3.50E-05	**82**	48	1.90E-05
5	**0.015**	0.012	7.50E-05	**0.02**	0.025	3.20E-05	**0.0025**	0.0034	3.40E-05	**12.25**	0.97	1.80E-05
Average	*0.023*	*0.0134*		*0.0102*	*0.028*		*0.00122*	*0.00316*		*25.79*	*10.608*	

Appendix H: Archaeological Samples Raw Data

Table H.15: Melhagen (EgNn-1) Artifact 3 Cat #7205 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.06**	0.012	1.40E-05	**0.157**	0.021	1.20E-05	**0.0264**	0.0058	1.10E-05	**0.115**	0.031	8.50E-06
2	**0.096**	0.017	1.70E-05	**0.252**	0.023	1.70E-05	**0.0332**	0.0058	1.40E-05	**0.1**	0.02	7.90E-06
3	**0.098**	0.012	2.10E-06	**0.262**	0.018	1.60E-05	**0.0344**	0.0036	9.10E-06	**0.165**	0.024	3.80E-05
4	**0.381**	0.058	2.40E-06	**1.12**	0.1	1.50E-05	**0.17**	0.025	1.00E-05	**0.75**	0.12	8.20E-06
5	**3.4**	1.4	1.20E-05	**10**	4.2	1.10E-05	**1.46**	0.64	1.80E-06	**5.9**	2.5	5.50E-05
Average	***0.807***	***0.2998***		***2.3582***	***0.8724***		***0.3448***	***0.13604***		***1.406***	***0.539***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.019**	0.0097	7.80E-05	**0.004**	0.0022	2.90E-06	**0.017**	0.011	6.20E-05	**0.0033**	0.0013	1.70E-06
2	**0.029**	0.018	9.80E-06	**0.0041**	0.0023	1.40E-05	**0.0237**	0.0094	7.50E-05	**0.0042**	0.0016	1.10E-05
3	**0.0305**	0.0085	8.60E-05	**0.007**	0.0021	1.70E-05	**0.0298**	0.0087	5.00E-05	**0.0054**	0.0015	1.70E-05
4	**0.171**	0.038	1.00E-05	**0.0295**	0.0068	2.80E-06	**0.15**	0.033	5.70E-05	**0.0199**	0.0054	1.60E-06
5	**1.32**	0.6	5.10E-05	**0.26**	0.11	1.40E-05	**0.77**	0.32	9.90E-06	**0.115**	0.053	1.50E-06
Average	***0.3139***	***0.13484***		***0.06092***	***0.02468***		***0.1981***	***0.07642***		***0.02956***	***0.01256***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.0191**	0.0083	7.00E-06	**0.0035**	0.0016	1.80E-06	**0.0101**	0.0047	5.40E-06	**0.0237**	0.0077	8.50E-06
2	**0.0185**	0.0073	6.40E-06	**0.0038**	0.0017	1.70E-06	**0.0174**	0.0068	5.00E-06	**0.0247**	0.0095	7.70E-06
3	**0.0336**	0.0082	5.80E-06	**0.008**	0.0018	1.50E-06	**0.0192**	0.0053	4.50E-06	**0.038**	0.0093	7.00E-06
4	**0.114**	0.024	6.70E-06	**0.0235**	0.0054	1.20E-05	**0.062**	0.016	5.10E-06	**0.083**	0.021	8.00E-06
5	**0.6**	0.23	6.20E-06	**0.122**	0.05	1.60E-06	**0.25**	0.1	4.80E-06	**0.28**	0.11	7.40E-06
Average	***0.15704***	***0.05556***		***0.03216***	***0.0121***		***0.07174***	***0.02656***		***0.08988***	***0.0315***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.122**	0.029	7.40E-06	**0.0012**	0.0016	1.20E-05	**0.0018**	0.0013	7.10E-06	**0.0027**	0.002	6.10E-06
2	**0.089**	0.024	3.70E-05	**-0.00031**	0.0004	1.90E-05	**0.0194**	0.0078	6.50E-06	**0.0166**	0.0063	5.60E-06
3	**0.0467**	0.0085	6.10E-06	**0.00124**	0.0007	1.80E-06	**0.0064**	0.0029	6.00E-06	**0.0076**	0.0031	2.70E-05
4	**0.068**	0.017	7.00E-06	**-0.0002**	0.0012	1.70E-05	**0.0021**	0.0015	6.80E-06	**-0.0007**	0.0022	5.90E-06
5	**0.086**	0.02	6.50E-06	**0.0006**	0.0013	1.00E-05	**0.013**	0.0057	6.30E-06	**0.0119**	0.0056	5.50E-06
Average	***0.08234***	***0.0197***		***0.000506***	***0.00104***		***0.00854***	***0.00384***		***0.00762***	***0.00384***	

Table H.15: Melhagen (EgNn-1) Artifact 3 Cat #7205 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**7.8**	1.4	0.0015	**0.149**	0.023	4.40E-05	**0.114**	0.022	5.60E-05	**0.103**	0.017	1.30E-05
2	**12.4**	2.5	0.0022	**0.248**	0.034	5.10E-05	**0.182**	0.025	4.60E-05	**0.197**	0.02	2.40E-05
3	**7.82**	0.95	0.0017	**0.304**	0.03	4.60E-05	**0.22**	0.024	4.80E-06	**0.243**	0.025	2.30E-05
4	**11.6**	2.1	0.0019	**0.252**	0.028	6.60E-05	**0.193**	0.027	4.70E-05	**0.187**	0.022	1.20E-05
5	**10.4**	2	0.0019	**0.7**	0.19	3.30E-05	**0.62**	0.18	5.10E-05	**0.57**	0.16	2.30E-05
Average	***10.004***	***1.79***		***0.3306***	***0.061***		***0.2658***	***0.0556***		***0.26***	***0.0488***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.0032**	0.0042	1.30E-05	**0**	1	1.80E-06	**3.42**	0.14	1.30E-06
2	**0.0089**	0.0024	4.30E-05	**0.7**	1.1	9.00E-06	**2.42**	0.15	1.20E-06
3	**0.007**	0.0021	4.30E-05	**0**	1	1.50E-06	**2.5**	0.16	1.10E-06
4	**0.0076**	0.0037	3.30E-05	**0.11**	0.2	1.70E-06	**3.01**	0.21	1.20E-06
5	**0.0124**	0.0048	1.90E-05	**2.6**	2.6	1.60E-06	**2.72**	0.18	1.20E-06
Average	***0.00782***	***0.00344***		***0.682***	***1.18***		***2.814***	***0.168***	

Table H.16: Crane (DiMv-93) Artifact 1 Cat #8584

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**239**	21	0.013	**150**	52	0.008	**501**	52	0.0092	**464890**	530	
2	**390**	110	0.056	**730**	710	0.034	**1240**	570	0.038	**462800**	2700	
3	**299**	24	0.011	**105**	54	0.006	**389**	86	0.0073	**466030**	220	
4	**282**	65	0.032	**44**	25	0.02	**417**	61	0.02	**466290**	130	
5	**223**	75	0.091	**150**	110	0.061	**590**	300	0.058	**465300**	1200	
Average	*286.6*	*59*		*235.8*	*190.2*		*627.4*	*213.8*		*465062*	*956*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**69**	15	0.017	**371**	40	0.0042	**344**	46	0.32	**3.98**	0.66	0.0026
2	**210**	160	0.062	**650**	240	0.017	**1300**	1600	1.2	**3.9**	1.5	0.011
3	**35**	18	0.013	**369**	40	0.0033	**174**	33	0.23	**5.92**	0.89	0.0021
4	**28**	23	0.034	**321**	67	0.01	**257**	72	0.63	**7.4**	3.2	0.0064
5	**35**	16	0.1	**273**	77	0.028	**520**	400	1.6	**5.7**	2.6	0.018
Average	*75.4*	*46.4*		*396.8*	*92.8*		*519*	*430.2*		*5.38*	*1.77*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**1.36**	0.72	0.0057	**6.5**	1.4	0.00015	**65**	97	0.0057	**3.4**	2.6	0.005
2	**30**	53	0.027	**0.91**	0.53	0.00074	**-1**	11	0.023	**9**	12	0.021
3	**2.5**	1.4	0.0042	**0.68**	0.31	0.00012	**0.4**	2	0.0044	**3.3**	3.2	0.0042
4	**9.1**	3.8	0.014	**0.45**	0.14	0.00032	**3**	12	0.013	**-0.2**	1	0.013
5	**6.8**	5.1	0.043	**0.5**	0.25	0.0008	**10**	16	0.038	**7.1**	9.7	0.034
Average	*9.952*	*12.804*		*1.808*	*0.526*		*15.48*	*27.6*		*4.52*	*5.7*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**3.48**	0.6	0.00072	**1000**	400	0.035	**0.23**	0.09	0.00019	**6**	2.2	0.002
2	**4.4**	3	0.0026	**1800**	1700	0.15	**13**	24	0.00094	**13**	18	0.0077
3	**1.96**	0.4	0.00052	**400**	150	0.027	**0.131**	0.05	0.00017	**24**	34	0.0015
4	**2.05**	0.73	0.0015	**290**	200	0.087	**0.24**	0.45	0.00047	**3.17**	0.95	0.0045
5	**6**	4.7	0.0044	**910**	720	0.24	**0.37**	0.34	0.0015	**10.2**	6.6	0.013
Average	*3.578*	*1.886*		*880*	*634*		*2.7942*	*4.986*		*11.274*	*12.35*	

Table H.16: Crane (DiMv-93) Artifact 1 Cat #8584 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	13.7	3.4	0.016	108	39	0.00061	20.6	7.1	0.00022	0.251	0.038	0.00011
2	35	31	0.077	150	140	0.0027	2.4	1.3	0.00098	0.5	0.24	0.00058
3	12.4	4	0.012	52	22	0.00048	0.76	0.21	0.00015	0.26	0.04	8.40E-05
4	12	5.7	0.042	22	39	0.0012	0.63	0.24	0.00056	0.374	0.048	0.00033
5	19	11	0.12	158	88	0.0032	1.44	0.61	0.0013	0.189	0.078	0.00084
Average	18.42	11.02		98	65.6		5.166	1.892		0.3148	0.0888	
Pt #	Sr88	Int2SE	LOD	Y89	Int2SE	LOD	Zr90	Int2SE	LOD	Nb93	Int2SE	LOD
1	8.8	1.8	0.00015	0.322	0.043	7.90E-05	5.6	1.9	0.00046	0.042	0.012	5.00E-05
2	6.5	3.4	0.00068	0.39	0.34	0.00027	9.5	5	0.002	0.094	0.054	0.0003
3	1.3	0.24	0.00012	0.258	0.043	7.10E-05	4.93	0.96	0.00041	0.056	0.015	4.60E-05
4	1.48	0.33	0.00033	0.225	0.057	0.00022	5.27	0.92	0.0012	0.074	0.028	0.00014
5	1.74	0.75	0.001	0.36	0.16	0.0006	4.08	0.91	0.0037	0.096	0.059	0.00038
Average	3.964	1.304		0.311	0.1286		5.876	1.938		0.0724	0.0336	
Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	0.083	0.026	3.20E-05	0.129	0.04	0.0001	0.124	0.042	0.00027	0.49	0.23	0.0003
2	0.45	0.7	0.00036	0.4	0.51	0.00047	0.21	0.15	0.0013	0.22	0.27	0.0024
3	0.065	0.033	3.90E-05	0.109	0.064	9.30E-05	0.091	0.041	0.00023	0.3	0.21	0.00027
4	0.32	0.55	0.00021	0.023	0.02	0.00027	0.121	0.084	0.00068	0.39	0.35	0.0011
5	0.1	0.12	0.00092	0.1	0.15	0.00058	0	0.18	0.0016	0.29	0.32	0.0017
Average	0.2036	0.2858		0.1522	0.1568		0.1092	0.0994		0.338	0.276	
Pt #	Cd114	Int2SE	LOD	Sn122	Int2SE	LOD	Cs133	Int2SE	LOD	Ba137	Int2SE	LOD
1	0.69	0.21	0.00013	0.131	0.057	0.00029	0.004	0.0042	7.90E-05	340	120	4.00E-05
2	0.43	0.55	0.0011	0.48	0.53	0.0024	-0.007	0.032	0.00035	32	31	0.00045
3	0.38	0.17	8.80E-05	0.06	0.044	0.00034	-0.0017	0.0023	6.30E-05	9.5	2.6	4.90E-05
4	0.41	0.44	0.00061	0.09	0.13	0.0012	-0.003	0.0067	0.00018	5.2	2.5	0.00025
5	0.33	0.24	0.0013	0.14	0.31	0.0027	0.029	0.028	0.0004	13.7	5.4	0.0017
Average	0.448	0.322		0.1802	0.2142		0.00426	0.01464		80.08	32.3	

Table H.16: Crane (DiMv-93) Artifact 1 Cat #8584 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.23**	0.028	2.20E-05	**0.86**	0.12	2.30E-05	**0.116**	0.018	2.30E-05	**0.406**	0.059	0.00012
2	**0.3**	0.15	0.00016	**0.73**	0.23	0.00016	**0.8**	1.3	0.00014	**0.53**	0.32	0.00058
3	**0.231**	0.032	3.00E-05	**1.02**	0.14	2.10E-05	**0.135**	0.013	1.60E-05	**0.453**	0.086	2.50E-05
4	**0.102**	0.031	0.0001	**1.13**	0.77	6.00E-05	**0.094**	0.022	7.10E-05	**0.246**	0.073	0.00013
5	**0.207**	0.089	4.90E-05	**0.86**	0.38	0.00019	**0.089**	0.044	0.00013	**0.39**	0.18	0.00058
Average	***0.214***	***0.066***		***0.92***	***0.328***		***0.2468***	***0.2794***		***0.405***	***0.1436***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.121**	0.031	2.60E-05	**0.048**	0.011	2.70E-05	**0.097**	0.028	0.00014	**0.0163**	0.0039	4.20E-06
2	**0.25**	0.22	0.00029	**0.046**	0.061	7.60E-05	**0.32**	0.5	0.00098	**0.0034**	0.0048	0.00014
3	**0.1**	0.037	3.10E-05	**0.028**	0.0095	8.20E-06	**0.102**	0.036	0.00013	**0.0113**	0.0034	5.20E-06
4	**0.082**	0.058	0.00016	**0.022**	0.017	8.90E-05	**0.076**	0.047	0.00037	**0.006**	0.0061	2.70E-05
5	**0.097**	0.062	0.00023	**0.032**	0.029	5.90E-05	**0.114**	0.084	0.00024	**0.012**	0.0094	0.00016
Average	***0.13***	***0.0816***		***0.0352***	***0.0255***		***0.1418***	***0.139***		***0.0098***	***0.00552***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.107**	0.023	1.70E-05	**0.0204**	0.005	2.80E-05	**0.039**	0.012	5.30E-05	**0.057**	0.015	8.30E-05
2	**0.083**	0.068	0.0002	**0.07**	0.12	0.00013	**0.012**	0.017	0.00015	**0.016**	0.022	0.00024
3	**0.074**	0.019	2.10E-05	**0.0181**	0.0065	5.50E-06	**0.035**	0.011	4.80E-05	**0.051**	0.021	2.50E-05
4	**0.062**	0.031	0.00011	**0.0088**	0.0087	2.90E-05	**0.026**	0.026	8.60E-05	**0.079**	0.057	0.00013
5	**0.075**	0.059	0.00015	**0.0119**	0.0081	0.00019	**0.032**	0.025	0.00012	**0.044**	0.045	0.00018
Average	***0.0802***	***0.04***		***0.02584***	***0.02966***		***0.0288***	***0.0182***		***0.0494***	***0.032***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.094**	0.021	1.80E-05	**0.0044**	0.0039	5.20E-06	**0.032**	0.014	6.00E-05	**0.032**	0.019	5.20E-05
2	**0.14**	0.11	0.00043	**0.024**	0.047	0.00012	**0.06**	0.06	0.00036	**0.011**	0.015	0.00015
3	**0.125**	0.056	2.20E-05	**0.0007**	0.0012	2.40E-05	**0.0043**	0.0034	7.00E-05	**0.0096**	0.0065	1.60E-05
4	**0.035**	0.016	0.00012	**0.0014**	0.0028	6.90E-05	**0.015**	0.017	0.00025	**0.008**	0.012	8.30E-05
5	**0.064**	0.057	0.00016	**-6.00E-05**	2.00E-05	0.0003	**0.069**	0.089	0.00013	**0.0041**	0.0082	0.00012
Average	***0.0916***	***0.052***		***0.006088***	***0.010984***		***0.03606***	***0.03668***		***0.01294***	***0.01214***	

Table H.16: Crane (DiMv-93) Artifact 1 Cat #8584 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**4.62**	0.53	0.0015	**0.71**	0.14	9.10E-05	**0.382**	0.065	4.80E-05	**0.52**	0.11	4.20E-05
2	**24**	18	0.013	**4.2**	3.8	0.00039	**1.13**	0.84	0.00063	**1.11**	0.65	0.00015
3	**3.31**	0.65	0.0021	**0.608**	0.079	7.80E-05	**0.423**	0.056	4.40E-05	**0.48**	0.051	3.80E-05
4	**7.3**	3.7	0.0071	**0.51**	0.26	0.00023	**0.52**	0.25	0.00016	**0.41**	0.19	0.00011
5	**25.1**	9.3	0.014	**1.02**	0.67	0.00041	**3**	2.4	0.00011	**1.35**	0.65	0.00022
Average	***12.866***	***6.436***		***1.4096***	***0.9898***		***1.091***	***0.7222***		***0.774***	***0.3302***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.077**	0.026	7.50E-05	**0.33**	0.67	1.40E-05	**3.13**	0.21	2.60E-06
2	**0.1**	0.17	0.00039	**15**	31	7.90E-05	**6.8**	4	3.00E-05
3	**0.031**	0.013	5.10E-05	**-0.0042**	0.0015	3.70E-06	**2.98**	0.32	3.20E-06
4	**0.024**	0.031	0.00014	**-0.028**	0.023	2.00E-05	**3.1**	0.48	1.70E-05
5	**0.037**	0.044	0.00033	**-0.132**	0.067	2.70E-05	**3**	1.1	2.30E-05
Average	***0.0538***	***0.0568***		***3.03316***	***6.3523***		***3.802***	***1.222***	

Table H.17: Crane (DiMv-93) Artifact 2 Cat #9083

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**580**	200	0.018	**330**	240	0.013	**660**	210	0.011	**464910**	510	
3	**365**	55	0.015	**350**	200	0.0097	**485**	65	0.0089	**465080**	780	
4	**398**	59	0.0097	**185**	70	0.0061	**579**	62	0.0057	**465930**	140	
5	**353**	36	0.015	**250**	130	0.0091	**750**	110	0.011	**465440**	340	
Average	***424***	***87.5***		***278.75***	***160***		***618.5***	***111.75***		***465340***	***442.5***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**34.3**	8.9	0.012	**440**	110	0.0069	**360**	100	0.32	**4.8**	1.5	0.0037
3	**21.2**	4.5	0.0095	**405**	83	0.0057	**187**	50	0.27	**4.06**	0.95	0.0031
4	**21.4**	6	0.006	**432**	45	0.0037	**160**	61	0.18	**3.66**	0.82	0.002
5	**60**	24	0.0097	**454**	65	0.0056	**314**	80	0.35	**2.76**	0.58	0.003
Average	***34.225***	***10.85***		***432.75***	***75.75***		***255.25***	***72.75***		***3.82***	***0.9625***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**3.4**	1.9	0.011	**1.69**	0.27	0.0002	**3.2**	2.9	0.01	**1.2**	1.3	0.0096
3	**1.59**	0.87	0.0085	**0.98**	0.22	0.0002	**6.2**	6	0.0086	**3.4**	2.5	0.0077
4	**2.5**	1.2	0.0054	**1.07**	0.19	0.0001	**3.6**	2.9	0.0056	**2.8**	3.3	0.0048
5	**2.05**	0.79	0.0077	**1.24**	0.21	0.00018	**-1.5**	1.7	0.0083	**3.4**	3.1	0.0072
Average	***2.385***	***1.19***		***1.245***	***0.2225***		***2.875***	***3.375***		***2.7***	***2.55***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**3.5**	1.5	0.001	**820**	480	0.054	**0.71**	0.48	0.00024	**9**	4.8	0.0026
3	**3.7**	2.8	0.00088	**1400**	1300	0.044	**0.26**	0.19	0.00022	**12.4**	6	0.0021
4	**1.36**	0.46	0.00054	**221**	57	0.029	**0.19**	0.16	0.00013	**10**	13	0.0013
5	**2.25**	0.76	0.00082	**510**	290	0.04	**0.24**	0.16	0.0002	**9.7**	5.8	0.0021
Average	***2.7025***	***1.38***		***737.75***	***531.75***		***0.35***	***0.2475***		***10.275***	***7.4***	

Table H.17: Crane (DiMv-93) Artifact 2 Cat #9083 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**13.1**	6.6	0.022	**208**	90	0.00064	**3.13**	0.78	0.00026	**0.499**	0.085	0.00017
3	**20**	22	0.024	**226**	83	0.00054	**1.28**	0.29	0.0002	**0.422**	0.085	0.00019
4	**7.7**	2.3	0.011	**63**	41	0.00033	**1.01**	0.18	0.00016	**0.412**	0.046	9.50E-05
5	**11.8**	4.5	0.018	**70**	23	0.00062	**1.25**	0.3	0.00019	**0.457**	0.051	0.00016
Average	***13.15***	***8.85***		***141.75***	***59.25***		***1.6675***	***0.3875***		***0.4475***	***0.06675***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**3.62**	0.58	0.00017	**2.32**	0.42	0.0001	**23**	11	0.00096	**0.054**	0.026	7.80E-05
3	**2.02**	0.26	0.00015	**2.2**	0.43	9.30E-05	**14.8**	2.9	0.00086	**0.066**	0.019	8.70E-05
4	**1.75**	0.12	8.90E-05	**1.19**	0.13	5.80E-05	**15.5**	4.6	0.00053	**0.062**	0.028	4.70E-05
5	**2.37**	0.36	0.00019	**2.24**	0.49	6.50E-05	**26.9**	4.7	0.00081	**0.056**	0.018	5.70E-05
Average	***2.44***	***0.33***		***1.9875***	***0.3675***		***20.05***	***5.8***		***0.0595***	***0.02275***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.105**	0.081	0.0001	**0.088**	0.061	6.60E-05	**0.308**	0.081	0.00055	**0.3**	0.17	0.0008
3	**0.016**	0.026	9.90E-05	**0.117**	0.084	6.40E-05	**0.33**	0.15	0.00046	**0.7**	0.42	0.00057
4	**0.037**	0.031	5.50E-05	**0.07**	0.046	9.10E-05	**0.212**	0.052	0.00027	**0.22**	0.11	0.0003
5	**0.097**	0.065	8.70E-05	**0.151**	0.083	5.60E-05	**0.173**	0.046	0.00046	**0.204**	0.087	0.00088
Average	***0.06375***	***0.05075***		***0.1065***	***0.0685***		***0.25575***	***0.08225***		***0.356***	***0.19675***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.31**	0.16	0.00023	**0.083**	0.074	0.00093	**0.018**	0.019	0.00012	**32.9**	3.8	1.50E-05
3	**0.27**	0.12	0.00016	**0.25**	0.25	0.0008	**0.08**	0.12	9.30E-05	**14.5**	5.5	1.50E-05
4	**0.32**	0.22	0.00012	**0.044**	0.05	0.00045	**0.0041**	0.004	4.60E-05	**12.8**	3.2	8.20E-06
5	**0.37**	0.14	0.00029	**0.065**	0.064	0.00061	**0.009**	0.007	0.0001	**12.1**	3.2	1.30E-05
Average	***0.3175***	***0.16***		***0.1105***	***0.1095***		***0.027775***	***0.0375***		***18.075***	***3.925***	

Table H.17: Crane (DiMv-93) Artifact 2 Cat #9083 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**1.01**	0.1	1.90E-05	**3.8**	1.5	1.50E-05	**0.42**	0.074	1.50E-05	**2.01**	0.3	6.40E-05
3	**0.94**	0.18	5.30E-05	**2.92**	0.45	3.40E-05	**0.472**	0.087	4.20E-05	**1.98**	0.35	6.20E-05
4	**0.52**	0.091	1.00E-05	**1.57**	0.25	2.60E-05	**0.209**	0.029	2.00E-05	**0.94**	0.19	3.40E-05
5	**0.96**	0.24	4.10E-05	**2.19**	0.51	3.30E-05	**0.32**	0.07	3.20E-05	**1.79**	0.48	0.00014
Average	***0.8575***	***0.15275***		***2.62***	***0.6775***		***0.35525***	***0.065***		***1.68***	***0.33***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.67**	0.16	8.10E-05	**0.164**	0.034	2.20E-05	**0.88**	0.21	8.90E-05	**0.166**	0.034	5.60E-05
3	**0.59**	0.12	7.90E-05	**0.161**	0.025	2.10E-05	**0.76**	0.14	8.60E-05	**0.136**	0.034	3.10E-05
4	**0.314**	0.055	4.40E-05	**0.078**	0.014	1.20E-05	**0.404**	0.083	4.80E-05	**0.066**	0.01	7.30E-06
5	**0.84**	0.26	6.90E-05	**0.162**	0.046	1.80E-05	**0.669**	0.093	7.50E-05	**0.118**	0.032	1.20E-05
Average	***0.6035***	***0.14875***		***0.14125***	***0.02975***		***0.67825***	***0.1315***		***0.1215***	***0.0275***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.84**	0.2	5.60E-05	**0.145**	0.035	3.80E-05	**0.311**	0.065	4.40E-05	**0.334**	0.085	6.80E-05
3	**0.76**	0.14	5.40E-05	**0.129**	0.03	1.40E-05	**0.313**	0.093	4.20E-05	**0.277**	0.087	6.60E-05
4	**0.342**	0.057	3.00E-05	**0.077**	0.018	7.90E-06	**0.18**	0.026	7.50E-05	**0.162**	0.033	3.60E-05
5	**0.68**	0.15	4.80E-05	**0.113**	0.021	1.20E-05	**0.38**	0.12	3.70E-05	**0.304**	0.084	0.00015
Average	***0.6555***	***0.13675***		***0.116***	***0.026***		***0.296***	***0.076***		***0.26925***	***0.07225***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.32**	0.074	6.10E-05	**0.0015**	0.0021	1.80E-05	**0.017**	0.012	4.90E-05	**0.025**	0.019	0.00011
3	**0.45**	0.2	0.00014	**0.0129**	0.009	4.90E-05	**0.01**	0.011	4.80E-05	**0.042**	0.031	4.20E-05
4	**0.86**	0.39	3.30E-05	**0.0034**	0.003	3.50E-05	**0.013**	0.011	2.70E-05	**0.0106**	0.0094	2.30E-05
5	**0.57**	0.14	0.00013	**0.0023**	0.002	3.80E-05	**0.022**	0.014	4.20E-05	**0.0122**	0.0094	3.70E-05
Average	***0.55***	***0.201***		***0.005025***	***0.004025***		***0.0155***	***0.012***		***0.02245***	***0.0172***	

Table H.17: Crane (DiMv-93) Artifact 2 Cat #9083 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**15.5**	6.1	0.0078	**0.6**	0.24	0.00011	**0.32**	0.12	0.00014	**0.56**	0.21	7.00E-05
3	**10.2**	1.6	0.0066	**0.5**	0.082	7.50E-05	**0.32**	0.14	8.40E-05	**0.39**	0.16	4.40E-05
4	**5.87**	0.83	0.0032	**0.368**	0.087	5.70E-05	**0.235**	0.072	5.10E-05	**0.34**	0.1	2.10E-05
5	**14.7**	3.9	0.0053	**0.333**	0.098	7.20E-05	**0.173**	0.037	0.0001	**0.288**	0.063	6.70E-05
Average	***11.5675***	***3.1075***		***0.45025***	***0.12675***		***0.262***	***0.09225***		***0.3945***	***0.13325***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.092**	0.055	8.40E-05	**0.7**	1.3	1.40E-05	**6.76**	0.94	8.30E-06
3	**0.081**	0.04	5.70E-05	**4.8**	5.5	1.30E-05	**3.7**	0.53	8.10E-06
4	**0.062**	0.028	3.40E-05	**2**	2.2	2.80E-05	**3.68**	0.35	4.50E-06
5	**0.055**	0.026	0.0001	**4.3**	3.7	1.20E-05	**4.18**	0.43	7.10E-06
Average	***0.0725***	***0.03725***		***2.95***	***3.175***		***4.58***	***0.5625***	

Table H.18: Crane (DiMv-93) Artifact 3 Cat #9211

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**13170**	460	0.78	**78600**	1500	0.43	**218800**	2900	0.48	**0**	1	
4	**322**	93	18	**380**	220	11	**420**	140	10	**462600**	5700	
Average	*6746*	*276.5*		*39490*	*860*		*109610*	*1520*		*231300*	*2850.5*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**8770**	420	0.65	**59500**	1200	0.27	**98700**	5600	14	**32**	6.5	0.14
4	**160**	160	15	**346**	52	6.6	**340**	210	340	**3.33**	0.13	3.5
Average	*4465*	*290*		*29923*	*626*		*49520*	*2905*		*17.665*	*3.315*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**26400**	1300	0.32	**387.3**	8.8	0.0051	**157**	13	0.42	**143**	14	0.4
4	**0.9**	0.58	7.5	**0.92**	0.48	0.18	**2.9**	2.8	10	**4.96**	0.48	9.6
Average	*13200.45*	*650.29*		*194.11*	*4.64*		*79.95*	*7.9*		*73.98*	*7.24*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**983**	30	0.04	**117300**	3400	2.2	**36.4**	1.9	0.0077	**97.4**	4.6	0.085
4	**4.596**	0.082	1	**50000**	10000	52	**0.1**	0.11	0.24	**5.9**	3.5	2
Average	*493.798*	*15.041*		*83650*	*6700*		*18.25*	*1.005*		*51.65*	*4.05*	
Pt #	**Ni61**	**Int2SE**	**LOD**	**Cu63**	**Int2SE**	**LOD**	**Ga69**	**Int2SE**	**LOD**	**Rb85**	**Int2SE**	**LOD**
1	**70**	29	0.98	**118.6**	5.2	0.028	**386**	15	0.0087	**274.3**	8.7	0.0072
4	**5.3**	3.3	25	**140**	240	0.59	**0.73**	0.28	0.27	**0.52**	0.3	0.18
Average	*37.65*	*16.15*		*129.3*	*122.6*		*193.365*	*7.64*		*137.41*	*4.5*	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**469**	14	0.0075	**84**	17	0.0028	**1750**	540	0.027	**56.6**	7.1	0.00028
4	**3.5**	3	0.2	**0.081**	0.039	0.074	**130**	260	0.74	**0.12**	0.23	0.054
Average	*236.25*	*8.5*		*42.0405*	*8.5195*		*940*	*400*		*28.36*	*3.665*	

Table H.18: Crane (DiMv-93) Artifact 3 Cat #9211 Continued

Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	**5.7**	1.1	0.0014	**4.94**	0.73	0.0051	**0.99**	0.47	0.015	**1.86**	0.8	0.021
4	**0.8**	1.4	0.13	**0.047**	0.093	0.081	**0.205**	0.079	0.43	**0.58**	0.21	0.21
Average	***3.25***	***1.25***		***2.4935***	***0.4115***		***0.5975***	***0.2745***		***1.22***	***0.505***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**2.24**	0.67	0.0054	**5.2**	1.6	0.018	**14.7**	1	0.0033	**4010**	140	0.0019
4	**0.9**	1.5	0.086	**0.12**	0.24	0.28	**-0.0013**	0.0035	0.1	**6.18**	0.75	0.17
Average	***1.57***	***1.085***		***2.66***	***0.92***		***7.34935***	***0.50175***		***2008.09***	***70.375***	
Pt #	**La139**	**Int2SE**	**LOD**	**Ce140**	**Int2SE**	**LOD**	**Pr141**	**Int2SE**	**LOD**	**Nd146**	**Int2SE**	**LOD**
1	**79**	13	0.0014	**145**	24	0.00021	**17.8**	2.8	0.0011	**65.9**	9.9	0.00083
4	**0.052**	0.015	0.049	**0.26**	0.11	0.05	**0.02553**	0.00038	0.018	**0.17**	0.25	0.074
Average	***39.526***	***6.5075***		***72.63***	***12.055***		***8.912765***	***1.40019***		***33.035***	***5.075***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**13.7**	2.3	0.001	**3.1**	0.49	0.0016	**11.9**	1.7	0.0011	**2.05**	0.35	0.00017
4	**0.019**	0.038	0.093	**0.018**	0.035	0.025	**-5.60E-06**	1.80E-06	0.22	**0.0054**	0.002	0.034
Average	***6.8595***	***1.169***		***1.559***	***0.2625***		***5.9499972***	***0.8500009***		***1.0277***	***0.176***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**13.9**	2.3	0.00072	**2.62**	0.48	0.00019	**9.6**	2.2	0.00056	**11.4**	3.3	0.0049
4	**0.052**	0.078	0.064	**6.70E-08**	2.20E-08	0.017	**0.0244**	0.0078	0.05	**-1.53E-06**	4.90E-07	0.077
Average	***6.976***	***1.189***		***1.310000034***	***0.240000011***		***4.8122***	***1.1039***		***5.699999235***	***1.650000245***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**44**	14	0.00078	**3.3**	0.49	0.0017	**4.15**	0.86	0.00067	**3.87**	0.84	0.00059
4	**0.14**	0.15	0.069	**0.006**	0.011	0.044	**0.032**	0.039	0.13	**0.0261**	0.0083	0.053
Average	***22.07***	***7.075***		***1.653***	***0.2505***		***2.091***	***0.4495***		***1.94805***	***0.42415***	

Table H.18: Crane (DiMv-93) Artifact 3 Cat #9211 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**708**	54	0.41	**70.6**	6.4	0.0041	**65.5**	5.2	0.0038	**64.6**	3.9	0.003
4	**5.2**	3.4	11	**0.419**	0.023	0.041	**0.32**	0.13	0.17	**0.37**	0.51	0.052
Average	***356.6***	***28.7***		***35.5095***	***3.2115***		***32.91***	***2.665***		***32.485***	***2.205***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.51**	0.12	0.0033	**500**	1000	0.00018	**14.4**	2.3	0.00012
4	**0.1**	0.14	0.049	**-0.00013**	8.00E-05	0.016	**1.87**	0.29	0.011
Average	***0.305***	***0.13***		***249.999935***	***500.00004***		***8.135***	***1.295***	

Table H.19: Avery (DhLs-2) Artifact 1 Cat #M9

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**275**	25	0.014	**219**	72	0.0076	**352**	40	0.0076	**465270**	430	
2	**261**	44	0.014	**73**	41	0.0086	**276**	38	0.0078	**465640**	580	
3	**275**	13	0.012	**190**	130	0.0069	**304**	47	0.0069	**465910**	260	
4	**262**	32	0.011	**37.2**	9.5	0.0064	**223**	22	0.0055	**466460**	150	
Average	***268.25***	***28.5***		***129.8***	***63.125***		***288.75***	***36.75***		***465820***	***355***	

Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	**78**	11	0.014	**385**	49	0.0054	**285**	40	0.24	**4.38**	0.44	0.0023
2	**47**	18	0.013	**356**	63	0.0052	**303**	72	0.23	**3.93**	0.82	0.0023
3	**51**	11	0.011	**434**	64	0.0045	**202**	60	0.2	**5.67**	0.64	0.002
4	**38.1**	7.2	0.0099	**300**	32	0.0041	**250**	110	0.19	**4.68**	0.85	0.0019
Average	***53.525***	***11.8***		***368.75***	***52***		***260***	***70.5***		***4.665***	***0.6875***	

Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	**3.88**	0.94	0.0072	**4.66**	0.36	0.00016	**1.1**	1.2	0.0064	**3.4**	1.3	0.0057
2	**4.4**	3.5	0.0072	**3.69**	0.62	0.00015	**0.3**	1.3	0.006	**1.34**	0.98	0.0057
3	**1.32**	0.57	0.0057	**3.08**	0.37	0.00012	**27**	30	0.0054	**18**	12	0.0046
4	**3.9**	1.4	0.0048	**3.22**	0.33	0.00012	**-1.18**	0.53	0.005	**0.38**	0.45	0.0044
Average	***3.375***	***1.6025***		***3.6625***	***0.42***		***6.805***	***8.2575***		***5.78***	***3.6825***	

Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	**4.93**	0.91	0.00061	**830**	210	0.043	**0.147**	0.039	0.0002	**7.5**	3	0.0021
2	**2.92**	0.51	0.00056	**640**	320	0.041	**0.31**	0.33	0.00018	**6.6**	2.3	0.0019
3	**6.8**	3.2	0.00053	**730**	360	0.035	**0.134**	0.069	0.00018	**8.5**	2.9	0.0016
4	**2.95**	0.39	0.00045	**265**	49	0.036	**0.055**	0.043	0.00016	**3.8**	1.3	0.0015
Average	***4.4***	***1.2525***		***616.25***	***234.75***		***0.1615***	***0.12025***		***6.6***	***2.375***	

Table H.19: Avery (DhLs-2) Artifact 1 Cat #M9 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**15.5**	2.1	0.019	**75**	29	0.00078	**1.1**	0.13	0.00018	**0.447**	0.049	0.00014
2	**11.9**	3	0.018	**120**	120	0.00085	**1.01**	0.32	0.00015	**0.26**	0.046	0.00015
3	**13.5**	3.7	0.017	**37**	26	0.00066	**0.71**	0.1	0.00022	**0.37**	0.062	0.00012
4	**8.8**	2.3	0.014	**10**	9	0.00046	**0.96**	0.1	0.00018	**0.288**	0.051	0.0001
Average	***12.425***	***2.775***		***60.5***	***46***		***0.945***	***0.1625***		***0.34125***	***0.052***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**3.32**	0.36	0.00013	**19.3**	2.9	5.00E-05	**11**	12	0.00058	**0.0419**	0.0076	5.40E-05
2	**2.31**	0.58	0.00012	**13**	5.2	6.50E-05	**2.23**	0.96	0.00061	**0.048**	0.017	5.50E-05
3	**1.91**	0.17	0.00011	**11.5**	2.2	3.10E-05	**2.41**	0.44	0.0005	**0.063**	0.017	4.10E-05
4	**2**	0.2	0.00011	**10.1**	1.2	4.10E-05	**1.68**	0.17	0.00041	**0.067**	0.018	3.20E-05
Average	***2.385***	***0.3275***		***13.475***	***2.875***		***4.33***	***3.3925***		***0.054975***	***0.0149***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.18**	0.094	2.60E-05	**0.07**	0.032	1.70E-05	**22.5**	6.4	0.00035	**0.269**	0.075	0.00031
2	**0.024**	0.028	0.00016	**0.046**	0.026	0.00013	**21**	25	0.00033	**0.12**	0.1	0.00055
3	**0.21**	0.24	0.00015	**0.122**	0.082	3.90E-05	**0.27**	0.18	0.00032	**0.065**	0.062	0.0005
4	**0.0083**	0.0094	0.00014	**0.026**	0.016	8.80E-05	**2.5**	2.5	0.00023	**0.2**	0.15	0.00035
Average	***0.105575***	***0.09285***		***0.066***	***0.039***		***11.5675***	***8.52***		***0.1635***	***0.09675***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.46**	0.11	2.00E-05	**1.08**	0.29	0.00054	**0.0093**	0.0046	6.10E-05	**11.1**	1.3	3.40E-05
2	**0.24**	0.14	0.0002	**0.64**	0.65	0.0007	**0.0111**	0.0069	0.00011	**12.9**	4	0.00021
3	**0.21**	0.13	0.00016	**0.06**	0.12	0.00079	**0.0034**	0.0048	6.80E-05	**6.48**	0.65	7.80E-05
4	**0.167**	0.069	0.00019	**0.31**	0.26	0.00054	**0.005**	0.0042	7.00E-05	**10.8**	1.8	6.80E-05
Average	***0.26925***	***0.11225***		***0.5225***	***0.33***		***0.0072***	***0.005125***		***10.32***	***1.9375***	

Table H.19: Avery (DhLs-2) Artifact 1 Cat #M9 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	21.8	3.4	4.40E-06	37.2	5.7	2.50E-05	7.9	1.2	1.80E-05	33	5.1	0.00012
2	10.6	4.1	3.40E-05	22	6.8	2.30E-05	4.1	1.3	3.80E-05	17.6	6.6	0.00012
3	12	2.6	2.50E-05	30.5	6.9	8.70E-06	5.1	1.2	8.10E-06	19	3.9	3.50E-05
4	6.92	0.96	2.30E-05	20.6	3.5	7.60E-06	3.29	0.62	1.80E-05	12.9	2	7.80E-05
Average	*12.83*	*2.765*		*27.575*	*5.725*		*5.0975*	*1.08*		*20.625*	*4.4*	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	7	1.1	1.90E-05	1.53	0.24	2.60E-05	6.9	1.1	0.0001	0.88	0.13	2.50E-05
2	3.7	1.5	0.00012	0.88	0.35	1.20E-05	4.1	1.6	4.90E-05	0.52	0.22	7.50E-06
3	3.96	0.8	0.00011	0.79	0.15	2.90E-05	3.81	0.59	4.70E-05	0.437	0.067	2.30E-05
4	2.86	0.41	3.90E-05	0.604	0.095	2.60E-05	2.78	0.5	4.10E-05	0.38	0.056	6.30E-06
Average	*4.38*	*0.9525*		*0.951*	*0.20875*		*4.3975*	*0.9475*		*0.55425*	*0.11825*	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	4.42	0.68	6.50E-05	0.79	0.12	3.30E-06	1.94	0.29	1.00E-05	1.57	0.24	1.60E-05
2	2.7	1.1	3.10E-05	0.43	0.12	2.10E-05	1.35	0.47	6.20E-05	1.17	0.42	3.70E-05
3	2.31	0.45	3.00E-05	0.435	0.082	7.70E-06	1.08	0.17	2.30E-05	0.84	0.15	3.60E-05
4	2.08	0.25	2.60E-05	0.386	0.048	6.80E-06	1.02	0.13	2.00E-05	0.91	0.11	3.10E-05
Average	*2.8775*	*0.62*		*0.51025*	*0.0925*		*1.3475*	*0.265*		*1.1225*	*0.23*	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	0.032	0.012	1.40E-05	0.00087	0.00088	2.00E-05	0.019	0.0092	1.30E-05	0.062	0.044	1.10E-05
2	0.0106	0.0086	8.60E-05	0.0021	0.0024	2.50E-05	0.009	0.01	3.10E-05	0.009	0.0087	2.60E-05
3	0.0065	0.006	7.90E-05	-1.20E-05	3.10E-06	2.30E-05	0.027	0.021	3.00E-05	0.048	0.031	7.90E-05
4	0.023	0.013	2.80E-05	0.00049	0.00068	2.50E-05	0.0095	0.0056	2.60E-05	0.0093	0.0072	2.20E-05
Average	*0.018025*	*0.0099*		*0.000862*	*0.000990775*		*0.016125*	*0.01145*		*0.032075*	*0.022725*	

Table H.19: Avery (DhLs-2) Artifact 1 Cat #M9 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**125**	13	0.018	**5.8**	0.89	8.90E-05	**5.38**	0.68	5.00E-05	**5.28**	0.79	3.80E-05
2	**160**	32	0.016	**3.3**	1.3	7.00E-05	**3.2**	1.2	7.70E-05	**3.6**	1.7	5.50E-05
3	**75**	11	0.02	**3.15**	0.63	0.0001	**3.5**	1.2	7.10E-05	**2.99**	0.73	3.90E-05
4	**58**	6.4	0.017	**4.6**	1.5	8.10E-05	**4.4**	1.4	2.00E-05	**4.8**	1.8	4.60E-05
Average	***104.5***	***15.6***		***4.2125***	***1.08***		***4.12***	***1.12***		***4.1675***	***1.255***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.08**	0.018	7.90E-05	**-0.000323**	7.80E-05	1.60E-05	**3.37**	0.23	2.20E-06
2	**0.035**	0.015	8.90E-05	**-0.0003**	0.00014	7.70E-06	**2.55**	0.3	5.40E-06
3	**0.034**	0.02	5.80E-05	**-0.000245**	8.20E-05	7.40E-06	**2.37**	0.2	5.20E-06
4	**0.0158**	0.0091	4.60E-05	**-0.00028**	8.50E-05	6.50E-06	**2.49**	0.22	4.50E-06
Average	***0.0412***	***0.015525***		***-0.000287***	***0.00009625***		***2.695***	***0.2375***	

Table H.20: Howden (EbLi-1) Artifact 1 Cat #M402

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**365**	57	0.017	**94**	79	0.01	**351**	65	0.0084	**466090**	290	
2	**342**	35	0.0095	**57**	38	0.0055	**225**	26	0.005	**466410**	120	
3	**462**	76	0.0099	**60**	15	0.0056	**312**	36	0.0058	**466160**	240	
4	**384**	41	0.0086	**87**	24	0.0051	**263**	31	0.005	**466270**	120	
5	**291**	32	0.0078	**165**	81	0.0044	**237**	22	0.0044	**466440**	110	
Average	***368.8***	***48.2***		***92.6***	***47.4***		***277.6***	***36***		***466274***	***176***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**17.5**	7.7	0.015	**305**	41	0.0061	**233**	80	0.28	**5.08**	0.94	0.0029
2	**6.3**	1.7	0.0082	**276**	30	0.0034	**116**	26	0.15	**4.84**	0.55	0.0016
3	**8.6**	2	0.0088	**345**	46	0.0034	**142**	36	0.16	**4.51**	0.9	0.0016
4	**18**	6.2	0.0078	**280**	27	0.0029	**180**	56	0.15	**3.79**	0.51	0.0014
5	**14.9**	3.7	0.0072	**231**	26	0.0027	**127**	31	0.13	**3.29**	0.32	0.0013
Average	***13.06***	***4.26***		***287.4***	***34***		***159.6***	***45.8***		***4.302***	***0.644***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**-0.2**	1.1	0.0088	**1**	0.12	0.0002	**-2.8**	1.8	0.0078	**-0.26**	0.75	0.0072
2	**0.54**	0.4	0.0049	**1.07**	0.11	9.60E-05	**-0.87**	0.63	0.0043	**0.2**	0.26	0.0039
3	**0.29**	0.38	0.0049	**1.11**	0.11	0.0001	**-1.88**	0.55	0.0042	**0.62**	0.8	0.004
4	**0.45**	0.56	0.0037	**1.08**	0.1	6.30E-05	**-1.26**	0.61	0.0036	**0.78**	0.75	0.0034
5	**1.16**	0.53	0.0036	**1.1**	0.18	7.40E-05	**-0.62**	0.56	0.0034	**0.5**	0.46	0.0031
Average	***0.448***	***0.594***		***1.072***	***0.124***		***-1.486***	***0.83***		***0.368***	***0.604***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**1.63**	0.4	0.0007	**360**	260	0.05	**0.25**	0.14	0.00021	**25**	42	0.0025
2	**1.64**	0.4	0.00039	**410**	120	0.027	**0.102**	0.083	0.00013	**5.3**	1.4	0.0012
3	**1.88**	0.33	0.00041	**470**	320	0.025	**0.23**	0.17	0.00014	**3.31**	0.82	0.0013
4	**2.07**	0.49	0.00039	**420**	120	0.022	**0.137**	0.077	0.00013	**3.01**	0.59	0.0012
5	**1.37**	0.2	0.00033	**289**	65	0.022	**0.23**	0.12	0.00011	**2.56**	0.53	0.001
Average	***1.718***	***0.364***		***389.8***	***177***		***0.1898***	***0.118***		***7.836***	***9.068***	

Table H.20: Howden (EbLi-1) Artifact 1 Cat #M402 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	**12.4**	3.9	0.024	**23**	14	0.00057	**7.9**	1.1	0.00027	**0.255**	0.042	0.00015
2	**9.1**	1.5	0.012	**38**	28	0.00038	**5.05**	0.98	0.00014	**0.239**	0.043	9.80E-05
3	**9.8**	2	0.012	**14**	15	0.00055	**5.5**	1.7	0.00013	**0.288**	0.031	0.0001
4	**7.4**	1.2	0.011	**38**	19	0.0004	**4.92**	0.87	0.00012	**0.23**	0.034	8.70E-05
5	**5.5**	1.5	0.0094	**23.4**	8.5	0.00031	**3.32**	0.57	0.00011	**0.194**	0.028	6.70E-05
Average	*8.84*	*2.02*		*27.28*	*16.9*		*5.338*	*1.044*		*0.2412*	*0.0356*	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**7.5**	1.6	0.00016	**0.109**	0.024	0.00011	**8.2**	1.5	0.00064	**0.04**	0.015	1.20E-05
2	**4.1**	1	8.20E-05	**0.109**	0.019	6.80E-05	**5.41**	0.55	0.0004	**0.0263**	0.0066	3.20E-05
3	**3.83**	0.84	0.0001	**0.138**	0.026	5.20E-05	**7.11**	0.97	0.00038	**0.0265**	0.0065	3.80E-05
4	**4.06**	0.81	8.40E-05	**0.212**	0.051	4.20E-05	**7.2**	1.1	0.00032	**0.0336**	0.0075	1.70E-05
5	**3.14**	0.41	8.60E-05	**0.083**	0.02	3.90E-05	**7.6**	1.3	0.0003	**0.0297**	0.0071	2.80E-05
Average	*4.526*	*0.932*		*0.1302*	*0.028*		*7.104*	*1.084*		*0.03122*	*0.00854*	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
1	**0.0036**	0.0073	6.20E-05	**0.01**	0.01	0.0002	**0.31**	0.13	0.00045	**0.29**	0.18	0.00049
2	**0.0077**	0.0076	0.00013	**0.004**	0.0034	8.40E-05	**0.088**	0.021	0.00026	**0.15**	0.11	0.00023
3	**0.0081**	0.0074	0.00011	**0.032**	0.022	7.10E-05	**0.287**	0.095	0.00025	**0.15**	0.12	0.00029
4	**0.033**	0.017	3.00E-05	**0.048**	0.029	6.00E-05	**0.21**	0.18	0.00022	**0.134**	0.077	0.00021
5	**0.033**	0.021	2.50E-05	**0.017**	0.01	1.60E-05	**0.138**	0.03	0.00018	**0.061**	0.045	0.00019
Average	*0.01708*	*0.01206*		*0.0222*	*0.01488*		*0.2066*	*0.0912*		*0.157*	*0.1064*	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
1	**0.147**	0.088	0.00025	**0.025**	0.05	0.00093	**0.003**	0.01	9.40E-05	**120**	23	0.00023
2	**0.12**	0.063	0.00014	**0.051**	0.039	0.00043	**0.0029**	0.0034	4.20E-05	**70**	14	3.90E-05
3	**0.15**	0.11	0.00012	**0.054**	0.047	0.00032	**0.0064**	0.0061	6.40E-05	**69**	16	4.70E-05
4	**0.128**	0.049	2.30E-05	**0.054**	0.056	0.00039	**0.0011**	0.0036	4.70E-05	**74**	13	3.80E-05
5	**0.098**	0.031	9.10E-05	**0.046**	0.037	0.00028	**0.0038**	0.004	3.60E-05	**49**	7.5	3.10E-05
Average	*0.1286*	*0.0682*		*0.046*	*0.0458*		*0.00344*	*0.00542*		*76.4*	*14.7*	

Table H.20: Howden (EbLi-1) Artifact 1 Cat #M402 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.099**	0.025	4.50E-05	**0.356**	0.05	3.30E-05	**0.048**	0.014	8.20E-06	**0.155**	0.066	3.60E-05
2	**0.095**	0.02	5.00E-06	**0.491**	0.067	2.40E-05	**0.0588**	0.0092	4.00E-06	**0.211**	0.044	1.80E-05
3	**0.124**	0.018	4.00E-05	**0.586**	0.075	1.50E-05	**0.077**	0.013	2.10E-05	**0.227**	0.043	2.20E-05
4	**0.188**	0.037	2.30E-05	**0.89**	0.17	1.70E-05	**0.137**	0.05	1.80E-05	**0.41**	0.11	0.00011
5	**0.059**	0.012	4.00E-06	**0.266**	0.031	1.40E-05	**0.0417**	0.0087	3.20E-06	**0.105**	0.03	1.40E-05
Average	***0.113***	***0.0224***		***0.5178***	***0.0786***		***0.0725***	***0.01898***		***0.2216***	***0.0586***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.033**	0.021	0.00017	**0.047**	0.019	1.20E-05	**0.016**	0.015	4.80E-05	**0.0041**	0.0032	7.40E-06
2	**0.055**	0.02	2.20E-05	**0.0335**	0.0081	5.90E-06	**0.034**	0.012	2.40E-05	**0.0036**	0.002	3.60E-06
3	**0.059**	0.024	7.90E-05	**0.0316**	0.0093	2.10E-05	**0.052**	0.023	0.00011	**0.0057**	0.002	4.40E-06
4	**0.093**	0.038	2.20E-05	**0.0441**	0.0084	1.80E-05	**0.074**	0.024	2.30E-05	**0.0093**	0.0042	3.60E-06
5	**0.0195**	0.0096	1.80E-05	**0.0188**	0.0084	4.80E-06	**0.0239**	0.0088	1.90E-05	**0.0045**	0.0023	2.90E-06
Average	***0.0519***	***0.02252***		***0.035***	***0.01064***		***0.03998***	***0.01656***		***0.00544***	***0.00274***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.032**	0.02	3.00E-05	**0.0102**	0.006	7.80E-06	**0.035**	0.015	0.0001	**0.0097**	0.0083	3.60E-05
2	**0.0308**	0.0089	1.50E-05	**0.007**	0.0023	3.90E-06	**0.0119**	0.0056	3.80E-05	**0.013**	0.0072	5.90E-05
3	**0.039**	0.014	5.30E-05	**0.0102**	0.0042	1.40E-05	**0.02**	0.0098	1.40E-05	**0.031**	0.012	2.20E-05
4	**0.063**	0.028	4.50E-05	**0.0156**	0.0044	3.80E-06	**0.043**	0.016	1.10E-05	**0.033**	0.013	1.80E-05
5	**0.023**	0.013	1.20E-05	**0.0052**	0.0027	1.00E-05	**0.0099**	0.0057	9.20E-06	**0.023**	0.013	1.40E-05
Average	***0.03756***	***0.01678***		***0.00964***	***0.00392***		***0.02396***	***0.01042***		***0.02194***	***0.0107***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.165**	0.044	3.20E-05	**0.00018**	0.00042	4.90E-05	**0.0094**	0.0092	3.00E-05	**0.013**	0.014	2.60E-05
2	**0.124**	0.032	1.60E-05	**0.0021**	0.0014	1.90E-05	**0.003**	0.0034	4.80E-05	**0.0021**	0.0029	1.30E-05
3	**0.146**	0.024	1.90E-05	**0.002**	0.0021	2.00E-05	**0.0064**	0.0056	5.30E-05	**0.002**	0.0025	1.50E-05
4	**0.122**	0.036	1.50E-05	**0.0018**	0.0013	1.40E-05	**0.0126**	0.0085	1.50E-05	**0.016**	0.016	7.10E-05
5	**0.108**	0.022	1.30E-05	**0.00129**	0.00091	1.20E-05	**0.0081**	0.005	1.20E-05	**0.0009**	0.0015	1.00E-05
Average	***0.133***	***0.0316***		***0.001474***	***0.001226***		***0.0079***	***0.00634***		***0.0068***	***0.00738***	

Table H.20: Howden (EbLi-1) Artifact 1 Cat #M402 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**9.9**	3.8	0.033	**0.71**	0.21	0.0001	**0.42**	0.11	8.90E-05	**0.6**	0.18	4.90E-05
2	**5.6**	1.2	0.011	**0.54**	0.12	5.20E-05	**0.412**	0.084	3.80E-05	**0.426**	0.09	3.00E-05
3	**7.1**	1.4	0.01	**0.47**	0.12	7.30E-05	**0.37**	0.16	4.10E-05	**0.46**	0.19	2.90E-05
4	**7.4**	1.4	0.0097	**0.54**	0.12	4.00E-05	**0.39**	0.13	1.10E-05	**0.5**	0.13	2.70E-05
5	**5.92**	0.86	0.0076	**0.52**	0.13	2.70E-05	**0.333**	0.057	3.00E-05	**0.46**	0.12	1.70E-05
Average	***7.184***	***1.732***		***0.556***	***0.14***		***0.385***	***0.1082***		***0.4892***	***0.142***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.03**	0.014	6.80E-05	**-0.0052**	0.0036	7.50E-06	**5.85**	0.84	5.20E-06
2	**0.05**	0.019	2.70E-05	**-0.00104**	0.0003	1.20E-05	**7.17**	0.48	2.60E-06
3	**0.074**	0.042	7.00E-05	**-0.00136**	0.00061	4.50E-06	**5.9**	0.51	3.10E-06
4	**0.035**	0.011	3.70E-05	**1.7**	2.3	3.60E-06	**6.01**	0.43	2.50E-06
5	**0.058**	0.031	2.90E-05	**-0.00118**	0.00043	3.00E-06	**4.72**	0.27	2.10E-06
Average	***0.0494***	***0.0234***		***0.338244***	***0.460988***		***5.93***	***0.506***	

Table H.21: Howden (EbLi-1) Artifact 2 Cat #M405

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
2	**139**	20	0.013	**135**	42	0.0079	**93**	10	0.0065	**466270**	190	
3	**171.9**	8.5	0.0056	**139**	24	0.0034	**187**	12	0.0029	**466506**	72	
4	**142**	19	0.012	**159**	53	0.0073	**132**	12	0.0058	**466500**	110	
5	**169**	17	0.011	**151**	30	0.0062	**282**	53	0.0052	**465980**	210	
Average	*155.475*	*16.125*		*146*	*37.25*		*173.5*	*21.75*		*466314*	*145.5*	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
2	**43.6**	5.8	0.011	**112.4**	8.9	0.0044	**315**	61	0.21	**3.29**	0.34	0.0022
3	**20.1**	2	0.0049	**173.2**	6.4	0.0019	**207**	17	0.088	**3.26**	0.32	0.00096
4	**25.9**	3.7	0.01	**118.9**	9.1	0.004	**196**	30	0.19	**1.96**	0.41	0.002
5	**26.4**	2.7	0.009	**170**	8.1	0.0036	**225**	21	0.16	**2.76**	0.39	0.0018
Average	*29*	*3.55*		*143.625*	*8.125*		*235.75*	*32.25*		*2.8175*	*0.365*	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
2	**10.9**	3.4	0.0062	**0.728**	0.074	0.00011	**-2.39**	0.91	0.0056	**2.1**	3.1	0.005
3	**6.5**	1	0.0028	**1.03**	0.3	3.40E-05	**1.58**	0.68	0.0025	**1.95**	0.76	0.0022
4	**1.54**	0.57	0.0045	**0.352**	0.077	9.50E-05	**-2.3**	1.5	0.0052	**0.19**	0.65	0.0045
5	**33**	16	0.0049	**1.118**	0.077	8.20E-05	**10.2**	7.3	0.0049	**8.7**	4.1	0.0043
Average	*12.985*	*5.2425*		*0.807*	*0.132*		*1.7725*	*2.5975*		*3.235*	*2.1525*	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
2	**1.7**	0.24	0.00051	**630**	130	0.034	**0.6**	0.15	0.00017	**3.68**	0.71	0.0017
3	**1.19**	0.12	0.00024	**385**	62	0.014	**0.27**	0.026	6.80E-05	**2.72**	0.34	0.00072
4	**1.44**	0.27	0.00052	**470**	110	0.031	**0.309**	0.05	0.00018	**2.59**	0.73	0.0016
5	**2.46**	0.84	0.00042	**590**	120	0.028	**0.36**	0.11	0.00015	**7.9**	3.9	0.0015
Average	*1.6975*	*0.3675*		*518.75*	*105.5*		*0.38475*	*0.084*		*4.2225*	*1.42*	

Table H.21: Howden (EbLi-1) Artifact 2 Cat #M405 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
2	**8.3**	1.2	0.017	**26**	8	0.00047	**7.48**	0.32	0.00012	**0.105**	0.021	0.0001
3	**6.62**	0.88	0.0069	**30**	13	0.00019	**1.64**	0.18	6.10E-05	**0.229**	0.014	5.30E-05
4	**9.4**	2.6	0.014	**39**	15	0.00042	**1.82**	0.13	0.00019	**0.135**	0.016	0.0001
5	**7.9**	1.9	0.011	**42**	17	0.0004	**15.4**	1.5	0.00015	**0.196**	0.018	0.00011
Average	***8.055***	***1.645***		***34.25***	***13.25***		***6.585***	***0.5325***		***0.16625***	***0.01725***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
2	**7.44**	0.36	0.00011	**0.76**	0.14	4.10E-05	**2.5**	3.4	0.00051	**0.034**	0.012	2.80E-05
3	**2.72**	0.15	5.30E-05	**0.268**	0.021	1.90E-05	**0.81**	0.19	0.00022	**0.0386**	0.0051	1.30E-05
4	**1.91**	0.11	0.0001	**0.211**	0.031	5.50E-05	**22**	15	0.00049	**0.034**	0.013	4.10E-05
5	**9.59**	0.79	8.80E-05	**1.46**	0.3	4.10E-05	**11.1**	6	0.00044	**0.058**	0.032	2.30E-05
Average	***5.415***	***0.3525***		***0.67475***	***0.123***		***9.1025***	***6.1475***		***0.04115***	***0.015525***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
2	**0.072**	0.026	2.20E-05	**0.062**	0.021	1.50E-05	**0.32**	0.18	0.0003	**0.171**	0.048	0.0004
3	**0.049**	0.012	5.10E-05	**0.058**	0.012	6.30E-06	**0.144**	0.07	0.00013	**0.107**	0.03	0.00015
4	**0.039**	0.018	2.70E-05	**0.047**	0.018	7.20E-05	**0.141**	0.037	0.00028	**0.133**	0.047	0.00042
5	**0.069**	0.031	9.40E-05	**0.112**	0.074	1.20E-05	**0.079**	0.025	0.00026	**0.143**	0.043	0.00036
Average	***0.05725***	***0.02175***		***0.06975***	***0.03125***		***0.171***	***0.078***		***0.1385***	***0.042***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
2	**0.208**	0.058	1.70E-05	**0.138**	0.057	0.00051	**-0.0007**	0.0029	6.50E-05	**124**	6.1	2.80E-05
3	**0.075**	0.016	6.10E-05	**0.124**	0.037	0.00012	**0.0005**	0.0012	3.00E-05	**22.3**	1.6	6.30E-05
4	**0.21**	0.061	0.00011	**0.048**	0.038	0.00065	**-0.0008**	0.0045	5.40E-05	**26**	1.7	3.30E-05
5	**0.175**	0.04	1.40E-05	**0.179**	0.065	0.00039	**0.0037**	0.0043	4.60E-05	**251**	23	0.00012
Average	***0.167***	***0.04375***		***0.12225***	***0.04925***		***0.000675***	***0.003225***		***105.825***	***8.1***	

Table H.21: Howden (EbLi-1) Artifact 2 Cat #M405 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
2	**0.444**	0.069	1.80E-05	**0.86**	0.12	2.50E-05	**0.129**	0.025	1.50E-05	**0.504**	0.094	6.50E-05
3	**0.0623**	0.008	1.60E-06	**0.159**	0.027	7.00E-06	**0.0165**	0.0033	1.30E-06	**0.065**	0.012	2.90E-05
4	**0.062**	0.011	4.30E-06	**0.102**	0.025	3.70E-06	**0.0123**	0.0042	1.40E-05	**0.034**	0.014	1.50E-05
5	**1.09**	0.28	2.70E-05	**1.59**	0.32	1.70E-05	**0.254**	0.053	2.40E-06	**1.13**	0.31	5.40E-05
Average	***0.414575***	***0.092***		***0.67775***	***0.123***		***0.10295***	***0.021375***		***0.43325***	***0.1075***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
2	**0.079**	0.017	1.60E-05	**0.0452**	0.0076	4.40E-06	**0.155**	0.035	0.00017	**0.0184**	0.0045	1.80E-05
3	**0.0159**	0.0057	7.10E-06	**0.0081**	0.0022	1.90E-06	**0.0188**	0.0065	5.20E-05	**0.004**	0.0012	1.10E-06
4	**0.0057**	0.0048	1.90E-05	**0.0059**	0.0027	5.20E-06	**0.011**	0.0078	2.10E-05	**0.003**	0.0014	1.30E-05
5	**0.251**	0.067	1.40E-05	**0.089**	0.019	3.70E-06	**0.307**	0.087	1.50E-05	**0.0334**	0.0083	2.20E-06
Average	***0.0879***	***0.023625***		***0.03705***	***0.007875***		***0.12295***	***0.034075***		***0.0147***	***0.00385***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
2	**0.108**	0.019	1.10E-05	**0.0205**	0.0045	2.80E-06	**0.057**	0.012	8.30E-06	**0.086**	0.025	1.30E-05
3	**0.0311**	0.0059	4.70E-06	**0.0058**	0.0014	6.30E-06	**0.0315**	0.0067	3.60E-06	**0.053**	0.011	5.60E-06
4	**0.0198**	0.0084	1.30E-05	**0.0048**	0.002	3.30E-06	**0.0175**	0.0079	9.90E-06	**0.078**	0.028	1.50E-05
5	**0.198**	0.047	9.10E-06	**0.0429**	0.009	2.30E-06	**0.124**	0.029	7.00E-06	**0.138**	0.031	1.10E-05
Average	***0.089225***	***0.020075***		***0.0185***	***0.004225***		***0.0575***	***0.0139***		***0.08875***	***0.02375***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
2	**0.1**	0.15	1.10E-05	**0.00078**	0.00057	2.20E-05	**0.0196**	0.0094	1.10E-05	**0.0246**	0.0084	9.30E-06
3	**0.026**	0.016	4.90E-06	**0.00156**	0.00068	1.50E-05	**0.035**	0.012	4.70E-06	**0.026**	0.0093	4.00E-06
4	**0.47**	0.3	1.30E-05	**0.0037**	0.0024	1.60E-05	**0.0044**	0.0038	1.30E-05	**0.0078**	0.0042	1.10E-05
5	**0.32**	0.2	9.50E-06	**0.0039**	0.0014	2.70E-06	**0.078**	0.017	4.50E-05	**0.071**	0.013	7.80E-06
Average	***0.229***	***0.1665***		***0.002485***	***0.0012625***		***0.03425***	***0.01055***		***0.03235***	***0.008725***	

Table H.21: Howden (EbLi-1) Artifact 2 Cat #M405 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
2	**10.4**	1.4	0.011	**3.08**	0.53	3.80E-05	**3.07**	0.58	5.60E-05	**3.07**	0.57	3.90E-05
3	**7.28**	0.58	0.0047	**3.23**	0.26	2.30E-05	**3.31**	0.38	3.70E-06	**3.15**	0.31	1.30E-05
4	**8.3**	1.5	0.012	**0.358**	0.077	9.10E-06	**0.299**	0.085	5.60E-05	**0.41**	0.15	2.80E-05
5	**12.8**	1.4	0.011	**0.905**	0.092	3.20E-05	**0.772**	0.082	3.50E-05	**0.845**	0.098	2.70E-05
Average	***9.695***	***1.22***		***1.89325***	***0.23975***		***1.86275***	***0.28175***		***1.86875***	***0.282***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
2	**0.0276**	0.0074	2.90E-05	**-0.00275**	0.00072	2.70E-06	**1.624**	0.092	1.90E-06
3	**0.069**	0.02	1.60E-05	**-0.00058**	0.00011	1.20E-06	**1.143**	0.036	8.20E-07
4	**0.051**	0.024	3.90E-05	**-0.0052**	0.0023	3.20E-06	**1.61**	0.13	2.20E-06
5	**0.046**	0.012	2.30E-05	**0.17**	0.25	1.10E-05	**0.723**	0.041	1.60E-06
Average	***0.0484***	***0.01585***		***0.0403675***	***0.0632825***		***1.275***	***0.07475***	

Table H.22: Richards Kill (DhLw-2) Artifact 1 Cat #M71

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
2	165	17	0.0094	74	28	0.0062	385	47	0.0071	466340	110	
3	84	11	0.011	45	21	0.0074	253	31	0.0079	466857	51	
4	184	25	0.01	101	34	0.0065	536	52	0.0074	465840	260	
5	124	13	0.011	93	37	0.0074	330	28	0.008	466280	240	
Average	139.25	16.5		78.25	30		376	39.5		466329.25	165.25	
Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
2	28.8	6	0.0064	186	14	0.0037	167	30	0.21	3.59	0.44	0.0018
3	20.9	2.7	0.007	114.7	8.1	0.0041	111	21	0.22	2.94	0.41	0.002
4	26.7	2.9	0.0069	263	38	0.0038	284	76	0.22	3.53	0.46	0.0019
5	22	2.5	0.0078	165	13	0.0043	169	25	0.23	3	0.34	0.0022
Average	24.6	3.525		182.175	18.275		182.75	38		3.265	0.4125	
Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
2	1.53	0.93	0.0061	0.801	0.085	0.00012	-1.7	1.8	0.0053	0.37	0.71	0.0049
3	1.71	0.48	0.0071	0.602	0.05	0.00012	-3.05	0.94	0.0059	0.34	0.54	0.0052
4	0.3	1.2	0.0051	0.721	0.068	0.00011	-2.2	2.8	0.0055	1.6	1.2	0.0049
5	2.23	0.74	0.0062	0.781	0.057	0.0001	-2.7	1.3	0.0063	1.4	1.1	0.0057
Average	1.4425	0.8375		0.72625	0.065		-2.4125	1.71		0.9275	0.8875	
Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
2	1.4	0.17	0.00052	270	79	0.026	0.06	0.036	0.00017	2.56	0.73	0.0015
3	0.66	0.11	0.00059	79	20	0.029	0.041	0.019	0.00014	1.7	0.57	0.0016
4	1.42	0.35	0.00057	540	260	0.025	0.25	0.33	0.00013	10	8.7	0.0015
5	1.42	0.36	0.0007	670	390	0.033	0.097	0.051	0.00018	3.8	1.5	0.0017
Average	1.225	0.2475		389.75	187.25		0.112	0.109		4.515	2.875	

Table H.22: Richards Kill (DhLw-2) Artifact 1 Cat #M71 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
2	**11**	2.4	0.013	**69**	23	0.0005	**6.2**	0.48	0.00014	**0.236**	0.034	0.00011
3	**7.7**	1.8	0.014	**33**	12	0.00052	**2.17**	0.13	0.00017	**0.136**	0.016	0.00012
4	**15.4**	3.7	0.012	**33**	12	0.00046	**4.02**	0.4	0.00012	**0.296**	0.047	9.60E-05
5	**7.9**	2.2	0.013	**33**	10	0.00038	**2.08**	0.18	0.00014	**0.189**	0.024	0.00013
Average	***10.5***	***2.525***		***42***	***14.25***		***3.6175***	***0.2975***		***0.21425***	***0.03025***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
2	**5.56**	0.48	9.80E-05	**0.526**	0.092	6.40E-05	**3.45**	0.5	0.00058	**0.04**	0.012	3.40E-05
3	**2.14**	0.11	0.0001	**0.49**	0.093	5.90E-05	**4.5**	3.7	0.00058	**0.0225**	0.0069	4.30E-05
4	**3.89**	0.3	0.00011	**0.299**	0.047	6.70E-05	**21**	16	0.00055	**0.026**	0.01	3.50E-05
5	**1.98**	0.15	0.00013	**0.419**	0.071	5.30E-05	**16**	11	0.00056	**0.0277**	0.0078	6.60E-05
Average	***3.3925***	***0.26***		***0.4335***	***0.07575***		***11.2375***	***7.8***		***0.02905***	***0.009175***	
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
2	**0.029**	0.015	2.00E-05	**0.033**	0.013	1.30E-05	**0.594**	0.073	0.00034	**0.121**	0.079	0.00047
3	**0.022**	0.012	0.00015	**0.0134**	0.0069	1.40E-05	**0.161**	0.042	0.00034	**0.066**	0.043	0.00047
4	**0.043**	0.025	0.00014	**0.08**	0.057	6.90E-05	**0.478**	0.081	0.00026	**0.139**	0.09	0.00034
5	**0.036**	0.019	2.40E-05	**0.038**	0.02	1.60E-05	**0.265**	0.035	0.00032	**0.095**	0.054	0.00046
Average	***0.0325***	***0.01775***		***0.0411***	***0.024225***		***0.3745***	***0.05775***		***0.10525***	***0.0665***	
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
2	**0.159**	0.062	0.00019	**0.061**	0.054	0.00046	**0.0031**	0.0044	5.30E-05	**75.2**	5.7	2.90E-06
3	**0.096**	0.047	0.00019	**0.054**	0.042	0.00051	**0.0016**	0.0044	8.60E-05	**26.2**	1.8	3.30E-06
4	**0.101**	0.043	7.70E-05	**0.057**	0.069	0.00052	**0.0064**	0.0077	6.30E-05	**46.6**	4.8	2.80E-06
5	**0.103**	0.05	0.00023	**0.04**	0.052	0.00078	**0.0026**	0.0046	7.20E-05	**21.2**	1.5	3.50E-06
Average	***0.11475***	***0.0505***		***0.053***	***0.05425***		***0.003425***	***0.005275***		***42.3***	***3.45***	

Table H.22: Richards Kill (DhLw-2) Artifact 1 Cat #M71 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
2	**0.281**	0.042	3.50E-05	**0.82**	0.1	1.50E-05	**0.107**	0.018	2.00E-05	**0.413**	0.075	8.60E-05
3	**0.307**	0.061	4.30E-05	**0.63**	0.11	3.30E-06	**0.096**	0.025	2.20E-05	**0.442**	0.099	9.60E-05
4	**0.205**	0.028	2.00E-05	**0.502**	0.048	2.80E-06	**0.078**	0.015	2.10E-05	**0.286**	0.039	1.20E-05
5	**0.218**	0.03	3.60E-05	**0.67**	0.089	3.60E-06	**0.092**	0.02	3.50E-06	**0.342**	0.061	1.50E-05
Average	***0.25275***	***0.04025***		***0.6555***	***0.08675***		***0.09325***	***0.0195***		***0.37075***	***0.0685***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
2	**0.129**	0.034	1.60E-05	**0.043**	0.011	2.90E-05	**0.132**	0.041	1.70E-05	**0.0234**	0.0076	1.90E-05
3	**0.11**	0.03	1.80E-05	**0.0366**	0.0092	4.70E-06	**0.188**	0.054	0.00013	**0.0224**	0.0064	1.50E-05
4	**0.082**	0.026	8.50E-05	**0.0201**	0.0067	4.00E-06	**0.074**	0.023	9.40E-05	**0.0112**	0.0036	1.40E-05
5	**0.118**	0.037	9.80E-05	**0.028**	0.01	5.10E-06	**0.122**	0.037	2.10E-05	**0.0159**	0.0055	1.60E-05
Average	***0.10975***	***0.03175***		***0.031925***	***0.009225***		***0.129***	***0.03875***		***0.018225***	***0.005775***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
2	**0.109**	0.034	1.10E-05	**0.0212**	0.0066	2.80E-06	**0.048**	0.018	8.50E-06	**0.041**	0.017	7.00E-05
3	**0.161**	0.048	1.20E-05	**0.0275**	0.0094	2.20E-05	**0.061**	0.021	5.00E-05	**0.049**	0.017	1.50E-05
4	**0.06**	0.021	1.10E-05	**0.0104**	0.0027	2.80E-06	**0.0192**	0.0076	8.20E-06	**0.051**	0.021	1.30E-05
5	**0.117**	0.031	1.30E-05	**0.0207**	0.0055	3.50E-06	**0.037**	0.011	1.00E-05	**0.055**	0.028	1.60E-05
Average	***0.11175***	***0.0335***		***0.01995***	***0.00605***		***0.0413***	***0.0144***		***0.049***	***0.02075***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
2	**0.114**	0.032	1.20E-05	**0.00113**	0.00084	1.80E-05	**0.0019**	0.0014	9.40E-06	**0.005**	0.0026	8.20E-06
3	**0.073**	0.041	1.30E-05	**0.002**	0.0014	2.00E-05	**0.0051**	0.0047	1.10E-05	**0.009**	0.0074	4.80E-05
4	**0.34**	0.16	1.10E-05	**0.0047**	0.0028	1.90E-05	**0.02**	0.017	9.10E-06	**0.021**	0.014	8.00E-06
5	**0.092**	0.025	1.40E-05	**0.00043**	0.0005	2.80E-05	**0.0092**	0.0047	1.20E-05	**0.016**	0.01	1.00E-05
Average	***0.15475***	***0.0645***		***0.002065***	***0.001385***		***0.00905***	***0.00695***		***0.01275***	***0.0085***	

Table H.22: Richards Kill (DhLw-2) Artifact 1 Cat #M71 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
2	**17.1**	2.3	0.0031	**7.48**	0.46	4.50E-05	**6.94**	0.46	3.80E-05	**7.08**	0.48	4.20E-05
3	**11.6**	1.3	0.0029	**2.36**	0.27	6.80E-05	**2.2**	0.28	5.60E-05	**2.3**	0.23	6.40E-05
4	**15.3**	3.3	0.0035	**4.85**	0.43	6.30E-05	**4.54**	0.53	3.90E-05	**4.75**	0.5	3.00E-05
5	**12**	1.9	0.0042	**2.78**	0.18	5.30E-05	**2.49**	0.2	8.70E-06	**2.64**	0.16	4.70E-05
Average	***14***	***2.2***		***4.3675***	***0.335***		***4.0425***	***0.3675***		***4.1925***	***0.3425***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
2	**0.035**	0.012	6.40E-05	**0.035**	0.077	2.70E-06	**3.83**	0.3	8.40E-06
3	**0.0126**	0.0061	7.50E-05	**1**	1	3.00E-06	**3.46**	0.25	1.80E-06
4	**0.038**	0.012	4.40E-05	**-0.0047**	0.0024	2.60E-06	**4.13**	0.41	1.50E-06
5	**0.068**	0.019	4.80E-05	**0.23**	0.26	3.30E-06	**3.4**	0.3	2.00E-06
Average	***0.0384***	***0.012275***		***0.315075***	***0.33485***		***3.705***	***0.315***	

Table H.23: Richards Kill (DhLw-2) Artifact 2 Cat #M122

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	75	8.2	0.0084	65	28	0.0051	101	21	0.0059	466900	130	
2	46.8	5.4	0.013	17	6.8	0.0081	150	16	0.0089	467027	59	
3	78	21	0.02	36	37	0.012	286	90	0.013	466720	200	
4	71	12	0.0097	64	27	0.0068	236	39	0.0065	466720	180	
5	185	23	0.01	34	18	0.0069	143	22	0.0067	466790	110	
Average	*91.16*	*13.92*		*43.2*	*23.36*		*183.2*	*37.6*		*466831.4*	*135.8*	
Pt #	P31	Int2SE	LOD	K39	Int2SE	LOD	Ca43	Int2SE	LOD	Sc45	Int2SE	LOD
1	24.2	3.4	0.0057	67.8	9.3	0.003	88	28	0.17	1.72	0.22	0.0016
2	19.9	2.3	0.0086	69.7	4.6	0.0049	79	22	0.28	1.32	0.3	0.0025
3	30	17	0.013	114	30	0.0072	105	34	0.4	2.09	0.45	0.0038
4	20.8	5.3	0.0061	101	9.4	0.0036	112	26	0.19	2.05	0.38	0.0019
5	16.9	2.3	0.0065	124.8	7.9	0.0038	96	30	0.18	2.06	0.35	0.002
Average	*22.36*	*6.06*		*95.46*	*12.24*		*96*	*28*		*1.848*	*0.34*	
Pt #	Ti49	Int2SE	LOD	V51	Int2SE	LOD	Cr52	Int2SE	LOD	Cr53	Int2SE	LOD
1	2.7	2.6	0.0042	0.599	0.044	7.20E-05	5.2	7.5	0.0045	4.5	3.4	0.0039
2	1.08	0.58	0.0074	0.485	0.056	0.00015	-1.1	3.1	0.0074	-0.02	0.62	0.0066
3	4.4	2	0.011	0.7	0.14	0.00018	-5.3	2.1	0.011	0.3	1.1	0.0098
4	6.1	4	0.0048	0.316	0.043	8.80E-05	-1.4	1.9	0.0055	2.1	1.4	0.0048
5	1.26	0.49	0.0051	0.598	0.051	8.00E-05	3.9	9.1	0.0059	4	2.9	0.0053
Average	*3.108*	*1.934*		*0.5396*	*0.0668*		*0.26*	*4.74*		*2.176*	*1.884*	
Pt #	Mn55	Int2SE	LOD	Fe57	Int2SE	LOD	Co59	Int2SE	LOD	Ni60	Int2SE	LOD
1	0.41	0.14	0.00049	210	64	0.022	0.093	0.053	0.00013	1.9	1	0.001
2	0.43	0.18	0.00075	171	75	0.038	0.028	0.021	0.00016	0.82	0.34	0.0017
3	0.38	0.2	0.0011	87	27	0.055	0.035	0.031	0.00027	30	28	0.0026
4	0.82	0.31	0.00053	250	150	0.027	0.074	0.055	0.00012	1.61	0.72	0.0012
5	0.9	0.43	0.00055	199	64	0.03	0.036	0.03	0.00017	10.4	9.4	0.0013
Average	*0.588*	*0.252*		*183.4*	*76*		*0.0532*	*0.038*		*8.946*	*7.892*	

Table H.23: Richards Kill (DhLw-2) Artifact 2 Cat #M122 Continued

Pt #	Ni61	Int2SE	LOD	Cu63	Int2SE	LOD	Ga69	Int2SE	LOD	Rb85	Int2SE	LOD
1	7.4	2.8	0.011	25	12	0.00034	0.683	0.098	7.70E-05	0.072	0.024	7.30E-05
2	10.8	6.7	0.017	21	14	0.00047	0.586	0.087	0.00017	0.09	0.017	0.00012
3	13.2	6.6	0.022	7.7	5.3	0.00082	0.94	0.2	0.00023	0.41	0.3	0.0002
4	13.1	7.4	0.012	17.7	8.4	0.00036	1.34	0.11	0.00014	0.138	0.016	8.70E-05
5	9.4	3.8	0.012	7.3	2.8	0.00035	0.787	0.071	0.00016	0.123	0.018	0.00011
Average	*10.78*	*5.46*		*15.74*	*8.5*		*0.8672*	*0.1132*		*0.1666*	*0.075*	
Pt #	Sr88	Int2SE	LOD	Y89	Int2SE	LOD	Zr90	Int2SE	LOD	Nb93	Int2SE	LOD
1	0.565	0.062	8.60E-05	0.134	0.023	4.20E-05	3.75	0.66	0.00041	0.0608	0.0099	4.00E-05
2	0.672	0.09	0.00013	0.47	0.076	6.10E-05	3.15	0.65	0.00066	0.055	0.011	4.00E-05
3	1.14	0.11	0.00021	0.96	0.16	8.20E-05	1.91	0.22	0.001	0.033	0.011	4.70E-05
4	1.69	0.14	9.20E-05	0.43	0.1	4.80E-05	3	1.7	0.0005	0.0382	0.0082	2.10E-05
5	0.977	0.093	0.00011	0.152	0.027	2.50E-05	8	1.5	0.00053	0.084	0.015	4.00E-05
Average	*1.0088*	*0.099*		*0.4292*	*0.0772*		*3.962*	*0.946*		*0.0542*	*0.01102*	
Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	0.027	0.013	0.00012	0.044	0.027	1.00E-05	0.045	0.017	0.00022	0.111	0.052	0.00015
2	0.025	0.015	0.00015	0.074	0.074	2.00E-05	0.009	0.025	0.00033	0.05	0.036	0.00025
3	0.009	0.012	0.00023	0.014	0.011	3.80E-05	0.003	0.033	0.0005	0.004	0.034	0.00039
4	0.028	0.015	0.0001	0.03	0.013	1.20E-05	0.036	0.018	0.00026	0.082	0.04	0.00035
5	0.083	0.055	0.00011	0.097	0.091	6.80E-05	0.027	0.023	0.00025	0.059	0.034	0.00039
Average	*0.0344*	*0.022*		*0.0518*	*0.0432*		*0.024*	*0.0232*		*0.0612*	*0.0392*	
Pt #	Cd114	Int2SE	LOD	Sn122	Int2SE	LOD	Cs133	Int2SE	LOD	Ba137	Int2SE	LOD
1	0.096	0.029	0.00013	0.068	0.031	0.00043	0.0024	0.0031	5.10E-05	6.12	0.92	2.40E-06
2	0.045	0.025	0.00016	0.11	0.061	0.00069	-0.002	0.0037	7.20E-05	6.33	0.86	5.70E-05
3	0.014	0.011	0.00016	0.057	0.056	0.00097	0.0059	0.0064	0.00012	10.6	1.1	8.80E-06
4	0.081	0.035	0.00014	0.093	0.052	0.00041	0.0029	0.0034	5.70E-05	18.6	1.9	2.70E-06
5	0.051	0.018	0.00012	0.09	0.056	0.00031	0.0025	0.0031	5.80E-05	9.1	1.1	2.90E-06
Average	*0.0574*	*0.0236*		*0.0836*	*0.0512*		*0.00234*	*0.00394*		*10.15*	*1.176*	

Table H.23: Richards Kill (DhLw-2) Artifact 2 Cat #M122 Continued

Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.085**	0.017	3.00E-05	**0.212**	0.045	1.30E-05	**0.036**	0.01	1.30E-05	**0.133**	0.031	1.00E-05
2	**0.35**	0.055	5.60E-06	**0.78**	0.12	4.50E-06	**0.132**	0.022	2.10E-05	**0.66**	0.11	1.90E-05
3	**0.56**	0.11	1.10E-05	**1.38**	0.22	3.40E-05	**0.215**	0.044	8.50E-06	**0.94**	0.18	0.00014
4	**0.283**	0.07	2.50E-05	**0.68**	0.14	2.70E-06	**0.111**	0.023	1.50E-05	**0.47**	0.12	1.10E-05
5	**0.067**	0.014	3.10E-05	**0.195**	0.039	2.90E-06	**0.0304**	0.0084	2.80E-06	**0.128**	0.034	6.60E-05
Average	***0.269***	***0.0532***		***0.6494***	***0.1128***		***0.10488***	***0.02148***		***0.4662***	***0.095***	
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
1	**0.037**	0.013	1.30E-05	**0.0049**	0.0024	3.40E-06	**0.041**	0.014	1.40E-05	**0.0048**	0.0019	2.10E-06
2	**0.158**	0.039	2.40E-05	**0.0347**	0.0087	6.50E-06	**0.154**	0.04	2.60E-05	**0.0254**	0.0059	4.00E-06
3	**0.304**	0.076	4.60E-05	**0.053**	0.02	6.30E-05	**0.277**	0.07	5.10E-05	**0.043**	0.013	7.70E-06
4	**0.11**	0.032	1.40E-05	**0.0262**	0.009	2.20E-05	**0.111**	0.039	8.80E-05	**0.0155**	0.0048	1.30E-05
5	**0.031**	0.012	1.50E-05	**0.009**	0.0032	4.10E-06	**0.037**	0.013	1.70E-05	**0.0044**	0.0016	2.50E-06
Average	***0.128***	***0.0344***		***0.02556***	***0.00866***		***0.124***	***0.0352***		***0.01862***	***0.00544***	
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
1	**0.032**	0.01	8.70E-06	**0.0075**	0.0023	1.30E-05	**0.0216**	0.0079	6.80E-06	**0.0214**	0.0092	1.10E-05
2	**0.169**	0.036	7.90E-05	**0.0236**	0.0065	2.10E-05	**0.064**	0.014	1.30E-05	**0.071**	0.021	9.60E-05
3	**0.283**	0.085	3.20E-05	**0.04**	0.011	8.30E-06	**0.141**	0.044	2.50E-05	**0.142**	0.057	3.90E-05
4	**0.102**	0.025	9.90E-06	**0.0154**	0.0042	2.60E-06	**0.045**	0.012	7.70E-06	**0.064**	0.024	1.20E-05
5	**0.038**	0.012	1.00E-05	**0.0043**	0.0021	2.70E-06	**0.0144**	0.0063	8.10E-06	**0.022**	0.011	1.30E-05
Average	***0.1248***	***0.0336***		***0.01816***	***0.00522***		***0.0572***	***0.01684***		***0.06408***	***0.02444***	
Pt #	**Hf178**	**Int2SE**	**LOD**	**Ta181**	**Int2SE**	**LOD**	**W182**	**Int2SE**	**LOD**	**W184**	**Int2SE**	**LOD**
1	**0.112**	0.083	9.40E-06	**0.00127**	0.00079	1.50E-05	**0.0071**	0.0041	7.70E-06	**0.0085**	0.0052	6.80E-06
2	**0.032**	0.015	1.80E-05	**0.0012**	0.001	3.30E-05	**0.0078**	0.0067	1.50E-05	**0.007**	0.0046	1.30E-05
3	**0.016**	0.01	0.00013	**0.0068**	0.0051	3.90E-05	**0.0006**	0.0013	2.80E-05	**0.012**	0.01	2.50E-05
4	**0.145**	0.093	6.00E-05	**0.00102**	0.00085	3.10E-05	**0.0118**	0.0075	8.90E-06	**0.0143**	0.0075	7.80E-06
5	**0.11**	0.1	1.10E-05	**0.0015**	0.0012	2.90E-05	**0.001**	0.001	5.10E-05	**0.017**	0.014	4.50E-05
Average	***0.083***	***0.0602***		***0.002358***	***0.001788***		***0.00566***	***0.00412***		***0.01176***	***0.00826***	

Table H.23: Richards Kill (DhLw-2) Artifact 2 Cat #M122 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**5.2**	0.44	0.0031	**0.212**	0.068	3.90E-05	**0.091**	0.034	4.30E-05	**0.13**	0.056	2.40E-05
2	**7.8**	1.3	0.0048	**0.141**	0.031	9.90E-06	**0.052**	0.016	8.40E-05	**0.075**	0.019	3.50E-05
3	**16**	3.2	0.0069	**0.18**	0.1	0.00011	**0.077**	0.03	0.00013	**0.46**	0.36	3.50E-05
4	**5.9**	1.4	0.0036	**0.173**	0.029	4.40E-05	**0.082**	0.02	5.90E-05	**0.101**	0.028	3.10E-05
5	**11.1**	2.2	0.0039	**0.134**	0.03	6.20E-06	**0.063**	0.021	5.10E-05	**0.068**	0.02	2.90E-06
Average	***9.2***	***1.708***		***0.168***	***0.0516***		***0.073***	***0.0242***		***0.1668***	***0.0966***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**0.032**	0.013	4.40E-05	**-0.00102**	0.00026	2.20E-06	**6.15**	0.34	1.30E-06
2	**0.008**	0.0052	4.70E-05	**-0.0035**	0.0012	4.10E-06	**3.25**	0.22	2.50E-06
3	**-0.0001**	0.0049	7.50E-05	**4**	6.3	7.90E-06	**2.58**	0.21	4.80E-06
4	**0.049**	0.018	3.40E-05	**-0.0042**	0.0017	2.50E-06	**2.03**	0.11	1.50E-06
5	**0.0146**	0.0042	3.80E-05	**-0.0048**	0.0019	2.60E-06	**5.38**	0.56	1.60E-06
Average	***0.0207***	***0.00906***		***0.797296***	***1.261012***		***3.878***	***0.288***	

Table H.24: Snyder II (DgMg-15) Artifact 1 Cat #M491

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
5	**362**	59	4.3	**1600**	1200	2.6	**5700**	5800	2.5	**453000**	11000	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
5	**310**	390	3.8	**3300**	1500	1.6	**3500**	4500	82	**6.22**	0.47	0.84
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
5	**280**	210	1.8	**12**	12	0.031	**11.4**	1.1	2.4	**13**	12	2.1
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
5	**500**	920	0.24	**5100**	3200	14	**0.83**	0.13	0.052	**180**	340	0.47
Pt #	**Ni61**	**Int2SE**	**LOD**	**Cu63**	**Int2SE**	**LOD**	**Ga69**	**Int2SE**	**LOD**	**Rb85**	**Int2SE**	**LOD**
5	**14.5**	5	5.8	**152**	55	0.16	**3.7**	3.2	0.056	**7.1**	8.4	0.052
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
5	**5.4**	5.8	0.034	**1.3**	1.2	0.02	**8**	10	0.16	**0.72**	0.7	0.011
Pt #	**Mo95**	**Int2SE**	**LOD**	**Mo98**	**Int2SE**	**LOD**	**Ag107**	**Int2SE**	**LOD**	**Cd111**	**Int2SE**	**LOD**
5	**0.158**	0.09	0.09	**0.68**	0.99	0.034	**0.17**	0.1	0.069	**0.65**	0.7	0.086
Pt #	**Cd114**	**Int2SE**	**LOD**	**Sn122**	**Int2SE**	**LOD**	**Cs133**	**Int2SE**	**LOD**	**Ba137**	**Int2SE**	**LOD**
5	**0.215**	0.068	0.036	**1.01**	0.7	0.035	**1**	1.1	0.021	**25**	23	0.072
Pt #	**La139**	**Int2SE**	**LOD**	**Ce140**	**Int2SE**	**LOD**	**Pr141**	**Int2SE**	**LOD**	**Nd146**	**Int2SE**	**LOD**
5	**1.7**	2.2	0.0029	**2.96**	0.72	0.0079	**0.36**	0.37	0.0023	**1.3**	1.5	0.0095
Pt #	**Sm147**	**Int2SE**	**LOD**	**Eu153**	**Int2SE**	**LOD**	**Gd157**	**Int2SE**	**LOD**	**Tb159**	**Int2SE**	**LOD**
5	**0.234**	0.056	0.012	**0.087**	0.082	0.0032	**0.2**	0.1	0.044	**0.031**	0.038	0.0067
Pt #	**Dy163**	**Int2SE**	**LOD**	**Ho165**	**Int2SE**	**LOD**	**Er166**	**Int2SE**	**LOD**	**Yb172**	**Int2SE**	**LOD**
5	**0.224**	0.066	0.0084	**0.059**	0.044	0.0022	**0.49**	0.78	0.0065	**0.12**	0.19	0.01

Table H.24: Snyder II (DgMg-15) Artifact 1 Cat #M491 Continued

Pt #	Hf178	Int2SE	LOD	Ta181	Int2SE	LOD	W182	Int2SE	LOD	W184	Int2SE	LOD
5	**0.152**	0.02	0.03	**0.057**	0.046	0.0026	**0.114**	0.033	0.0076	**0.115**	0.023	0.0066
Pt #	**Pb204**	**Int2SE**	**LOD**	**Pb206**	**Int2SE**	**LOD**	**Pb207**	**Int2SE**	**LOD**	**Pb208**	**Int2SE**	**LOD**
5	**21.3**	6.7	1.6	**33**	53	0.017	**6.1**	5.9	0.019	**8.6**	3.8	0.012
Pt #	**Bi209**	**Int2SE**	**LOD**	**Th232**	**Int2SE**	**LOD**	**U238**	**Int2SE**	**LOD**			
5	**0.15**	0.13	0.015	**-0.000359**	7.80E-05	0.0021	**1.09**	0.28	0.0013			

Table H.25: Snyder II (DgMg-15) Artifact 2 Cat #M1412

Pt #	Na23	Int2SE	LOD	Mg25	Int2SE	LOD	Al27	Int2SE	LOD	Si29	Int2SE	LOD
1	**180**	70	8.8	**1000**	1300	5.3	**3600**	3100	5.1	**460300**	6500	
2	**210**	210	8	**790**	790	4.2	**3500**	3500	4.6	**460000**	460000	
Average	***195***	***140***		***895***	***1045***		***3550***	***3300***		***460150***	***233250***	
Pt #	**P31**	**Int2SE**	**LOD**	**K39**	**Int2SE**	**LOD**	**Ca43**	**Int2SE**	**LOD**	**Sc45**	**Int2SE**	**LOD**
1	**130**	120	8	**1300**	1000	3.2	**1230**	980	150	**7.4**	2.2	1.7
2	**110**	110	6.4	**1200**	1200	2.9	**990**	990	150	**4.1**	4.1	1.6
Average	***120***	***115***		***1250***	***1100***		***1110***	***985***		***5.75***	***3.15***	
Pt #	**Ti49**	**Int2SE**	**LOD**	**V51**	**Int2SE**	**LOD**	**Cr52**	**Int2SE**	**LOD**	**Cr53**	**Int2SE**	**LOD**
1	**100**	140	3.8	**8.8**	6.7	0.099	**8**	12	4.8	**4.8**	8.7	4.5
2	**130**	130	3.5	**9.4**	9.4	0.088	**16**	16	4.4	**3**	3	4.2
Average	***115***	***135***		***9.1***	***8.05***		***12***	***14***		***3.9***	***5.85***	
Pt #	**Mn55**	**Int2SE**	**LOD**	**Fe57**	**Int2SE**	**LOD**	**Co59**	**Int2SE**	**LOD**	**Ni60**	**Int2SE**	**LOD**
1	**25**	21	0.5	**1800**	1900	25	**0.54**	0.72	0.12	**9.6**	5.1	1.1
2	**19**	19	0.42	**1600**	1600	24	**0.21**	0.21	0.097	**10**	10	0.97
Average	***22***	***20***		***1700***	***1750***		***0.375***	***0.465***		***9.8***	***7.55***	
Pt #	**Ni61**	**Int2SE**	**LOD**	**Cu63**	**Int2SE**	**LOD**	**Ga69**	**Int2SE**	**LOD**	**Rb85**	**Int2SE**	**LOD**
1	**21.1**	4.4	12	**269**	99	0.35	**8.4**	1.8	0.1	**2.7**	3	0.1
2	**9**	9	9.3	**160**	160	0.3	**54**	54	0.15	**2.7**	2.7	0.091
Average	***15.05***	***6.7***		***214.5***	***129.5***		***31.2***	***27.9***		***2.7***	***2.85***	
Pt #	**Sr88**	**Int2SE**	**LOD**	**Y89**	**Int2SE**	**LOD**	**Zr90**	**Int2SE**	**LOD**	**Nb93**	**Int2SE**	**LOD**
1	**5.9**	1.8	0.086	**0.52**	0.32	0.047	**40.4**	8.2	0.35	**0.28**	0.4	0.023
2	**11**	11	0.076	**0.86**	0.86	0.044	**6.1**	6.1	0.3	**0.22**	0.22	0.023
Average	***8.45***	***6.4***		***0.69***	***0.59***		***23.25***	***7.15***		***0.25***	***0.31***	

Table H.25: Snyder II (DgMg-15) Artifact 2 Cat #M1412 Continued

Pt #	Mo95	Int2SE	LOD	Mo98	Int2SE	LOD	Ag107	Int2SE	LOD	Cd111	Int2SE	LOD
1	**0.101**	0.021	0.042	**0.48**	0.83	0.027	**0.59**	0.24	0.19	**0.5**	0.71	0.24
2	**0.22**	0.22	0.049	**0.16**	0.16	0.091	**0.36**	0.36	0.19	**0.88**	0.88	0.19
Average	*0.1605*	*0.1205*		*0.32*	*0.495*		*0.475*	*0.3*		*0.69*	*0.795*	
Pt #	Cd114	Int2SE	LOD	Sn122	Int2SE	LOD	Cs133	Int2SE	LOD	Ba137	Int2SE	LOD
1	**0.17**	0.28	0.08	**0.78**	0.76	0.33	**0.143**	0.036	0.039	**81**	19	0.058
2	**0.28**	0.28	0.033	**0.32**	0.32	0.11	**0.15**	0.15	0.044	**160**	160	0.066
Average	*0.225*	*0.28*		*0.55*	*0.54*		*0.1465*	*0.093*		*120.5*	*89.5*	
Pt #	La139	Int2SE	LOD	Ce140	Int2SE	LOD	Pr141	Int2SE	LOD	Nd146	Int2SE	LOD
1	**0.61**	0.48	0.021	**1.467**	0.087	0.017	**0.239**	0.059	0.025	**0.8**	0.25	0.025
2	**0.87**	0.87	0.0088	**1.5**	1.5	0.0072	**0.15**	0.15	0.016	**0.62**	0.62	0.029
Average	*0.74*	*0.675*		*1.4835*	*0.7935*		*0.1945*	*0.1045*		*0.71*	*0.435*	
Pt #	Sm147	Int2SE	LOD	Eu153	Int2SE	LOD	Gd157	Int2SE	LOD	Tb159	Int2SE	LOD
1	**0.124**	0.024	0.11	**0.046**	0.017	0.024	**0.167**	0.034	0.096	**0.0099**	0.0085	0.0054
2	**0.18**	0.18	0.036	**0.083**	0.083	0.0097	**0.06**	0.06	0.04	**0.022**	0.022	0.014
Average	*0.152*	*0.102*		*0.0645*	*0.05*		*0.1135*	*0.047*		*0.01595*	*0.01525*	
Pt #	Dy163	Int2SE	LOD	Ho165	Int2SE	LOD	Er166	Int2SE	LOD	Yb172	Int2SE	LOD
1	**0.069**	0.099	0.022	**0.023**	0.016	0.0058	**0.062**	0.088	0.017	**0.052**	0.01	0.027
2	**0.063**	0.063	0.025	**0.02**	0.02	0.0066	**0.029**	0.029	0.057	**0.046**	0.046	0.03
Average	*0.066*	*0.081*		*0.0215*	*0.018*		*0.0455*	*0.0585*		*0.049*	*0.028*	
Pt #	Hf178	Int2SE	LOD	Ta181	Int2SE	LOD	W182	Int2SE	LOD	W184	Int2SE	LOD
1	**0.51**	0.45	0.066	**0.003**	0.006	0.0069	**0.036**	0.072	0.02	**0.047**	0.093	0.018
2	**0.12**	0.12	0.027	**0.012**	0.012	0.026	**-8.30E-07**	-8.30E-07	0.055	**0.02**	0.02	0.02
Average	*0.315*	*0.285*		*0.0075*	*0.009*		*0.017999585*	*0.035999585*		*0.0335*	*0.0565*	

Table H.25: Snyder II (DgMg-15) Artifact 2 Cat #M1412 Continued

Pt #	Pb204	Int2SE	LOD	Pb206	Int2SE	LOD	Pb207	Int2SE	LOD	Pb208	Int2SE	LOD
1	**66.4**	3.6	5.4	**8.1**	6.6	0.078	**7.8**	5.9	0.07	**7.5**	8.4	0.032
2	**18**	18	4.1	**5.9**	5.9	0.058	**5.5**	5.5	0.041	**6.2**	6.2	0.017
Average	***42.2***	***10.8***		***7***	***6.25***		***6.65***	***5.7***		***6.85***	***7.3***	

Pt #	Bi209	Int2SE	LOD	Th232	Int2SE	LOD	U238	Int2SE	LOD
1	**2.16**	0.43	0.037	**-0.00101**	0.00039	0.0056	**5.5**	1.2	0.0035
2	**0.54**	0.54	0.027	**-0.00031**	-0.00031	0.0064	**3**	3	0.0041
Average	***1.35***	***0.485***		***-0.00066***	***0.00004***		***4.25***	***2.1***	