The Osteology and Trace Element Analysis

of

DdKi - 2, Fort Frances, Ontario

A Thesis

Presented to

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by

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THE OSTEOLOGY AND TRACE ELEMENT ANALYSIS OF DdKi - 2, FORT FRANCES, ONTARIO

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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

This study was undertaken to provide an osteological analyses of the human skeletal remains recovered as a result of the 1984 rescue archaeology project DdKi-2, Fort Frances, Ontario initiated by the Ontario Northwestern Regional Archaeologist's office.

A major component of the analyses has focused upon the application of multi analytical trace element techniques, especially Proton Induced X-ray Emission Spectroscopy [PIXE] to the problem of identification of trace elements in human bone. This technique has not previously been applied to the problem of trace element identification in bone. This thesis intends to shown that the PIXE technique can provide trace element information useful to the anthropologist.

Finally, suggestions are made to the refinement of the PIXE and other techniques appropriate for the identification of trace elements in human bone in an archaeological context.

ACKNOWLEDGMENTS

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1.0 Introduction

The discovery of human remains in October of 1984 during the excavation of the Boise-Cascade Paper Company parking lot in Fort Frances, Ontario [Fig 1] resulted in a subsequent rescue excavation (DdKi-2) of twelve discrete burials of unknown provenience, representing at least fifteen individuals.

The human remains described in the following thesis were recovered in October of 1984 as part of the rescue archaeology project initiated by the Ontario Ministry of Citizenship and Culture. This recovery was necessitated by the accidental discovery of human remains by a heavy equipment operator working on the Boise-Cascade Paper Company parking lot expansion. This discovery resulted in an immediate work stoppage.

Jim McQuarrie, assistant to the Regional Manager of Boise Cascade Canada, contacted the Ontario Ministry of Citizenship and Culture and a five day rescue project was initiated by the Ontario Northwestern Regional Archaeologist's office under the supervision of Grace Rajnovich.

At the time of discovery, three-quarters of the site area had been cleared of its sandy top soil to a depth of about one metre. Visible prior to the

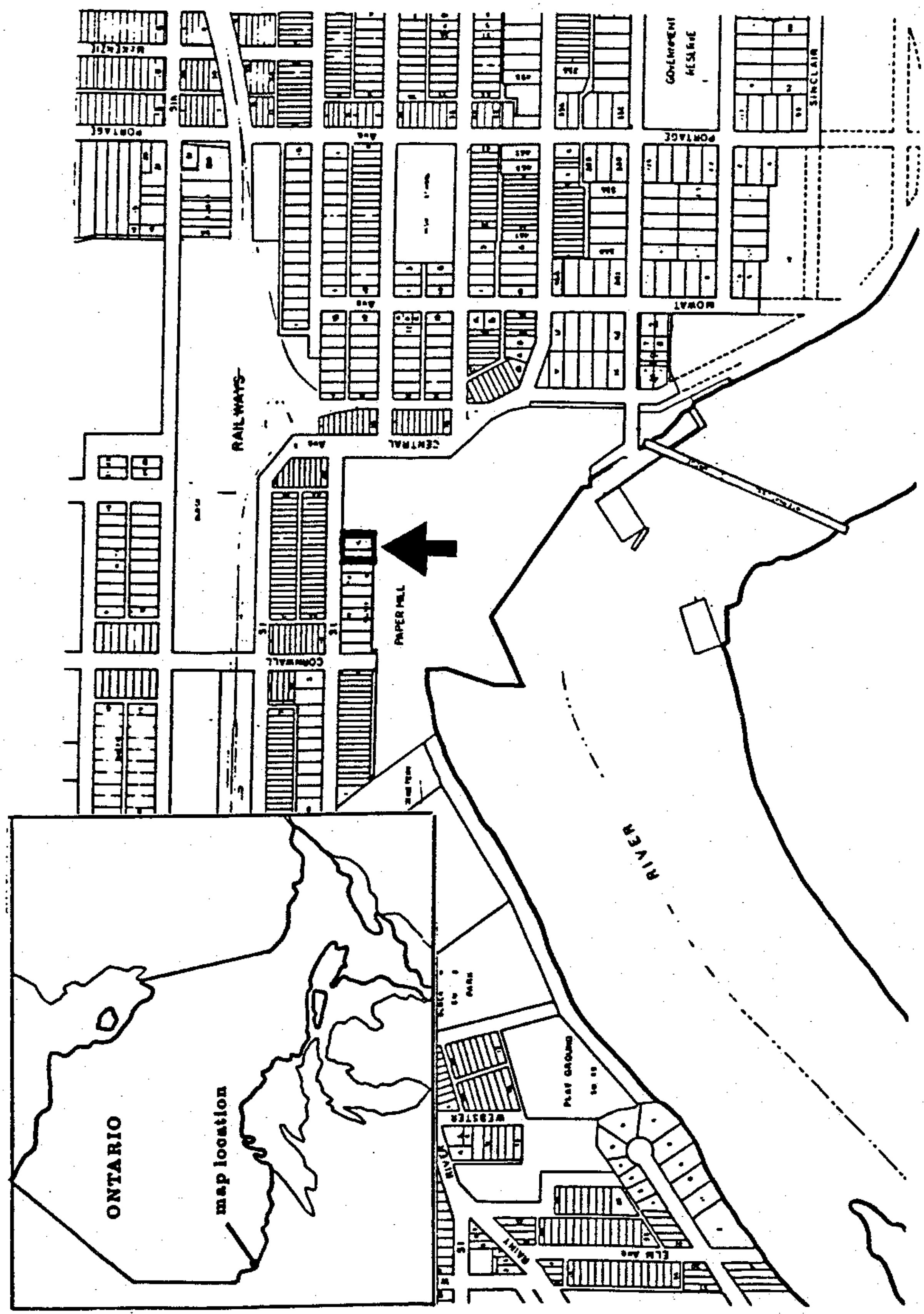


Figure 1: Fort Frances Town Site

archaeological excavation were all of Burial 1, the cranium of Burial 2, and numerous elements of Burial 3. This last burial[s] represented at least three individuals whose remains had been bagged by the town police prior to the arrival of the archaeologist [Rajnovich 1985;p.2].

A halt work order was issued on the parking lot expansion and archaeological recovery was carried out under a warrant issued by the Coroner of District 22 and a Disinterment Order issued by the District Medical Officer of Health.

The five day project dealt only with the impacted or threatened portion of the site and recovered the remains of at least 15, and possibly as many as 17 individuals from 11 burials [Fig 2]. The archaeologist believes that more human remains are present in this general area but were outside the current construction area and therefore not covered by the warrant.

1.1 Statement of Purpose

Given the above situation the primary objective of this thesis was to recover the maximum amount of information from the osteological material recovered. The secondary objective, is to apply existing

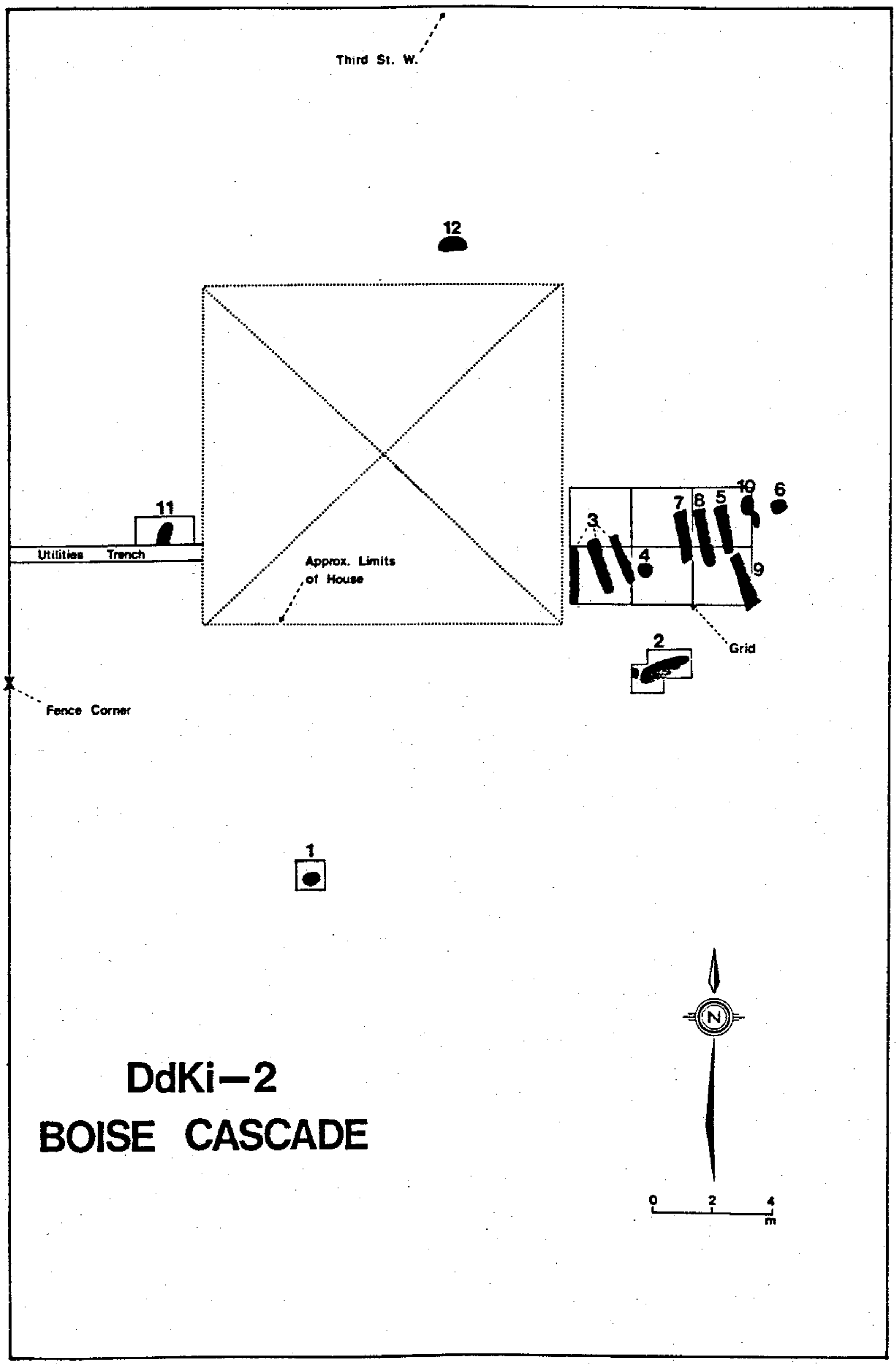


Figure 2: Site Plan DdKi-2

techniques of trace element detection, especially Proton Induced X-ray Emission [PIXE] to a previously untried sample material i.e., human bone.

Excavation of the material from the impacted portion has shown that all of the burials were shallow, one metre or less from the current ground surface, and laying on a clay soil horizon identified as a Lake Agassiz clay. This last named layer was cited as being impenetrable with a shovel by the archaeological team [Rajnovich 1985;p.2].

Previous development on the site between 1940 and 1962 [i.e., house indicated on Fig 2] and the construction work of 1984 resulted in major disturbance to the site material prior to excavation by the rescue team [Rajnovich 1985;p.1]. This disturbance resulted in heavy bone breakage, missing bone elements, and intermixing of site material rendering individual identification impossible in some cases. The objective of the excavation, and subsequently this study, was to recover the maximum amount of archaeological material in context prior to the complete destruction of the impacted portion of the site by the construction project. The analyses of the recovered material is intended to provide information for inclusion into both the provincial and regional data bases.

The overall data base present in the published literature, for both the region and the country, has a paucity of osteological material which can be directly associated with the historical fur trade period. Although probably only a portion of an original cemetery [Rajnovich 1985;p.2] the sample recovered from DdKi-2 represents a unique opportunity to increase our knowledge regarding this previously overlooked population directly engaged in, or exposed to, a European lifestyle in a North American setting.

The current information in the Ontario osteological data base presents a unique problem for the physical anthropologist. Excavations initiated in 1912 (Roebuck site - 84 individual graves :Wintemberg:1937 and Knowles:1937) started the systematic recovery of osteological, and specifically Amerindian remains in Ontario. Since then many other sites have been identified to form the bulk of the osteological record of Ontario. To date little information on European style burials in Canada, and specifically in Ontario, has been published. The major published information on coffin burials from the historic period for the entire country is from two isolated burials: one in Quebec City and the other in Nottingham House, Alberta [Cybulski 1976;

1983]. Consequently, the current osteological record reflects the demography of prehistoric populations. As a result, the site information published to date represents an ethnically biased sample of the osteological record. Further, although representing a statistically significant sample of prehistoric populations, these sites reflect ossuary material rather than the individual interments in the "Christian style" of discrete coffin burials identified at this site designated as DdKi-2 at Fort Frances, Ontario in the historic Lac La Pluie region.

1.2 Methodology

The following methods were used to maximize the recovery of information pursuant to the stated objective. The first approach was analyses of the skeletal osteology of the represented individuals. Metric and non-metric analysis followed established laboratory techniques in Bass (1971) and Brothwell (1965), in conjunction with the latest University of Toronto, Department of Anthropology IBM codification guideline (1985) for recording of skeletal information.

These analyses focused upon the sex, age at death, and "racial" character where possible of each individual in the sample. Although difficult to address, the question of "race" must be dealt with to satisfy the requirement of reburial of Amerindian burials as stipulated by the oral agreement on the conditions of excavation negotiated by the regional provincial archaeologist and the local Rainy River Indian band.

The second approach used in the study was to identify any skeletal pathology or anomaly which may be reflected in the sample. Identification of skeletal pathology depended upon visual recognition using criteria described in Bass (1971) and El-Najjar and McWilliams (1978) and subjective evaluation using standard recording techniques as outlined in University of Toronto data recording sheets. This information can be used to provide a better general insight into the general health of the historical population associated with fur trade activities.

The third approach used in this inquiry was identification of the trace elements present and their levels using Atomic Absorption [AA] and an experimental Proton Induced X-ray Emission [PIXE] technique [Discussed in chapter 3]. Many of the recent osteological studies are focusing upon paleonutrition and ecological exploitation models based upon trace element work [Parker and Toots 1980, Katzenberg 1982, Lambert et al. 1982, Price and Kavanagh 1982, Pfeiffer and King 1983]. In addition recent work on disease detection has indicated the possible connection between some diseases and alteration of normal trace element concentrations of individuals within a population [Ortner and Putschar 1981;p.25].

1.3 Existing Literature on Methodology

The amount of literature available which deals with metric and non-metric osteological analyses is considerable. Completion of metrical and non-metrical analyses for this study made specific reference to Anderson (1969), Bass (1971) and El-Najjar and McWilliams (1978) and utilized the University of Toronto's data recording forms. Stature estimations and 'racial' identification referred to Trotter and Gleser (1952 and 1958) works on young male white North Americans and articles in Stewart's Personal Identification in Mass Disasters (1970). Work on sexing the skeleton by Thieme and Schull (1957), and Giles and Elliot (1963), and os pubis work by McKern and Stewart (1957), Gilbert and McKern (1973) and Phenice (1969) supplemented Bass (1971).

Identification of age from cranial suture closure and epiphyseal union was based upon material from Kerley (1970), McKern (1970), Bass (1971), Lovejoy (1985), Meindl and Lovejoy (1985a), Meindl et al.(1985b). Information on age from dental eruption and attrition was based upon Brothwell (1965), McKern (1970), and Bass (1971).

Identification of pathologies focused primarily on Brothwell (1965), Brothwell and Sandison (1967), Steinbock (1976), Zivanovic (1982) and Manchester (1983). Ortner and Putschar's (1981) work dealing specifically with the Smithsonian collection was also considered.

The small sample size and incomplete nature of the material, and the lack of an existing data base for comparison makes comparative osteological statistical analysis unreliable at this juncture.

The basic use of trace elements in skeletal analysis is well presented in Gilbert (1977). Specific work on atomic absorption analysis of trace elements has been examined by Szpunar et al. (1978) and Lambert et al. (1979) on middle and late Woodlands sites and in a subsequent article by Lambert et al. (1982).

2.0 Historical Background

As stated by Harris and Warkentin...

> "The fur traders imposed a robber economy on the region, with both animal and human resources relentlessly exploited by the Northwest and the Hudson's Bay Company men for their own ends. Relatively few men were required to conduct trade with the Indians, who did the actual trapping, and to convey the pelts to markets thousands of miles away." (1974:p.245)

The contact between the Indians and the Europeans quickly established a symbiotic relationship which resulted in most Indians becoming ..."'Company' Indians, free in day to day activities but constrained in the long run to secure pelts for the Hudson's Bay Company." (Harris and Warkentin 1974:p.252) These 'Company' Indians became engaged in a debt system which acted to tie native trappers and their families to a single post.

The staffing of the Hudson's Bay Company posts depended upon active recruitment of young Scotsmen and especially Orkneymen, often in their mid teens, who signed on as servants and stayed with the Company in the hope of advancement. Upper level members of the post did not generally stay in the fur trade regions but returned to their homeland upon retirement (Harris and Warkentin 1974:p.245).

After the 'Proclamation of 1763' all major European settlements beyond the 'Western line' required that a treaty with existing Amerindian groups be established (Harris and Warkentin 1974:p.65). As the government was the only agency with the authority to do this, wholesale settlement by Europeans in Northwestern Ontario was severely restricted. Therefore fur trade posts represent the main source of European influence upon Amerindian and lower status Europeans in Canada during this period. As a consequence osteological material associated with fur trade activities constitutes the main source of available or potentially available European osteological material, for central and western Canada, during the important period of first contact and subsequent settlement.

Part of the legacy of the fur trade is the well documented location of fur trade posts [Harris and Warkentin 1974;p.244,284] including the location of associated "burial grounds".

Legislation in English common law provided protection for burials through two methods. Prior to 1788 A.D. protection from disturbance was based upon the premise that an interred body was "nullius in bonis"

(Coke 1628;p.202) which translates as "in the property of no one" and therefore was the concern of the church, not the state.

The state afforded limited protection to interments on the basis of the presence of a marker or monument. Disturbance of the monument was considered a crime under common law [Simonds 1953;p.102]. Sir Edmond Coke in his <u>The Third Part of the Institutes of the Laws of England</u> cites the following four reasons for the state to consider burial monuments important...

> "Besides the religious, and Christian regard abovesaid, these monuments do serve for four good uses and ends. First, for evidence, and proof of Decents, and pedegrees[sic]. Secondly, what time he that is there buried deceased. Thirdly, for example to follow the good or to eschew the evil. Fourthly, to put the living in mind of their end, for all the sons of Adam must die."
>
> (1628;p.203)

In addition to the direct protection of grave markers the interred remains were indirectly protected by a 1604 act against witchcraft and sorcery (<u>Government of England, The Statutes At Large</u> 1762). Though not specifically cited in the act, the assumption of the legislators was that the use of human remains in witchcraft or sorcery was the only logical reason for the intentional disturbance of interred human remains.

This act, repealed and replaced by a similar act in 1763 (Government of England, The Statues At Large 1764), became the main legal recourse against the disturbance of interred bodies.

The state used both of these legal methods to prevent the site disturbance of burial areas with "marked Catholic", including Church of England, burials (Government of England, The English Reports 1909;p.394).

The English Burial Act of 1857 extended this protection to non-Catholic Christian faiths and further added direct legal protection of buried remains by stating that...

> "...it shall not be lawful to remove any body, or the remains of any body, which may have been interred in any place of burial , without licence under the hand of one of her majesty's principal secretaries of state,..."
> (Aggs 1911;p. 1187)

The Upper Canada Cemeteries Act of 1859 (Government of Canada, Consolidated Statutes for Upper Canada; p. 775) added the right of civil groups, (twenty or more individuals) to establish formal cemeteries outside the limits of towns and cities following the established guidelines of the act. These civil cemeteries were extended the same protection as canonical cemeteries. The Amerindian burials not located in these recognized areas were not protected due to the absence of their acknowledgment as being sacrosanct in the European legal, religious and ethical assessment of the time. As a result of this differential treatment the literature which is available on Ontarian osteology is composed almost entirely of Amerindian samples. The early establishment of marked cemetery sites is associated with the incursion of Europeans into the "frontier" region of Ontario.

To date meager historical osteological collections affiliated with fur trade life have been published in the literature. One unpublished work from the Long Lac site DkIp-1 [Morgan 1983] is the only comparative study available. Two isolated coffin burials, one in Quebec City [Cybulski 1976] and the other at Nottingham House in Northern Alberta [Cybulski 1983] are the only other 'Christian burial' osteological material published to date.

2.1 Regional Historical Situation

The historic land use pattern of the area has been well documented [Hambley 1976; Harris and Warkentin 1974; Nute 1950]. The southern portion of northwestern Ontario served as an important link into the interior of

Ruperts Land. This southern Canadian link was formed as a result of the southwardly expanding water courses and interconnected lakes [Nute 1950]. These lake and river networks form a natural link between the drainage systems of the Hudson's Bay and the Mississippian basin. Thus, use of these routes was not confined to Canadian interests but also allowed for an American presence in the region.

The limited settlement by Europeans in the Canadian frontier along these major routes acted to create focal points of interest from which fur trade activities would radiate into local networks expanding in all directions. Logically these focal points encouraged the congregation of European settlement and interests at sites of environmental significance such as major river junctions and hazards.

Competition between fur trading companies to secure these preferred sites encouraged the development of permanent trading structures with minor subsidiary and/or seasonal sites located within the catchment areas. Recognition of ownership of a given catchment region, with native populations considered as part of the local resources, formed the basis of much of the hostility between competitive companies during the expansive period of the fur trade.

The competition and hostility amongst these companies was directly responsible for the Hudson's Bay Company founding the post in the Lac La Pluie district in 1793. The fort had been abandoned in 1797 because of the unprofitablity of the area due to the complete penetration by the Northwest company prior to the Hudson's Bay Company arrival [Nute 1950;p.1]. The Hudson's Bay Company had concentrated on the more northern routes into the interior early on, making the southern routes most attractive for the other fur trading companies. This allowed the other companies, especially the Northwest Company, the time to develop post networks in the southern regions.

The Lac La Pluie region was also scouted by the XY Company in 1804 and they established a limited operation in the region. In addition to the Canadian interests, the American Fur Company arrived in the region in 1808 [Nute 1950;p.1].

In 1818, American interest in the area due to border discussions and competitive exploitation by the Northwest Company, resulted in the re-establishment of the Hudson's Bay Company presence by a post being relocated to a site above the falls on Rainy River. The unification of the Hudson's Bay Company and the Northwest Company resulted in the relocated post becoming the major centre for the the district of Lac La Pluie [Hambley 1976;p.30].

The border differences which arose after the Treaty of Paris in 1783 were partially resolved with the Convention of 1818 which established the 49th parallel as the Canada - United States of America borderline west of Lake of the Woods. The arrival of scientific parties in 1823 from both Great Britain and the United States of America worked to resolve the border issue for lands east of Lake of the Woods [Nute 1950;p.25]. As a result of these studies some of the traditional southern voyageur's route into the Canadian interior passed through American soil [Hambley 1976;p.xii].

Normal post staffing between 1818 and 1830 went from a low of 32 men to a high of 44 men but averaged about 36 men according to the winter records for the period [HBCA B.105 d/1][1]. The early district reports indicate that there was a high percentage of native family groups in the area suffering from starvation. Upon the suggestion of the Factor, several of these groups were provided with relief packages with the belief that it would establish a binding relationship between the native groups and the Company thereby weakening the competitive advantage of other fur trading interests in the region [HBCA B.105/e/1 - 11].

The 1822 - 23 District report gives a listing of all natives in what the Company defined as the Lac La Pluie district. Each native male was identified with a character assessment. The unofficial Company census indicated that there were a total of 455 natives in the region divided into the following catagories...

107	Native males
118	Native women
230	Native children

The district report of 1829 - 30 further listed natives into rough age groups and indicated the numbers loyal to the Company and those belonging to the American Fur Trading Company [HBCA B.105/e/9].

The visit of Governor George Simpson and his wife Frances Ramsey Simpson on September 25, 1830 resulted in the renaming of the post to Fort Frances [HBCA B.105/e/9].

The Hudson's Bay Company reached an agreement in 1833 with the American Fur Company for their withdrawal from the region for a cash settlement of 300 pounds sterling per year. These payments occurred from 1833 to 1847 when the American Fur Company went out of business [Hambley 1976;p.36].

Friction over free passage of goods along the shared Canadian - U.S. route resulted in the Dominion government commissioning an attempt to locate and develop an all Canadian route into the interior [Nute 1950;p.46]. This route was identified in 1857 as the result of a survey by Dawson and Hind [Hambley 1976;p.xii].

Although remaining an important stop-over point on the route to the interior, Fort Frances did not receive any significant notice until 1869 when Wolseley's march westward during the Riel Rebellion resulted in the post being designated as a depot. To this end, after a five day layover, a garrison of one company of the First Ontario Rifles and surplus supplies were placed at the post. Part of their duties was the construction of a 36 bed hospital and a bakery [Nute 1950;p.47].

The signing of Treaty # 3 resulted in Fort Frances being made the central Indian Agency for reserves on the Canadian side of the border [Nute 1950;p.61]. The importance of the area around Fort Frances as an economic as well as administrative centre became more

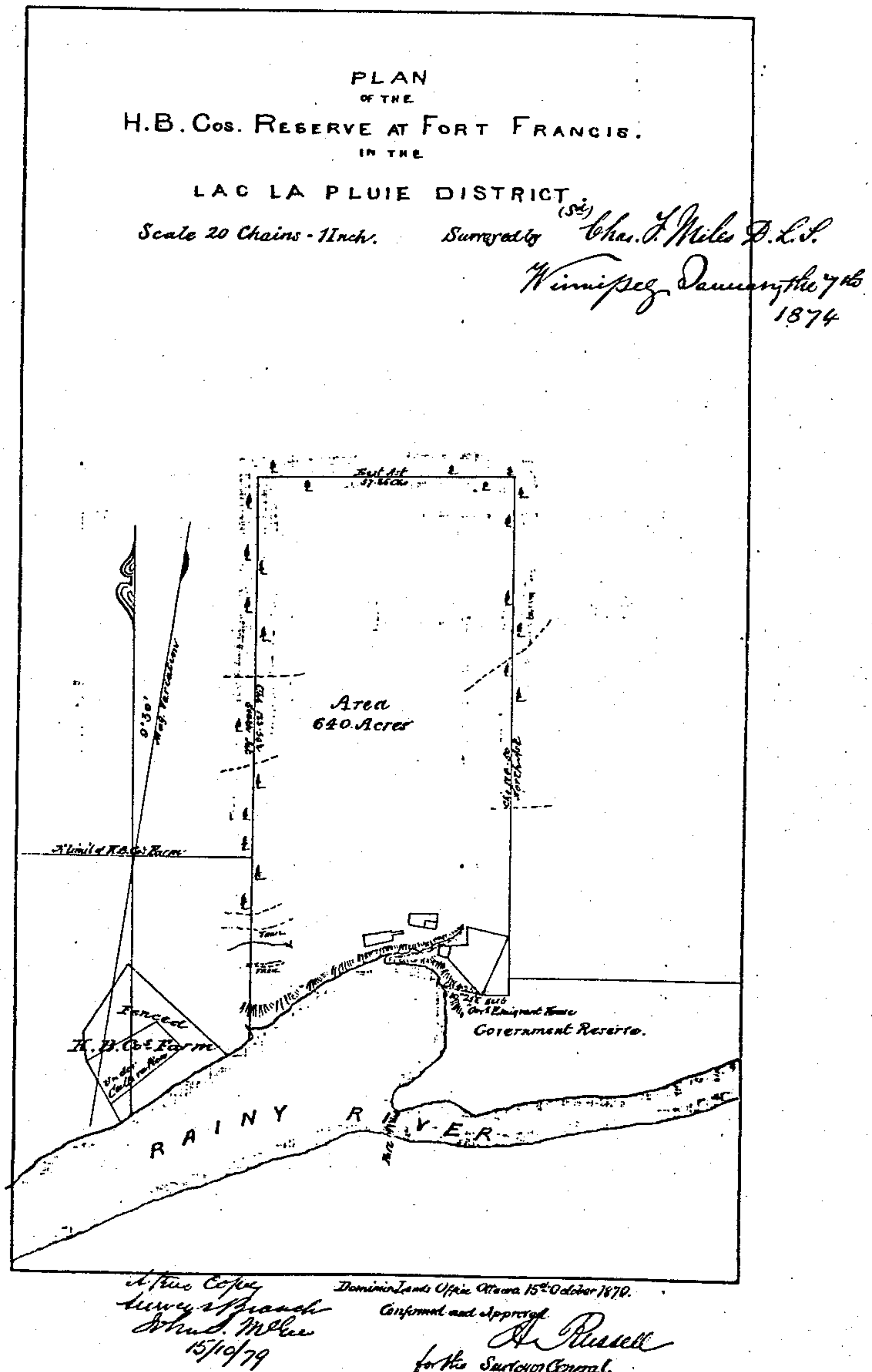


Figure 3: Official Survey Map 1879

apparent to the Canadian government. In 1875 a lock project was initiated to bypass the nearby falls and continued until 1878 when the project was abandoned in favour of an intercontinental railroad [Nute 1950;p.50]. As a result of that construction a large work force became resident in the area during this period. In 1890 at the height of its activity there were 21 steamboats on record with the Fort Frances United States timber agent plying their trade between Rat Portage [Kenora] and Fort Frances [Hambley 1976;p.72].

2.2 Probable Site Association

The preliminary excavation report by Grace Rajnovich, published by the Ontario Ministry of Citizenship and Culture, Northwestern Region (1985) indicates that the archaeological and osteological material recovered are the last surviving interments of the original Hudson's Bay Company cemetery (which may have numbered one hundred interments) prior to the Fort site being partially relocated after a fire on October 7, 1874 [Rajnovich 1985;p.1]. This identification is based upon a survey report completed by the Dominion Land Survey on October 2nd 1874 five days prior to the fire [Rajnovich 1985:p.1].

The historical affiliation of the burials recovered during the excavation of DdKi-2 is made much less certain when the location of the excavated burial site is compared with the official land survey report [Fig 3] prepared by Chas [Charles] F. Miles [1874] of the Dominion Land Survey. His official site plan, dated January 7, 1874 and filed October 15, 1879 in Ottawa has no notation regarding any cemetery or burial ground [HBCA A.12/L/111/1 #13].

An unofficial rendering by Miles, [Fig 4; HBCA A.12/L/111/1 #31] dated the same as the official document, indicated that a cemetery parcel was located near the DdKi-2 site but not corresponding directly to the excavation area. There is no indication as to why Miles omitted this cemetery parcel on the official survey map but included its location on an unofficial map. What is known is that the Ontario government, in 1893, allocated a 10 acre parcel of HBC land to the town of Alberton for the creation of a cemetery. The parcel granted is located to the west of the DdKi-2 site [HBCA A.12/L 111/1 #13/31 1893] and corrisponds to a present day cemetery site.

The HBC land patent of 1898, based upon the Miles' 1874 survey [HBCA A.12/L/111/1 #13], recognizes only this Alberton cemetery parcel. A hand written note, in

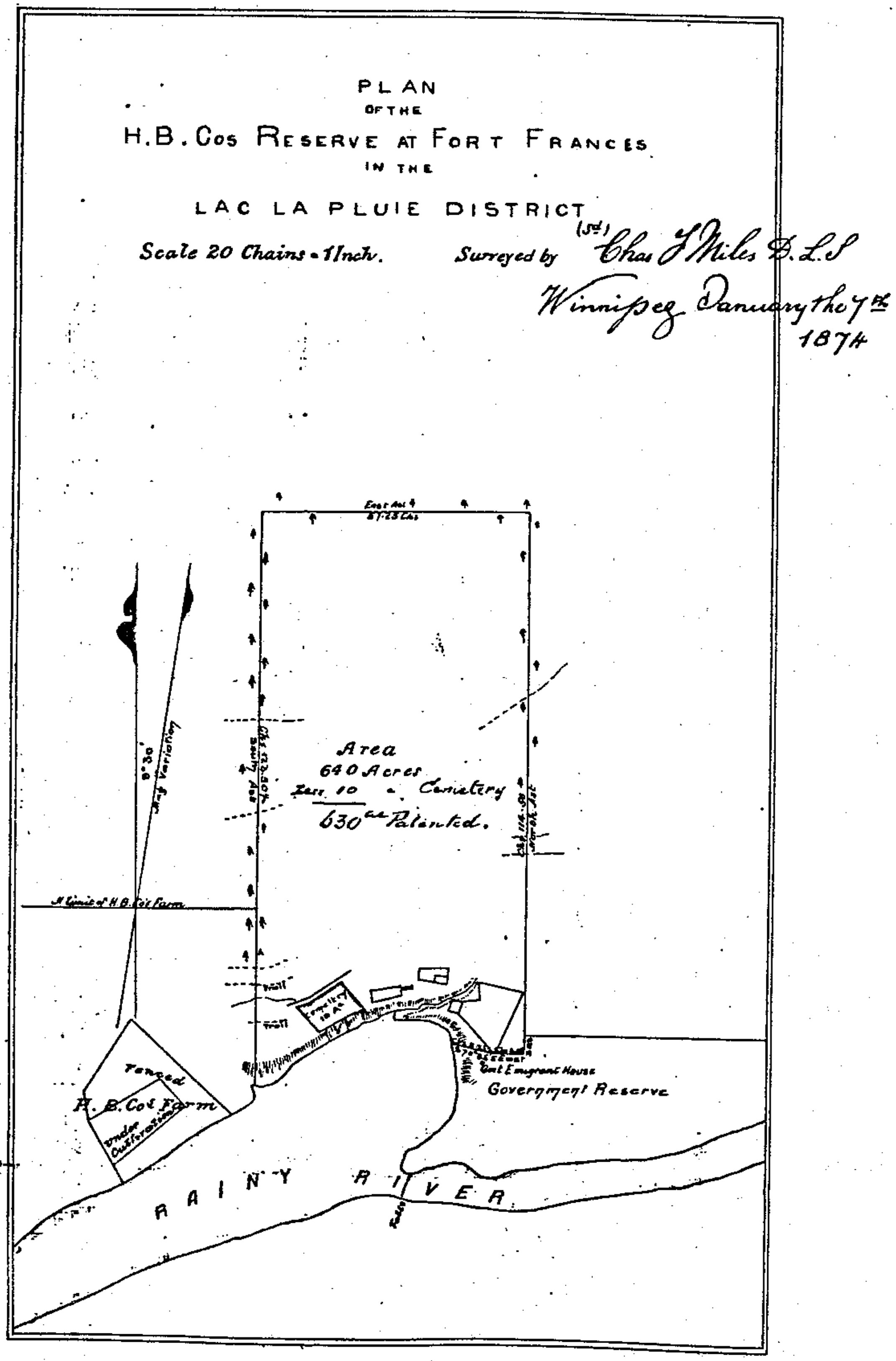


Figure 4: Unofficial Survey Map 1874

a style which appears to match that of the original document, and located in the centre of the HBC lands shown on the Miles' unfiled map, refers to a patent of 640 acres less 10 acres that was granted by the Ontario government to the town of Alberton prior to the HBC. patent of 1898. This suggests that the 10 acre parcel was added to the map [Fig 4] after the Ontario government granted the HBC patent in 1898. This would explain why there is no cemetery or burial ground indicated on the official map [Fig 3] filed with the Dominion Land Survey in Ottawa.

A map of Government reserve land at Fort Frances filed with Energy Mines and Resources [Fig 5; EMR 1141], and based on the 1874 survey by Miles, suggests that the area excavated in DdKi-2 corresponds to part of a "burying ground" noted with a written notation and a square (?). The location of this "burying ground" does not match the ten acre location indicated on Miles' unofficial map or provide any indication as to the affiliation or origin of the burials recovered in DdKi-2.

In addition, to the official documents, historical land use also indicates that the location of the original post, called Lac La Pluie in 1793, was below the falls and was moved to the new area above the falls

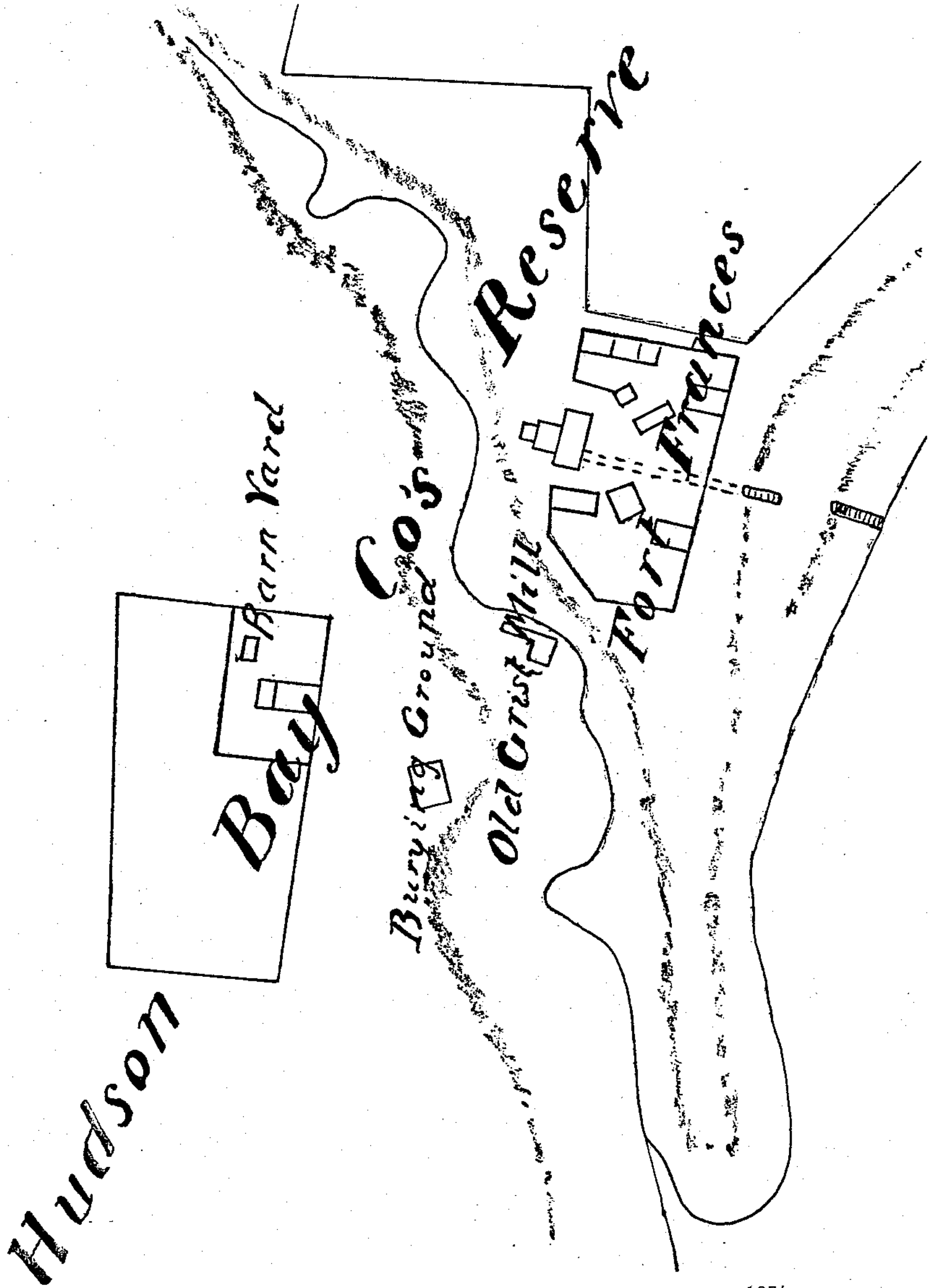


Figure 5: Plan #1141 Dominion Land Survey 1874

in 1818. Prior to the amalgamation of the HBC and the Northwest Company there had been several forts in the area belonging to the HBC, Northwest Company, the XY Fur Trading Company and the American Fur Trading Company [Nute 1950;p.17]. The amalgamation of the Hudson's Bay Company and the Northwest Company in 1823 resulted in the consolidation of the region and the establishment of Lac La Pluie as a district headquarters. The consolidation was part of the Company's attempt to forestall American border disputes, which were ongoing at the time of the Fort's relocation, and to assert ownership of the resources of the region [Nute 1950;p.22].

3.0 Introduction to Trace Element Research

The examination of osteological remains in archaeological context has expanded recently to include a larger emphasis on chemical analysis [Gilbert 1977; Lambert et al. 1979; Lambert et al. 1982; Katzenberg 1984]. As noted by Parker and Toots...

> "Biologically formed apatite always contains significant amounts of several minor elements in addition to the essential elements of the apatite structure...variations are caused by various biological and environmental factors." [1980;p.197]

In the past, the focus of chemical studies tended to deal with a specific element within the apatite structure and to look at its direct effect upon the organism. Examples of these element specific studies can be seen in the following studies on the modern effects of lead conducted in the late sixties and early seventies by Schroeder and Tipton [1968]; Crawford and Crawford [1969]; Crawford and Clayton [1973]; Barry [1975] and Aufderheide et al. [1985].

The development of data bases for trace element studies in modern populations has given anthropologists the basis with which to compare archaeological populations with these modern examples. Medical sciences have discovered, as a result of the better understanding of cellular processes, that the presence or absence and actual amount of various elements previously considered insignificant do in fact play an important role in the complex chemical interactions of the body. The ability to identify minute changes of the trace elements has shown that many elements in the living body must be maintained within stringent and often very narrow limits [Durocher 1978;p.2].

Recent work done on trace element analysis [Lambert et al. 1979; Lambert et al. 1982] has changed the focus to a more holistic examination of the trace elements in bone. Rather than looking at specific individual elements, much of the current research focuses upon multielement analysis. This research sees bone as a dynamic organ which reflects varied environmental, demographic and disease factors [Ortner and Putschar 1981; p.25]. Studies suggest that information regarding diet [Lambert et al. 1979; Lambert et al. 1982; Katzenberg 1984], disease [Ortner and Putschar 1981], and sex [Beattie 1982] can be obtained through recovery and analysis of osteological multielement trace data.

3.1 Multielement Analysis Methodology

Multielement trace analysis has utilized many different techniques including Atomic Absorption (AA), X-Ray Fluorescence (XRF), Rutherford Backscattering (RBS) and Proton Induced X-ray Emission (PIXE). Owing to cost and accessibility, the first technique, Atomic Absorption spectroscopy has been by far the most common method employed in osteological trace element applications. However recent developments in physics, and changes in the application of each of these techniques has made them available for the anthropologist.

The use of X-Ray Emission [XRE] analysis , utilized in XRF, RBS and PIXE, has provided new analytical techniques for multielement analysis. One method of generating XRE for analysis is the use of Proton Induced X-ray Emissions [PIXE] generated with a low energy particle accelerator. Changes in the direction of accelerator use have resulted in the availability of these machines for PIXE analysis [Durocher 1978; Malmqvist 1986].

Recent trace element studies using the PIXE technique to generate XRE have focused upon environmental impact of pollutants outside North America [Ishii et al. 1975; Svendsen, Hertel and Sorensen 1981] and biomedical analysis of tissue [Francey and Durocher 1986; Mckee et al. 1981; Okumusoglu et al. 1986; Pinsky and Bose 1986]. These techniques have recently been applied to the examination of archaeological and historical artifacts [Harbottle 1986; Lahanier, Preusser and Van Zelt 1986; and Malmqvist 1986]. Material types which have already undergone PIXE analysis include metals, stone (including obsidian and amber), ceramics, glass, paper and inks, and paintings. Noticeably absent has been any application to osteological material, either faunal or human.

One technique of multielement analysis which has been well documented, outside the field of anthropology, is X-Ray Fluorescence Emission analysis [XRF]. This process involves the identification of various elements in a sample by observing their characteristic X-ray emissions [Durocher 1978].

> "If one wishes to observe characteristic X-radiation in a given element, the essential requirement is the removal of an inner shell electron, followed by the subsequent filling of the vacancy left by this electron by one which is less tightly bound. The filling of this vacancy by an electron from a higher orbit is accompanied by the emission of either an X-ray or an Auger electron."
> [Durocher 1978;p.9]

XRF generally uses X-ray tubes to accelerate electrons towards a tungsten anode. The impact of the electrons causes X-rays and <u>bremsstrahlung</u>[2] to irradiate, either directly or through a filter, a target. The technique is based upon the theory that...

> "When electrons are deflected while travelling at a speed very close to the speed of light they emit radiation in the forward (tangential) direction. The energy spectrum of this radiation is dependent on the energy of the electrons (typically 1-6 GeV) and on the bending radius of the electron path. [Malmqvist 1986;p.86]

The deflection of these electrons results in a forward emitting radiation, termed a high photon flux [Malmqvist 1986;p.86], which is then directed toward the target. The photon flux creates inner-shell vacancies in the atoms of the sample which produces the X-ray emissions.

The X-ray emission produced through this process, is divided into groups according to the particular shell of various atomic level groups are labelled, K, L, and M, according to standard atomic physics notation, with K representing the innermost and M the outermost shell [Durocher 1978;p.10]. Of the three groups, the K are considered to be the best for analysis of X-ray emission [McKee et al. 1981;p.466].

3.2 PIXE Techinque Review

Proton Induced X-ray Emission technique [PIXE] is an alternate form of generating X-ray emissions for analysis. Unlike X-ray Fluorescence [XRF], PIXE does not use photons generated by X-ray tubes or radiation sources. Rather PIXE depends upon the generation of high speed protons through the use of a particle accelerator. Although protons can produce X-ray emissions when their energy is in the kiloelectronvolt [KeV] range, they function best when their energy is in the 1 to 50 megaelectronvolts [MeV] [Durocher 1978;p.9 and Malmqvist 1986;p.86]. Use of the lower energy ranges [1 - 10 MeV] does not allow direct observation of the K X-ray emissions from medium and heavy weight elements due to obscuring by light element K X-ray emissions. This has resulted in the use of the L X-ray emission in these cases. The accelerator in use at the University of Manitoba has been found to work well in the 20 to 50 MeV range, allowing analysis of K X-ray emission for medium and heavy elements as well as the K X-ray of the light elements [Mckee et al. 1981;p.465 and Prakash et al. 1986;p.207].

The important difference between using protons rather than secondary X-ray or gamma radiation in the production of X-ray emissions is that protons, because they use a variable energy excitation source and carry an electrical charge, can be focused and can scan across a target. This is done through the use of electric or magnetic fields [Durocher 1978;p.30]. Malmqvist in a review article comparing XRF and PIXE summarizes the advantages of using the PIXE technique to generate emissions as follows...

> "...high sensitivity in small samples, high speed, surface analysis, genuinely multielemental and quantitative, partly nondestructive, possible to combine simultaneously with other ion-beam techniques and microprobes."
>
> [1986;p.90]

Detection of the emission is achieved through the use of two detectors, one for light elements and the second for medium and heavy elements, connected with a computer controlled data collection program. Data collected is then analysed with a specially designed computer program which separates peaks from background noise [Francey And Durocher 1986;p.192] and provides a peak netcount which can be converted into parts per million [ppm] readings though the application of a correction formula [detailed in chapter 5.0).

4.0 Sample Selection and Preparation

Samples of both bone and earth were selected from the DdKi-2 site for preparation into usable potential trace element indicators. Two additional archaological samples from intential burials from Greece were also included [Appendix A6; samples X61 and X63].

4.1 Bone Samples

For this trace element study compact bone from rib elements was selected. Compact bone was used as it acts as a mineral bank for trace elements in the bone [Ortner and Putschar 1981;p.25] The rib elements were selected for a number of reasons. First, a few Atomic Absorption trace element studies (Szpunar et al. 1978, Lambert et al. 1979; and Lambert et al. 1982) have already utilized rib elements and therefore are available data bases for comparison. Secondly, ribs do not have a great value in osteological analysis and the loss of a gram of rib is not significant. Thirdly the DdKi-2 material had well represented, although fragmentary, rib material from almost every individual represented in the sample.

Although the material was fragmentary, the cortex of the ribs was intact with little or no surface erosion. Samples were selected from the cortical material which had been hand cleaned without the use of any metal implements or chemical solutions. No reconstruction of rib elements was attempted prior to sampling.

Samples were taken from twenty four rib elements, approximately 100 mg per skeleton from two different ribs, one from each side of the body if identifiable. These twenty four samples represent at least eleven of the possible fifteen individuals represented in the site material [identified in Appendix A1-3 and chapter 6]. One sample was taken from the material bagged prior to the excavation of Burial 3. A second sample taken from the material excavated from Burial 3b may represent a different individual than the material identified as Burial 3. In addition two different tibial samples from the site material were included in the sample material. The two cranial samples from Greece were also included.

4.2 Soil Samples

As noted by Parker and Toots...

> "After burial, vertebrate skeletons undergo a variety of chemical changes, the magnitude of which is a function of the chemical environment in the burial site, the properties of the enclosing sediment, and the properties of the the

hard tissue itself."

[1980;p.198]

This process of bone alteration as a function of natural environmental actions is termed "diagenesis". To identify changes which may have occurred in the samples as the result of diagenesis, four soil samples, selected from the matrix material excavated with the burials were included in the samples to test for soil contamination. These four samples were selected from soil taken from the matrixes from four different burials from different locations of the site as a check for intrasite variability.

4.3 Sample Preparation

An exact weight of 100 mg of bone was placed in a 8 ml boron silicate glass vial. To this 5 ml of 70 % chemically pure Nitric acid was added and the vial was tightly stoppered with a acid resistant teflon cap. The vials were sealed so that the acid could hydrolyze the organic component and liquify the inorganic component without any loss of volume. As soon as the vials were stoppered they were moved into a cold room to prevent contamination of the solutions as a result of the development of any bacterial action. The liquefaction process takes about 24 hours in a cold room.

Once in liquid form an internal dopant was added to the vials. In consultation with the University of Manitoba Accelerator Centre, dysprosium chloride hexahydrate $DyCl_36(H_2O)$ was selected for this study because it does not occur in the human skeleton or in the environment from which the sample material was obtained. The dopant was added to act as a internal standard. To create a dopant solution for this study, 50 mg of dysprosium salt (dysprosium chloride hexahydrate $DyCl_36(H_2O)$) was dissolved in 10 ml of pure distilled water [5mg/ml].

To each sample vial 100 microliters of dopant solution was added to create a stock solution.

4.31 PIXE Sample Preparation

Aluminum cyclotron slides for each sample were produced by the Cyclotron centre at the University of Manitoba. The slides consisted of flat aluminum slides, approximately 7 cm by 2.5 cm, with an central oval opening about 2.5 cm by 2 cm. A small amount of vacuum grease was applied at each end of the slide and precleaned 480 $\mu g/cm^2$ [microgram per centimeter squared] mylar was stretched over the entire surface and cut to prevent overhang. The grease was used to prevent the movement of the mylar film during drying of the samples.

From the prepared stock solutions a 100 microliter [μl] sample was extracted from each of the vials and applied onto the mylar covered slide targets. This was done in two applications of 50 μl each. First a 50 μl sample was applied to the center of the slide and the samples were than placed in a fumehood and allowed to dry. This first stage of the drying process took about 16 hours. Once dry, a second 50 μl application was placed upon the first and the samples returned to the fumehood to dry for about 24 hours. This two stage process was used to provide a thicker target sample. The initial samples utilizing a single application of solution resulted in the spreading of the solution over a much larger surface of the target thereby reducing the effective target thickness and decreasing the elemental presence to below the detection level.

The target slides were than loaded into target ladders, which hold five slides each, and exposed to a 23.7 MeV proton beam for approximately 25 minutes per target slide.

4.32 Atomic Absorption Sample Preparation

The remaining stock solution was used for atomic absorption analysis and did not receive any further treatment.

5.0 TRACE ELEMENT ANALYSIS TECHNIQUES

5.1 PIXE Analysis Technique

Work by McKee et al. [1981;p.465] on trace element research in mouse brain tissue had suggested the use of 30 Megaelectronvolt [MeV] proton beam of 5 nanoÅngström [nÅ] width for between 20 and 30 minutes duration to provide detection levels of approximately 5 parts per million [ppm] for most elements.

Detection of trace elements was done using the following detectors. The first is a KEVEX - RAY [model 3010] silicon/lithium [Si/Li] detector which is used to detect light elements. The second detector is a ORTEC [Model 1113-10205] hyperpure germanium [Ge] detector used for the detection of the medium and heavy elements.

Analysis of the detection results was done using the XSYS data collection system and the COAXS analysis program [Francey and Durocher 1986;p.192] run on a VAX 11/750 computer operating under version 4.3 of the VMS operating system [Anderson and Smith 1986;p.52].

A correction formula was applied to each elemental netcount identified by the XSYS program to provide a ratio between the netcount of dysprosium [N(Dy)] versus the netcount of a given element [N(x)].

The correction formula used in this research contains a number of variables. The detector solid angle (Ω) is the relationship between the angle difference of the two detectors. In this study the angle is the same so the value cancels itself out and is therefore equal to one. The fluorescence yield (F) refers to... " the probability that a vacancy in the K shell is filled through a radiative transition and not by a radiationless transition (autoionisation)" (Langenberg and van Eck 1979;p.1331). The cross section (σ) is defined as... "A measure of the probability of a particular process." (Weast 1975;p.F94). The values in the formula used in this work comes from a study by Ramsay et al. [1978;p.259] which contains a table simplifying the complex formula used to calculate the cross section (σ).

The correction factor for the efficiency of the germanian detector (Ge) used in this study is from a 1980 PH.D. dissertation by Ramsay and work from Russ [1972]. The correction factor for the silicon detector (Si) was provided by the manufacturer, KEVEX - RAY, on a specification sheet. The final factor calculated in this correction formula was transmission (T) which refers to the effect of a paraffin absorber placed in front of the Ge detector to prevent proton damage (Durocher 1988).

The formula is expressed as follows...

$$\left[\frac{x}{Dy}\right] = \frac{N(x)}{N(Dy)} * \left[\frac{\epsilon(Dy)}{\epsilon(x)} * \frac{\sigma(Dy)}{\sigma(x)} * \frac{F(Dy)}{F(x)} * \frac{T(Dy)}{T(x)}\right]$$

Where (N) is the netcount of a element
(Dy) is dysprosium
(x) is element (x)
(ϵ) is the efficiency of the detector
(σ) is the cross section
(T) is the transmission
(F) is the fluorescence

5.2 Atomic Absorption Analysis Technique

Atomic Absorption analysis [AA] was done on the same sample stock used in the preparation of the PIXE slides. Analysis was run on a Varian Spectraa Model 20 with a built-in computer system for analysis. The system was set up for use of Air - Acetylene analysis only. Instrument parameters were set according to the computer analysis program provided with the system. Calibration of known samples was done for each element tested prior to sample runs. Each sample was run four times at a one sec integration and the four numbers averaged to arrive at a ppm number. Hard copy results were printed as each sample was completed. The following elements were tested, calcium [Ca], copper [Cu], iron [Fe], magnesium [Mg], manganese [Mn], sodium [Na], nickle [Ni], lead [Pb], and zinc [Zn]. These elements were chosen as they had been considered in the past for Atomic Absorption [Szpunar et al. 1978; Lambert et al. 1979; Lambert et al. 1982] and are inexpensive to run with a good level of reliability. As there was no facility for running air-nitric oxide analysis, stromtium [Sr] and aluminum [Al] could not be tested.

6.0 Osteological Analysis

6.1 Burial Summary

The following is a summary of the raw data which appears in Appendices A1 - 3.

Burial 1

Burial 1 had been exposed by the construction back hoe but was identifiable as being a secondary burial [disarticulated after death burial] of a female 24 to 26 years of age. There was no cranial material recovered from the feature. Identification of sex was based upon the examination of pelvic material and maximum femur head diameter. Age was determined by the presence of both partially fused and unfused epiphyseal caps on thoracic vertebrae. The femur and humerus both exhibited completely fused ephiphyseal unions.

There was no evidence of any pathological changes on the elements present.

The estimation of stature was based upon the averaged combination of possible standard regression forumulas [see Appendix A4 for explanation] for the elements represented in each burial. The estimation for

Burial #1 is 159.15 cm ±4.2.

Burial 2

Burial 2 is an extended coffin burial of a female 42 - 47 years of age. The adult burial had coins placed on the eye sockets, an 1842 Bank of Montreal penny token and an 1852 American Liberty penny. Sex of this individual is based upon pelvic material and maximum femur head diameter. Age was based upon endocranial suture closure [McKern 1970, Meindl and Lovejoy 1985] as all post cranial material had fused ephiphyses.

A second individual is represented by three elements, right and left unfused temporal fragments and a right mid-femur fragment. The three elements are in very poor condition but have been identified as human fetal remains.

The adult female exhibited pathological changes of the sacral - iliac articular surface and vertebral column. There was evidence of extensive lipping and the collapse of three lumbar vertebrae. The collapsed vertebrae are an example of a compression fracture. The general appearance of the pathological articular surfaces would suggest the presence of rheumatoid arthritis. There was also a distal fusion of the left tibia/fibula which affected the distal articular surface.

The heavy attrition of the teeth precluded identification of any morphological or pathological conditions.

Stature for the adult burial was estimated at 161.35 cm ±3.92.

Burial 3

The material in Burial 3 is divided into two parts. The first part is the material bagged prior to excavation. This bag contains the cranial remains of at least four individuals. Laboratory examination has shown that some of the cranial material represents mixing from Burial 4. The second part of Burial 3 is from the excavation of the area from which the bagged material came. This area indicated the presence of three discrete coffin burials. Two of the three individuals represented can be associated with the archaeologically excavated remains.

Burial 3A is a gracile female 18 - 25 years of age represented by a calvaria and incomplete post cranial material. Age was determined on the basis of endocranial fusion and the absence of any visible ephiphyseal lines.

Stature estimation was calculated at 162.91 cm ±4.05.

Burial 3B represents a robust male 25 - 30 years of age. Age was determined by endocranial suture closure and the presence of some visible epiphyseal lines and unfused ephiphyses on vertebrae. All the long bone epiphyseal fusions were complete.

The left articular surface of the axis - atlas exhibited lipping and possible slippage. The right distal ulna had an ununited healed break.

Stature was calculated at 169.87 cm ±3.6.

Burial 3C is identified by cranial material only. Morphologically it represents a female 21 - 25 years of age. There is no evidence of third molar eruption and tooth wear is slight. Endocranial suture closure and dental attrition [Brothwell 1965] were used to determine age.

Burial 3U represents material which could not be positively identified with one of the three coffin burial stains. A mandible has male traits and seems to match the material in 3B. A frontal fragment recovered was from Burial 4. Fragmentary dentition is present but can not be identified to a specific individual. A loose premolar seems to have one weak line which may be the result of enamel hypoplasia [Brothwell 1965;p.152].

Burial 4

Burial 4 was represented by a scatter of bone. No burial style could be identified. The remains are of a male 21 - 25 years of age. The cranial material is very fragmentary and the burial had been very disturbed prior to excavation. Two right auditory meatuses were recovered. One belongs with the 3B material. The frontal was recovered with the bagged material from Burial 3U.

Age was determined by the presence of an unfused costal clavicular epiphysis and the presence of wear on 3rd molars [Brothwell 1965;p.67].

Stature, calculated on a single upper arm long bone, is estimated as 173.32 cm ±4.05.

Burial 5

Burial 5 contained the remains of a female in a coffin burial, 17 - 18 years of age. The entire material was very fragmentary. The hands had been crossed over the pelvic area. An extra right humeral shaft fragment was recovered with the material. This shaft fragment may relate to material found north of this burial feature where a left humerus of unknown provenience was recovered.

The age was determined by the absence of the distal radius epiphysis, and the presence of unfused occipital condyles. The 3rd molars were in the process of eruption. Sex was determined by the mandibular and fragmentary cranial morphology as no innominate material was present.

The single upper and lower incisors recovered gave no evidence of shoveling. There was indication of one hypoplasia line [Brothwell 1965;p.152] on each of the premolar and molar teeth.

Stature is estimated to have been 154.72 cm ±4.35.

Burial 6

Located east of Burial 10, no identifiable human osseous material was recovered from this feature. This feature appears to have been disturbed prior to the 1984 Boise - Cascade construction, however, evidence of a burial stain was noted.

Burial 7

Burial 7 is a male in a coffin style burial , 17 -

19 years of age. The cranial material was very fragmentary and the right arm, including scapula and clavicle had not been interred in the coffin but buried separately underneath the coffin. The distal portion of the right arm was recovered outside of the coffin 25 cm deeper and to the immediate west of the coffin proper. As with burial 2 the left hand was placed upon the left thigh. Sex was based upon mandibular and post cranial morphology.

The age was determined by the presence of unfused proximal and distal femur epiphyses, unfused and partially fused vertebral epiphyses and the presence of visible metacarpal epiphyses. The 3rd molars were present but not worn.

A complete set of dentition was recovered with this burial. There was no indication of any shoveling on the incisors. Three faint lines which may be hypoplasia can be identified on front surface of the upper incisors. One faint line can be identified on the back of the upper canines.

Stature is estimated to have been 173.59 cm ±4.26.

Burial 8

Burial 8 is a female in a coffin style burial, 15

Burial 8 is a female in a coffin style burial, 15 - 18 years of age. The lower portions of the legs were missing and both patellae were recovered to the west of the burial. The hands were placed on the thighs. Four silver earrings on each side of the cranium were also recovered. These have been identified as fur trade period ear bobs [Rajnovich 1985;p.4].

Sex determination was based on mandibular and post cranial morphology.

Age was determined by the presence of 3rd molars and the absence of fusion of the epiphyses of the iliac crest and distal tibia. The vertebral epiphyses were fused but only recently so.

The mandibular dentition was recovered in full and most of the maxillary dentition was present but fragmentary [missing right second incisor, canine and first premolar]. The upper incisors exhibited moderate shoveling [+2: U of T] with little to no shoveling on the lower incisiors. The buccal enamel surfaces indicated many faint lines which may be the result of hypoplasia.

Stature is estimated to have been 162.11 cm ±3.97.

Burial 9

Burial 9 is a male in a coffin style burial, 17 - 25 years of age. The hands were placed at the thigh area under the femur. The phalanges of the left foot were absent and are believed to have been missing at the time of interment. Sex was determined by mandibular and post cranial morphology.

Age estimate was based upon the presence of 3rd molars and partially fused vertebral epiphyses, unfused distal clavicular epiphyses, and recently fused proximal femur epiphysis.

The full dentition recovered indicated slight shoveling of the upper incisors [+1:U of T] with no shoveling present on the lower incisors. There is one hypoplasia line evident on the lower canines and lower first and second molars.

Stature is estimated to have been 179.42 cm ±3.65.

Burial 10

Burial 10 is a female in a flexed burial position with no coffin, 42 - 64 years of age. Heavy bone deterioration and significant site disturbance were evident. The burial was oriented in an east facing direction. The hands appear to have been folded on the chest holding a brass crucifix. A large number of seed beads were also recovered from the region between the knee and the foot. These are probably the decorations on mukluks or leggings [Rajnovich 1985;p.4]. Sex was determined on the basis of cranial and post cranial morphology.

Age was determined by endocranial suture closure and dental eruption and wear. The heavy attrition of the teeth [Brothwell 1965;p.62] and general worn condition of the articular surfaces suggest that the age would be toward the high end of the range.

The articular surfaces and vertebral elements had a ragged appearance which would suggest the presence of rheumatoid arthritis [Steinbock 1976;p.277, Ortner and Putschuar 1981;p.403,411].

Stature was estimated at 161.29 cm ±3.95.

Burial 11

Both Burial 11 and Burial 12, due to their location [Fig 2] were discovered after construction work had been restarted at the site. Burial 11 is a young male, 18 - 25 years of age. The burial had been previously disturbed in the 1940's by the construction of a house and utility trench [Fig 2]. This disturbance has resulted in the loss of the cranium and thoracic section of the burial. The burial appears to have been a coffin burial with the hands placed on the thighs as in majority of the coffin burials.

No dentition was recovered with Burial 11.

Stature was estimated at 173.74 cm ±3.4.

Burial 12

Burial 12 was represented by a scatter of bone fragments recovered from the scoop of the back hoe. As such the type of burial and its orientation is unknown. The remains are of a male, 38 - 42 years of age. A carved stone pipe was also recovered in the scoop and may have been part of the burial.

The mandibular dentition was too damaged to indicate any features.

Stature is estimated to have been 169.18 cm ±4.05.

Burial 13

North of Burial 5 a scatter of bone was recovered which included one left temporal fragment, three 2nd or 3rd phalanges and two shaft fragments tentatively identified as humeral. None of this material was able to be identified with any other burial.

Unidentified Remains

Recovered in the back dirt piles were a right and left humerus of unknown provenience.

6.2 Anomalies and Pathology Summary

6.21 Bone

The fragmentary nature and incomplete recovery of the cranial and postcranial remains provides little information in terms of anomalies or pathologies. In the following summary the numbers in parentheses indicate the percent of occurence of the feature in the total recovered material.

6.211 Anomalies

Burial 3C had an unfused metopic suture [16.7%]. Burial 5 had 2 wormian lambdoidal bones [12.5%]. Burial 9 had a well developed lambdic bone (os inca) [12.5%]. Burial 12 exhibited a well developed occipital bun [12.5%]. Burial 8 exhibited both a right and a left mylohyoid arch [10%]. A left mylohyoid arch [22%] was present on Burials 5 and 9 and a right arch [14.3%] was present on Burial 12.

Burial 9 exhibited well developed septal aperture [13.3%] on both humeri. The right femur in burial 10 had pronounced bowing [7.1%] which appears to have occured antemortem rather than as a function of taphonomy.

6.212 Pathologies

The majority of pathological features identified from the Boise Cascade material are found on the adult remains from Burial 2. Burial 2 exhibits three of the four traumatic induced pathologies identified in the site material.

Starting from the superior of Burial 2 and working inferiorly, the burial exhibited a displacement of the inferior articular surface of the atlas and superior articular suface of the axis [12.5%]. The second pathology is a vertebral collapse fracture [2.4%] [Manchester 1983;p.58] involving the T10, T11 and T12 thoracic vertebrae (Plate 2) and L1 lumbar vertebra. The third pathology is a fusion of the distal right tibia and fibula [7.7%]. This has resulted in a modification of the joint capsule with involvement of the calcaneus. Associated with this union (Plate 3) is a callus formation on the fibular shaft just superior to the fused area.

The fourth traumatic pathological condition noted was found on the Burial 3B material. This consisted of a ununited healed fracture [5%] of the distal right humerus (Plate 4). There is extensive remodeling of the two fracture points and the formation of a secondary articular facet.

In addition to the traumatic patholological injuries there are three distinct types of arthritis present in the site material. Burial 2 exhibits the typical symptoms of osteoarthritis [degenerative arthritis] as noted in both Ortner and Putschar [1981;p.419] and Steinbock [1976;p.278]. Most of the joint surfaces exhibit trace lipping and modification with extensive lipping of the lumbar vertabrae. The lipping tends to be very compact, with a uniform smooth texture.

A type of osteoarthritis, traumatic arthritis, [Steinbock 1976;p.289] is the second type of arthritis identified in the material. There is evidence of traumatic arthritis on the pathological axis and atlas, collapsed three thoracic vertebrae and single lumbar vertebra, and in the distal right tibial joint capsule involving the tibia, fibula and calcaneus of Burial 2.

The final type of arthritis identified in the material comes from Burials 10 and 12. Both burials exhibit a distinct type of arthritis which is concentrated in the vertabrae. The alteration of the bone surfaces is very extensive and exhibits a very ragged appearence. The location and appearence of the alterations suggests either rheumatoid arthritis or ankylosing spondylitis [Ortner and Putschar 1981;p.403,411; Steinbock 1976;p.277]. The incomplete skeletons make differential diagnosis difficult. Both burials have involvement of C1 and C2 with extensive remodeling of thoracic and lumbar vertebrae. Burial 10 has two fused thoracic vertebrae and involvement of the proximal articular rib surfaces. Burial 12 has extensive modification [+4; U of T criteria] of lumbar bodies and their articular facets.

6.22 Dentition

Dental remains were recovered for ten of the burials [Appendix A5]. Reference to specific teeth follows the International Tooth Identification System [ITIS] adopted by the Canadian Dental Association [Stonehocker 1988] which is a simplification of the system detailed in Brothwell [1965:p.45]. In the two digit number system [ITIS] the first number is the quadrant and the second the specific tooth.

Quadrant		Tooth	
Right Maxillary	= 1	Incisor 1	= 1
Left Maxillary	= 2	Incisor 2	= 2
Left Mandible	= 3	Canine	= 3
Right Mandible	= 4	Premolar 1	= 4
		Premolar 2	= 5
		Molar 1	= 6
		Molar 2	= 7
		Molar 3	= 8

The overall dental picture for the site is quite mixed. Two individuals, Burials 2 and 12, have extensive wear of both maxillary and mandibular teeth at the +3 and +4 level [U of T; 0 - 4 scale] which would correlate with Brothwell's [1965:69] 4 to 5++ attrition level, indicating exposed pulp chambers. In addition to attrition, tooth loss in the collection has occured antemortem as a function of pathological and possibly congenital factors, and postmortem as a result of incomplete dental recovery. The end result of this is the obscuring of dental features and inaccurate caries rates.

6.221 Anomalies

Enamel extensions, without pearls, [Brothwell 1965;p.118-119 and Bass 1971;p.238] were noted in two of the burials. Burial 7 had 6 teeth, all maxillary, with extensions. The other, Burial 8, had 9 teeth, 5 maxillary and 4 mandibular, with extensions.

There was one paramolar cusp [Brothwell 1965;p.119 and Bass 1971;p.230] detected and this was on tooth 18 of Burial 9.

The occlusal surface of teeth 38 and 48 of Burial 9 also exhibited an unusual surface (Plate 5). The centre occlusal surface of the two teeth was dished and lacked standard cusp formation. This central surface was formed with a series of sharp minicusps less than 1 mm in height. The very centre of the surface had a small cavity which appears to be of congenital rather than pathological origin.

6.222 Pathology

The overall caries rate based upon the number of teeth recovered [n=190] and the number of caries present [n=28] is calculated at 14.7%. This is a minimum figure as there were 10 teeth [not included in n above] not recovered due to pathological absence, 6 teeth missing premortem from unknown cause [not included in n; see Appendix A5 for explanation], and 26 teeth [included in n] which had an attrition level of 3 or greater obscuring any occulusal pit or upper crown approximal caries.

The distribution of caries is summarized in tables (A) and (B).

Table (A) Frequency of Caries

	I1	I2	C	PM1	PM2	M1	M2	M3	Total	
Maxillary										
Pit	0	0	0	2	1	7	0	3	13	
Approximal	0	0	0	0	0	1	0	0	1	
Both	0	0	0	0	0	1*	0	0	1*	14
Mandibular										
Pit	0	0	0	0	1	6	2	2	11	
Approximal	0	0	0	0	2	0	1	0	3	
Both	0	0	0	0	0	0	0	0	0	14
Total				2	4	14	3	5	28	

*counted in Pit and Approximal as separate occurrences.

Table (B) Frequency of Caries As a Percent

	I1	I2	C	PM1	PM2	M1	M2	M3	Total
Maxillary									
Pit	0	0	0	7.1%	3.6%	25%	0	10.7%	46.4%
Approximal	0	0	0	0	0	3.6%	0	0	3.6%
Both	0	0	0	0	0	3.6%*	0	0	3.6%*
Mandibular									
Pit	0	0	0	0	3.6%	21.4%	7.1%	7.1%	39.3%
Approximal	0	0	0	0	7.1%	0	3.6%	0	10.7%
Both	0	0	0	0	0	0	0	0	0
Total				7.1%	14.3%	50%	10.7%	17.9%	100%

*counted in Pit and Approximal as separate occurrences.

Table (C) breaks down by burial the number of caries, the percent of total caries, and the total number of teeth recovered from each burial which contained dentition.

Table (C) Number of Teeth and Caries By Burial

Burial Number	Number of Teeth	Number of Caries	Percent of Total Caries
2	19	2	7.1%
3C	16	4	14.3%
3U	28	2	7.1%
4	5	3	10.7%
5	8	0	0
7	32	5	17.9%
8	29	3	10.7%
9	32	4	14.3%
10	6	3	10.7%
12	15	2	7.1%
Total	190	28	100.0%

If anterior teeth are defined as including incisors, canines and premolars and posterior teeth as including the molars, we can compare the frequency of anterior to posterior caries. Using this definition, the ratio of posterior to anterior caries is 22 [79%] to 6 [21%].

Periodontal disease was detected in four of the burials. The degree varied from slight to medium using Brothwell's four stage system [1965:p.150]. Burials 3U and 12 had slight involvement of the mandibular alveolus. Burials 2 and 3C had medium involvement of both maxillary and mandibular alveoli.

7.0 TRACE ELEMENTS RESULTS SUMMARY

7.1 Atomic Absorption

The results of the Atomic Absorption [AA] runs selected for this study are presented in their entirety in Appendix 6. The element summary in Tables D and E is the calculation of the average parts per million [ppm] by sex, sample material and age respectively. Table F divides the data into criteria of three age sets, 16 - 21 years, 22 - 30 years and over 30 years of age for each sex.

The following elements were tested for by AA; calcium [Ca], copper [Cu], iron [Fe], magnesium [Mg], manganese [Mn], sodium [Na], nickle [Ni], lead [Pb], and zinc [Zn].

The results of the following four elements tested have to be considered questionable due their low level of detection.

The level of nickel [Ni] which was detected in each sample was either 20 or 25 ppm. The lack of variation in the samples supports the belief of some sort of problem with the samples. This could be the result of contamination of the sample as a function of trace elements present in either the acid used in sample preparation or through physical contamination from the soil. Logically the best explanation for the lack of variation would be an error resulting from the calibration curve generated from the laboratory standards used to calibrate the run or a minimal detection level given the established calibration.

Manganese [Mn] showed fairly weakly with values ranging from 20 - 229.5 ppm. Soil samples varied between 45.5 - 179.5 ppm. The two cranial samples from Greece [X61 and X63] registered at the top end of the range [147.0 and 200.0 ppm]. This may reflect the variation of trace element concentrations between samples from cranial versus rib specimens. The difference would warrant further study on a much larger scale to determine if there is a significant difference for Mn between different bone locations. There is however a slight [9%] difference between the male and female averages. Additionally there is a significant increase [27.3%] in the the female age sets with an increase in age.

The concentration of copper [Cu] was also weak [8 - 152.5 ppm]. The majority of the values are at the lower end of the calibration curve [8 - 25 ppm] and represent 75% of the total number of samples. This must be taken into account when considering the values in the Tables. The values indicate that the average

TABLE D ATOMIC ABSORPTION ANALYSIS BY SEX AND MATERIAL

AVERAGES IN PPM

N = []

ELEMENT	MALE and FEMALE	MALE	FEMALE	SOIL
As				
Ba				
Br				
Ca	47752.08 [24]	49142.31 [13]	46109.09 [11]	6237.50 [4]
Co				
Cr				
Cu	31.75 [24]	18.77 [13]	47.09 [11]	15.75 [4]
Dy				
Fe	635.42 [24]	574.23 [13]	707.73 [11]	3233.75 [4]
Ga				
Gd				
Ho				
K				
Mg	1704.17 [24]	1676.92 [13]	1736.36 [11]	1237.50 [4]
Mn	73.46 [24]	76.62 [13]	69.73 [11]	135.88 [4]
Mo				
Na	1410.42 [24]	1351.54 [13]	1480.00 [11]	136.25 [4]
Nb				
Ni	21.14 [22]	20.77 [13]	21.67 [9]	20.00 [4]
P				
Pb	72.23 [24]	65.27 [13]	80.45 [11]	55.75 [2]
Rb				
Ru				
Sb				
Sn				
Sr				
Ti				
Y				
Yb				
Zn	2499.35 [23]	2608.85 [13]	2357.00 [10]	255.00 [4]
Zr				

TABLE E ATOMIC ABSORPTION ANALYSIS BY AGE

AVERAGES IN PPM

N = []

		AGE 16 - 21 YRS	AGE 22 - 30 YRS	AGE > 30
E	As			
L	Ba			
E	Br			
M	Ca	47550.00 [9]	49333.33 [9]	45683.33 [6]
E	Co			
N	Cr			
T	Cu	53.86 [7]	21.61 [9]	21.25 [6]
	Dy			
	Fe	578.89 [9]	542.22 [9]	860.00 [6]
	Ga			
	Gd			
	Ho			
	K			
	Mg	1805.56 [9]	1550.00 [9]	1783.33 [6]
	Mn	48.72 [9]	98.33 [9]	73.25 [6]
	Mo			
	Na	1332.78 [9]	1457.78 [9]	1455.83 [6]
	Nb			
	Ni	22.78 [9]	20.00 [8]	20.00 [5]
	P			
	Pb	46.67 [9]	84.06 [9]	92.83 [6]
	Rb			
	Ru			
	Sb			
	Sn			
	Sr			
	Ti			
	Y			
	Yb			
	Zn	2417.50 [8]	2523.33 [9]	2572.50 [6]
	Zr			

TABLE F ATOMIC ABSORPTION ANALYSIS BY SEX AND AGE

AVERAGES in PPM

N = []

		MALE 16 - 21 YRS	MALE 22 - 30 YRS	MALE > 30 YRS	FEMALE 16 - 21 YRS	FEMALE 22 - 30 YRS	FEMALE > 30 YRS
E	As						
L	Ba						
E	Br						
M	Ca	50225.00 [8]	49907.14 [7]	44300.00 [2]	45410.00 [5]	47325.00 [2]	46375.00 [4]
E	Co						
N	Cr						
T	Cu	19.75 [2]	16.36 [7]	13.50 [2]	67.50 [5]	40.00 [2]	25.13 [4]
	Dy						
	Fe	586.25 [4]	505.00 [7]	792.50 [2]	573.00 [5]	672.50 [2]	893.75 [4]
	Ga						
	Gd						
	Ho						
	K						
	Mg	1787.50 [4]	1614.29 [7]	1675.00 [2]	1820.00 [5]	1325.00 [2]	1837.50 [4]
	Mn	33.88 [4]	107.79 [7]	53.00 [2]	60.60 [5]	65.25 [2]	83.38 [4]
	Mo						
	Na	1180.00 [4]	1446.43 [7]	1362.50 [2]	1455.00 [5]	1497.50 [2]	1502.50 [4]
	Nb						
	Ni	22.50 [4]	20.00 [7]	20.00 [2]	23.00 [5]	20.00 [2]	20.00 [3]
	P						
	Pb	51.25 [4]	74.64 [7]	60.50 [2]	43.00 [5]	117.00 [2]	109.00 [4]
	Rb						
	Ru						
	Sb						
	Sn						
	Sr						
	Ti						
	Y						
	Yb						
	Zn	2495.00 [4]	2683.57 [7]	2575.00 [2]	2340.00 [4]	1962.50 [2]	2571.25 [4]
	Zr						

concentration for Cu in the samples identified as female are two and a half times higher then the average concentration for samples identified as male. In addition there is a 60.6% decrease in ppm with age. This trend can also be seen in both male and female age set samples [Table F] but is much more pronounced in the female samples.

The fourth element which has a low representation is lead [Pb]. The range detected in the samples was small [0.5 - 206 ppm] with the bone samples falling between 31.0 - 206 ppm. Two of the four soil samples had no lead detected, the other two samples averaged 55.75 ppm [Table D]. Values in the tables also indicate differences in lead concentration for both age and sex. The age values indicate a two fold increase in lead between the youngest and oldest age sets. The averaged male samples exhibit 18.9% less lead than the averaged female samples. The female age set samples also show a strong increase, approximately 2.5 times higher, between the youngest age set and the other two age sets.

As expected given the amount of calcium [Ca] which is present in bone, the Ca level was the highest for all of the AA results. The bone samples ranged from 39,900 to 70,000 ppm with a calculated average of

49,414.5 ppm. The soil samples had a calculated Ca average of 6,237.5 ppm with a range between 2280 and 13,000 ppm. The values in Table D for the male samples exhibited a higher Ca level, approximately 6.7%, than the female samples. Table E exhibits a drop in level of about 12% between the youngest and oldest age group. The calculated averages for the female samples indicated a slight increase [2%] between youngest and oldest age group [Table F]. The two Greek cranial fragments [Samples X61 and X63] had a Ca level 30% higher than the calculated average for the DdKi-2 site material. This may reflect differential Ca levels between parts of the skeleton or their non-local provenience.

The level of iron [Fe] detected ranged between 190 and 5500 ppm for all samples tested. The bone samples ranged from 190 to 1650 ppm with a calculated average of 644.5 ppm. The soil samples had a calculated average of 3234 ppm and a range of 1605 to 5500 ppm. The female samples exhibited an 18.9% higher calculated average than the male samples. Examination of the age categories [Table E] indicate an increase in Fe level with age. This trend can best be seen in the female age sets [Table F] which exhibit a 36% increase in the calculated averages between the youngest and oldest age sets.

Magnesium [Mg] detection ranged between 800 and 2100 ppm with a calculated average of the bone samples of 1600 ppm. The Mg level in the soil samples ranged between 1050 and 1800 ppm with a calculated average of 1237.5 ppm. The two Greek cranial fragments [X61 and X63] exhibited a level 50% below the calculated average for the site bone samples. The two local tibial fragments tested from DdKi-2 site material [samples 11 and 18] are consistent with values determined for the rib samples. The magnitude of the variation in Mg for the cranial samples from the calculated average would seem to represent more than just a variation between specific parts of the skeleton. The male age sets [Table F] indicate a slight drop [6.3%] with age between the youngest and oldest categories.

The level of sodium [Na] detected in the site samples ranged from 75 to 1765 ppm. The bone samples ranged from 1070 to 1765 ppm with a calculated average of 1404.5 ppm. The soil samples ranged from 75 to 165 ppm with a calculated average of 136.5 ppm. The figures in Table D indicate a 8.5% difference between the calculated values by sex. The male average is reduced in the 16 to 21 age group which is 16% below the calculated average for tested bone samples [Table F].

The detection of zinc [Zn] in the samples ranged from 20 to 3300 ppm. The soil samples all tested out between 20 and 550 ppm with a calculated average of 255 ppm. The bone samples ranged from 435 to 3300 ppm with a calculated average of 2293 ppm. This average is decreased when the two Greek cranial samples are considered. The calculated average for the bone samples excluding the two Greek cranial samples is recalculated at 2525 ppm. Bone sample 12 was spilled prior to testing for Zn. The results in Table D show a difference in Zn levels between the male and female samples. The male samples tested to a 9.7% higher level of Zn than the female samples. Table F also indicates a small increase in Zn levels [6%] with an increase in age.

7.2 PIXE

Rather than being aimed at the detection of specific elements the PIXE results were aimed at the detection of a broad spectrum of light elements. The net effect of this was to increase the minimum detection level for the heavier elements. Unlike the data recovered using Atomic Absorption, several elements which were detected, bromine [Br], molybdenum [Mo],niobium [Nb], rubidium [Rb], yttruim [Y], ytterbium [Yb], zirconium [Zr], are not currently, considered important in the evaluation of human trace element work. Therefore the summary of the results will focus upon the key elements of calcium [Ca], copper [Cu], iron [Fe], manganese [Mn], nickle [Ni], phosphorus [P], strontium [Sr], and zinc [Zn]) which were detected using the PIXE technique.

The entire results of the PIXE runs are summarized in Tables G - I. These tables use the same sex, sample, and age/sex criteria as the Atomic Absorption technique Tables D through F.

Two additional elements, arsenic [As] and zirconium [Zr] were detected in a limited number of targets. The eight targets which were identified as having As represent only 5 individuals in the study sample. Detection levels were quite low ranging between 15.1 - 88.18 ppm and having a calculated average of 58.69 ppm. The data shows a similar drop in As level with increasing age [Table H]. Additionally female samples exhibited a 10% lower level than male samples [Table G]. The small sample size [male n=2, female n=3] minimizes the importance of As to the sample population.

The presence of zirconium [Zr] was unexpected. It was detected in 9 individuals [male n=5, female n=3, unidentified n=1] and three soil samples. The detection ranged between 20.35 - 138.04 ppm for all the samples with all the bone material registering in the 20.35 -

78.69 ppm range. The three soil samples had a calculated average of 89.28 ppm which is two times greater than the combined male/female bone average of 43.58 ppm [Table G]. Additionally Zr showed a marked increase, of 1.5 times, with an increase in age [Table H]. This is best seen in the male age sets which exhibit a twofold increase between the youngest and oldest age categories [Table I]. The small subset sample size limits the information which can be summarized.

The following eight trace elements were well represented in the detection material and have been considered in the existing literature on trace elements.

As with the Atomic Absorption results calcium [Ca] is the best represented element in the PIXE target material. The range of detection for the entire material was very large, 2139.34 - 229,023.85 ppm. The bone material varied from 43,408 - 229,023.85 ppm with a calculated male/female average of 94,883.35 ppm [Table G]. The four soil samples were at the low end of the range and varied from 2139.34 - 10,657.11 ppm with a calculated average of 5418.25 ppm [Table G]. The samples identified as male had a 12.6% lower level of Ca than the female material [Table G]. In addition the female age set material exhibited a 21.4% increase in Ca

TABLE G PIXE ANALYSIS BY SEX AND MATERIAL

AVERAGES in PPM

N = []

ELEMENT	MALE and FEMALE	MALE	FEMALE	SOIL
As	58.69 [8]	62.24 [3]	56.56 [3]	
Ba	126.58 [1]	126.58 [1]		
Br	24.21 [1]		24.21 [1]	
Ca	94883.35 [24]	89013.41 [13]	101820.55 [11]	5418.25 [4]
Co	10.12 [1]		10.12 [1]	
Cr				36.72 [2]
Cu	246.30 [11]	248.30 [4]	245.15 [7]	192.94 [2]
Dy	2500.00 [24]	2500.00 [13]	2500.00 [11]	2500.00 [4]
Fe	2484.25 [24]	2267.96 [13]	2739.87 [11]	11706.07 [4]
Ga	25.46 [1]		25.46 [1]	
Gd				
Ho				
K				1297.65 [4]
Mg				
Mn	6230.18 [24]	5725.27 [13]	6826.88 [11]	3882.11 [4]
Mo	17.78 [1]		17.78 [1]	
Na				
Nb	20.25 [2]		20.25 [2]	11.98 [1]
Ni	143.73 [17]	150.34 [10]	134.30 [7]	166.14 [2]
P	2137.04 [24]	2097.42 [13]	2183.88 [11]	81.72 [4]
Pb				
Rb	135.47 [1]		135.47 [1]	38.18 [3]
Ru				
Sb				83.65 [1]
Sn	107.37 [1]	107.37 [1]		220.63 [2]
Sr	137.43 [32]	148.23 [18]	123.55 [14]	81.20 [5]
Ti				901.96 [4]
Y	29.66 [1]		29.66 [1]	17.96 [1]
Yb	7919.58 [3]	7202.79 [2]	9353.16 [1]	
Zn	697.34 [24]	656.13 [13]	724.23 [11]	281.76 [4]
Zr	43.58 [10]	44.58 [7]	41.25 [3]	89.28 [4]

TABLE H PIXE ANALYSIS BY AGE

AVERAGES in PPM

N = []

ELEMENT		AGE 16 - 21 YRS	AGE 22 - 30 YRS	AGE > 30
E	As	77.49 [1]	61.79 [4]	48.30 [3]
L	Ba		126.58 [1]	
E	Br			24.21 [1]
M	Ca	93685.42 [9]	84044.93 [9]	112,937.87 [6]
E	Co		10.12 [1]	
N	Cr			
T	Cu	240.04 [5]	291.78 [3]	211.24 [3]
	Dy	2500.00 [9]	2500.00 [9]	2500.00 [6]
	Fe	2428.06 [9]	1813.64 [9]	3574.46 [6]
	Ga	25.46 [1]		
	Gd			
	Ho			
	K			
	Mg			
	Mn	5550.28 [9]	6247.87 [9]	7223.47 [6]
	Mo			
	Na			
	Nb	22.66 [1]		17.78 [1]
	Ni	135.43 [7]	115.86 [6]	200.08 [4]
	P	2283.68 [9]	1797.92 [9]	2425.77 [6]
	Pb			
	Rb			135.47 [1]
	Ru			
	Sb			
	Sn		107.37 [1]	
	Sr	136.69 [10]	112.99 [11]	162.55 [11]
	Ti			
	Y			29.66 [1]
	Yb		5665.57 [1]	9046.58 [2]
	Zn	682.65 [9]	603.85 [9]	619.63 [6]
	Zr	37.57 [5]	39.66 [2]	56.23 [3]

TABLE I PIXE ANALYSIS BY SEX AND AGE

AVERAGES in PPM

N = []

		MALE 16 - 21 YRS	MALE 22 - 30 YRS	MALE > 30 YRS	FEMALE 16 - 21 YRS	FEMALE 22 - 30 YRS	FEMALE > 30 YRS
E	As		62.24 [3]		77.49 [1]	60.42 [1]	48.30 [3]
L	Ba		126.58 [1]				
E	Br						24.21 [1]
M	Ca	94800.60 [4]	81805.84 [7]	102,665.51 [2]	92793.28 [5]	91881.73 [2]	118,074.05 [4]
E	Co					10.12 [1]	
N	Cr						
T	Cu	117.84 [1]	291.78 [3]		270.59 [4]		211.24 [3]
	Dy	2500.00 [4]	2500.00 [7]	2500.00 [2]	2500.00 [5]	2500.00 [2]	2500.00 [4]
	Fe	2727.52 [4]	1735.58 [7]	3212.16 [2]	2188.49 [5]	2086.85 [2]	3755.62 [4]
	Ga				25.46 [1]		
	Gd						
	Ho						
	K						
	Mg						
	Mn	5035.00 [4]	5911.35 [7]	6454.55 [2]	5962.51 [5]	7425.69 [2]	7607.94 [4]
	Mo						17.78 [1]
	Na						
	Nb				22.66 [1]		17.84 [1]
	Ni	196.57 [3]	116.49 [7]	165.61 [2]	89.57 [4]	112.71 [1]	234.55 [2]
	P	2427.20 [4]	1802.80 [7]	2469.01 [2]	2168.87 [5]	1780.84 [2]	2404.16 [4]
	Pb						
	Rb						135.47 [1]
	Ru						
	Sb						
	Sn		107.37 [1]				
	Sr	129.19 [5]	125.64 [9]	222.88 [4]	144.19 [5]	56.08 [2]	128.08 [7]
	Ti						
	Y						29.66 [1]
	Yb		5665.57 [1]	8740.00 [1]			9353.16 [1]
	Zn	580.36 [4]	678.97 [7]	727.73 [2]	764.47 [5]	340.93 [2]	865.58 [4]
	Zr	33.30 [3]	39.66 [2]	66.43 [2]	43.97 [2]		35.81 [1]

between the 16 - 21 age set and the over 30 age set [Table I]. Both the combined sex age set [Table H] and the male age set data [Table I] exhibited a decrease in the 21 - 30 age group but the overall trend supports an increase with age.

Copper [Cu] was detected in 14 of the 32 targets. The 14 detections represent 11 rib samples [male n=4, female n=6, unidentified n=1], 1 tibial sample [female n=1] and 2 soil samples. The range of detection in all samples varied from 31.77 - 476.96 ppm. The bone samples had a combined male/female average of 246.3 ppm. The 2 soil samples had an average of 192.94 ppm. There are no age or sex trends which can be identified due to the small sample size and the variation within the detection material.

The PIXE technique detected iron [Fe] in all 32 targets with the detection ranging from 645.45 - 19,212.23 ppm for all material. The detection of Fe in the soil material was in the upper area of the calibration curve with a range of 5986.44 - 19,212.23 ppm and a calculated average of 11,706.07 ppm. The bone material varied from 645.45 - 5831.9 ppm with a combined male female average of 2484.25 ppm. The male material had a 17.2% lower average level of Fe [Table G]. Examination of the age sets indicates an overall average increase of 32.1% between the 16 - 21 and over 30 combined sex sets [Table H]. This increase with age can be seen most graphically in the female age set material which exhibits a 41.7% increase between the youngest and oldest age sets [Table I].

The PIXE detection of manganese [Mn] was also very high with a range of 2292.08 - 15,295.95 ppm. The soil samples were in the low end of the range [2292.08 - 4851.59 ppm] with a calculated average of 3882.11 ppm. Detection in the bone material ranged from 3637.85 - 15,295.95 ppm with a combined male female average of 6230.18 ppm. The calculated average for the male targets had a 16% lower level of Mn detected in the sample material [Table G]. In addition the material shows a consistent increase [approximately 22%] of Mn with the increased age of the individual. This occurs not only in the general age sets [Table H] but also in both the male/female age sets [Table I].

Nickel [Ni] was detected in 21 of 32 targets and represents 2 soil samples and 12 individuals [male n=6, female n=4, unidentified n=2]. The levels detected ranged from 79.24 - 317.88 ppm. The average combined male/female average [n=10] was 143.73 ppm. The 2 soil samples had a combined average of 166.14 ppm. The values in Table G indicate a level of detection of 10.7%

less for the female bone material. In addition to the sex set material the 16 - 21 age material exhibits a 32.3% lower level of Ni than the over 30 age set [Table H]. This trend is most apparent in the female age set material with the over 30 set being 2.6 times higher the 16 - 21 set [Table I].

Phosphorus [P] was detected by PIXE in all 32 sample targets. The range of detection varied from 33.51 - 5130.56 ppm The four soil samples were in the low end of the detection level with a range of 33.51 - 148.35 ppm with a calculated average of 81.72 ppm. The bone samples had a detection range of 941.36 - 5130.56 ppm and a combined male/female average of 2137.04 ppm. The sex and age set data in Tables H - I exhibit no clear trends.

Also detected in all 32 of the targets was strontium [Sr]. The overall detection levels ranged from 17.99 - 383.14 ppm. The soil samples were in the low end of the detection level with a average of 81.2 ppm. The bone samples had a detection range of 44.99 - 383.14 ppm with a combined male/female average of 137.43 ppm. The values indicated in Table G show a 16.7% lower level of Sr detected in the female samples. The male age set material also indicate an increase in Sr [42%] between the 16 - 21 age set and the over 30 age set.

This is not the case for the female age sets which indicate a general decrease [11%] of Sr with increasing age [Table I].

The last element well represented in the PIXE target material was zinc [Zn]. The detection of Zn in the entire target material ranged from 141.23 - 2119.97 ppm. The level of Zn detection in the soil samples ranged from 224.7 - 386.73 ppm and had an average of 281.76 ppm. Exclusion of the two Greek bone samples changes the range for the bone material to between 257.6 and 2119.97 ppm. The average for the two Greek samples is 150.42 ppm. The combined average of the male-female material is 687.34 ppm which is 4.6 times higher than average for the Greek bone material. The values from Table G indicate that the male average is 9.4% lower than the female average. The age set values indicate an increase of Zn level [16.7%] between the 16 - 21 and over 30 combined sex averages [Table H]. This is most strongly illustrated by the 20.3% increase in Zn levels with age in males [Table I].

8.0 DISCUSSION AND CONCLUSION

8.1 Discussion

The lack of a data base developed with similar detection systems as well as the temporal and spatial differences between collections already studied makes comparisons difficult. As stated by Parker and Toots...

> "In all studies of bone and tooth minor elements, natural variation must be taken into account and reliance on comparisons of single analyses must be exchewed. One must compare sets of data, not individual analyses. Precision is influenced by the natural variations, ranging from slight to very large, within and between samples."
> [1980;p.198]

Parker and Toots [1980;199] have noted that the diagenetic changes which occur with trace elements can be either additive or subtractive to the overall total of any given element within all bone structure. Some elements may replace existing elements. For example, both fluorine [Fl] and yttrium [Y] can replace Ca in bone [op. cit.;p.85]. Other elements, notably zinc [Zn] and copper [Cu], are antagonistic to each other and as one increases the other decreases [Gilbert 1977;p.90].

Table J summerizes the results of the two techniques employed in this study with Atomic Absorption and X-Ray Fluorescence [XRF] results on human rib material from eleven archaeological sites and includes some limited data on ashed modern rib and cadaver specimens.

The archaeological bone material from the literature which is referred to in Table J can be separated into three geographical areas. The Dickson, Gibson and Ledders material are all from Woodland mound sites in Illinois [Szpunar 1978; p.201 and Lambert et al. 1979;p.116]. The Gibson site has been identified as a Middle Woodland site dated to A.D. 175 ± 80. The Ledders site is identified as a Late Woodland period site dated A.D. 1009 ± 43 [Lambert et al. 1979;p.116].

Three Wisconsin sites, Aztalan, Millville and Reigh, have also been included in the table. The Aztalan site has been identified as Middle Mississippian, A.D. 1120 [Price and Kavanagh 1982;p.66]. The Millville site is a Middle Woodland site dated at A.D. 350 [Price and Kavanagh 1982;p.66]. The last of the Wisconsin material comes from the Reigh site. This site has been identified as belonging to the 'Old Copper Culture', 710 B.C. [Price and Kavanagh 1982;p.66]

The last of the archaeological data drawn from the literature comes from southern Ontario: Fairty (Middle Ontarian Iroquois A.D. 1350 - 1400), Kleinburg (believed to be affiliated with the Huron A.D. 1600), Ossassane

Table J

Summary Trace Elements in Compact Human Rib Bone and Soil [ppm] From Archaological Sites

	DdKi - 2 Bone		DdKi - 2 Soil		Gibson Bone [1]	Ledders Bone [1]	Dickson Bone [2]	Reigh Bone [3]	Millville Bone [3]	Aztalan Bone [3]
Technique	PIXE	AA	PIXE	AA	AA	AA	AA	AA	AA	AA
[n=]	n=27	n=27	n=4	n=4	n=86	n=32	n=25	n=3	n=2	n=3
[Sr n=]	n=27	n=27	n=4	n=4	n=91	n=45	n=25	n=3	n=2	n=3
Element										
Al					2260± 1840	2360± 1420		2270	1865	1089.7
As	58.69									
Ba	126.58							63.24	520.85	384.9
Br	24.21									
Ca	94883.35	47752.08	5418.25	6237.5	33.0± 4.3*	32.9± 3.3*		39.22*	28.26*	32.59*
Co	10.12									
Cu	246.3	31.75	192.94	15.75	10.6± 7.5	10.5± 2.3	1.6± 1.2	73.14	17.48	42.2
Fe	2484.25	635.42	11706.07	3233.75	3460± 2320	3630± 1420		3222.3	1837	1203.7
Ga	25.46									
Mg		1704.17		1237.5	5870± 2380	3340± 1250	2740± 516			
Mn	6230.18	73.46	6230.18	135.88	338± 125	410± 148				
Mo	17.78									
Na		1410.42			4130± 1120	3710± 1250				
Nb	20.25		11.98							
Ni	143.73	21.14	166.14	20.00						
P	2137.04		81.72							
Pb		72.23		55.75						
Rb	135.47		38.18							
Sn	107.37		220.63							
Sr	137.43		81.2		192± 105	158± 41	189± 28	115.7	213.2	247.1
Y	29.66		17.96							
Yb	7919.58									
Zn	687.34	2499.35	281.76	255.0	302± 158	308± 129	131± 44	419.7	221.2	263.8
Zr	43.58		89.28							

*Ca figures given in % not ppm

1 from Lambert, Szpunar and Buikstra [1979;p.118]

2 from Gilbert 1975 in Szpunar, Lambert and Buikstra [1978;p.201]

3 human rib samples only from Price & Kavangh [1982;p.75]

TABLE J [Cont.]

Summary Trace Elements in Compact Human Rib Bone and Soil [ppm] From Archaological Sites

	Serpent Mound Bone [4]	Serpent Pit Bone [4]	Farity Bone [4]	Kleinburg Bone [4]	Ossussane Bone [4]	Recent Ashed Rib Bone [4]	Cadaver4 Bone
Technique	XRF	XRF	XRF	XRF	XRF	XRF	XRF
Element							
Al	2243.81	1598.18	1602.38	1566.43	1460.59	5 - 110	674.73
As							
Ba							
Br							
Ca	383,936.82	385,137.52	387,181.54	387,924.84	382,736.12		
Co							
Cu							
Fe	1615.61	1986.29	1279.89	1140.02	1168.00	400± 300	262.28
Ga							
Mg	5016.96	4884.3	4329.54	4691.34	4980.78	4600± 1000	8442.0
Mn	480.19	542.15	247.84	294.31	387.25	2 - 10	116.18
Mo							
Na							
Nb							
Ni							
P	162,236.06	175,366.79	176,532.52	173,565.00	180,041.18		
Pb							
Rb	7.6± 4.7	5.0± 1.5	4.0± 1.2	2.8± 0.9	1.5± 0.4	0.8± 0.5	
Sn							
Sr	201.9	236.9	181.1	129.7	101.6		
Y	7.5± 3.4	7.8± 3.1	2.8± 2.1	1.9± 0.8	0.6± 0.5		
Yb							
Zn							
Zr	29.2± 27.8	10.4± 7.3	4.6± 3.5	3.5± 4.1	0.6± 1.2	5.1± 1.8	

[4] Archaeological rib bone material from five distinct populations in southern Ontario [Katzenberg 1984;p.82,92-93,140-145].

(Huron A.D. 1636), Serpent Mound (Middle Woodlands A.D. 100 - 300), and Serpent Pit (Late Woodlands A.D. 1250) [Katzenberg 1984;p.32 to 46].

Five elements [Ca,Cu,Fe,Mn,Zn] were detected by both AA and PIXE in this study. Four of the five elements [Ca,Cu,Fe,Mn] detected by both techniques had much higher ppm readings using PIXE. The fifth element [Zn] had a much higher AA detection.

When compared to the archaeological rib bone data from the literature, summerized in Table J, several observations can be made. None of the AA results from the DdKi - 2 material correspond to the AA data from the Gibson, Ledders, or Dickson sites included in Table J. The PIXE detection of Fe and Sr in the DdKi-2 samples are close to the expectations of XRF and AA studies but all other elements are significantly different. However it should also be noted that there is considerable detection variation between the different techniques exemplified in Table J.

Very little can be said in terms of comparison of the two analytical techniques used on the DdKi-2 material. The data indicates some shared and some distinct trends for each technique. Whether the sharing of trends is a function of actual similarity in sensitivity of detection or is the result of coincidence is unclear at this time.

8.2 Suggestions For Future Studies

In real terms the sample preparation resulted in too great a dilution of the detectable trace elements. Further work should concentrate upon the establishment of a technique(s) to increase the amount of bone to sample solution. The work by Szpunar et al. [1978] on the ashing of bone samples may be one solution of the dilution problem. As stated in their paper "We can conclude that complete dissolution [of bone] achieves superior analytical results in certain cases and in no cases gives lower results." [op. cit. 1978;p.201].

A second solution may be the use of a PIXE microprobe such as used by Wheeler et al. [1987] which works directly on the bone without any alteration of the actual bone material. The technique produces data similar to standard PIXE analysis but does not require chemical or mechanical reduction of the bone for sample preparation. This would be a preferred technique as it limits laboratory sample contamination during sample preperation.

The low detection of heavier elements with the

PIXE technique utilized in this study, was a function of the energy levels chosen to enunciate lighter elements. A second run focusing upon heavier elements is indicated to give a more complete picture of the actual working parameters of the PIXE technique.

It is clear that both thin target analysis such as used in this study or the microprobe technique of PIXE can supplement and possibly replace existing techniques of trace element analysis [i.e. AA] for bone material.

One important application of PIXE trace element analysis would be the comparative study of different bones from a small sample of identified complete skeletons. Three blind runs of the same samples run blind would probably provide the required information for establishing sensitivity and detection levels for the PIXE techniques.

Additionally, the laboratory preparation of a synthetic bone sample with known amounts of select trace elements would help identify sensitivity parameters of elements not commonly found in bone.

8.3 Conclusion

The objectives of this thesis were two-fold. The first objective was the maximization of the recovery of osteological data from the disturbed site material. Central to this question was the association of the site material with a specific historical site, HBC Fort Frances, Ontario. The historical information and the archaeological data support the hypothesis that the material recovered in DdKi-2 was a burial ground associated with the fur trading activities which occurred in the Fort Frances region during the last part of the 18th century and early part of the 19th century. The evidence for the direct identification of this site as the original HBC cemetery can not be established at this time. However, the indirect evidence does support Rajnovich's theory that the site is the original burial ground for the Fort Frances post [Rajnovich 1985;p.1].

The osteological data from DdKi-2 has been unable to ascertain "racial" identity. The European populations which were active in the region during this period were not a homogeneous group. Moreover the the problems associated with mixed European populations is complicated by the potential for Amerindian/European offspring present within the site material. It is therefore not possible, at this time, to establish osteological normative data which could be used to address the question of ethnic origin. Given this situation it is the recommendation of this study that all the osteological material from DdKi-2 be curated by the Office of the Provincial Archaeologist of Ontario until a reliable normative data base is developed or some technique(s) refined for the establishment of ethnicity.

The inability to identify the ethnicity of the interred remains adds to the problem of establishing the biological, social and economic relationships between the interred individuals. The site material may represent the burials of a single community over time or the interaction of several separate and distinct populations and lifestyles in the same or different temporal periods. Given the 'linear' orientation of the majority of the burials [Figure 2] the suggestion could be made that the material represents a single burial site in use for an extended period of time i.e. 1817 - 1874.

When one considers the problems of association, speculation regarding osteometric and pathological data based upon proximity of burials to each other for the entire site material, would be contestable. This problem is compounded by the small sample size recovered.

The osteological information provided by the recovered material indicates a population which has almost an equal representation of the sexes [female = 7, male = 6]. The average age calculated for the sample is 27.15 years. The average age calculated by sex is similar with the female average [28.86] slightly higher than the male average [25.17].

The pathologies identified in the sample do not provide any specific information regarding causes of death. Only two individuals in the sample exhibited pathologies which were traumatic in origin. Two of the burials had evidence of either rheumatoid arthritis or ankylosing spondylitis.

The overall caries rate in the sample averaged at least 14.7%. Of the identified caries, 50% occurred in the M1 location. The majority of the caries were pit or fissure [85.7%]. In addition to caries, four [40%] out of the ten individuals with recovered dental remains exhibited evidence of periodontal disease. Dental attrition varied from trace to extreme [i.e. 0 - +4; U of T]. The majority of heavy attrition commonly involved the mandibular M1 and M2.

The second objective of this thesis was to employ an extant research methodology [PIXE] which would facilitate osteological multielement trace analysis. The work presented in this thesis is only an initial step toward this aim. The data presented in this study did not provide a good fit for direct correlation between the two trace element techniques, AA and PIXE. However the results do demonstrate that both these trace element techniques can be readily applied to soil samples and bone material found in archaeological context.

The preliminary results of this study indicate that follow-up studies should concentrate on establishing the range of detection, minimal detection levels and identification of standardized errors for Proton Induced X-Ray Emission [PIXE] spectroscopy before this technique can be applied with confidence to the question of trace element identification in human skeletal remains.

ENDNOTES

[1]HBCA refers to the Hudsons Bay Company Archives held in the Manitoba Provincial Archives in Winnipeg. The accesession system used by the archive works as follows.

Given an accession designation such as B.105/d/1. The first letter indicates what type of item the record is. In this case "B" indicates that it is a post record. The following number is the identification number of the post, which is arbitrarily assigned. The small letter following the post number refers to the type of post record, in this case "d" refers to an account book. The number following this designator is a numerical code assigned when the item was received and counts from one.

[2] Type of radiation which occurs whenever a charged particle accelerates or decelerates within the electric feild[sic] of another charged particle" [Durocher 1978;p.17]

Bibliography

AGGS, W.H. [editor] 1911 Chitty's Statutes of Practical Utility 6th Edition, Vol 1, 1235 - 1910 A.D.

ANDERSON, J.E. 1969 The Human Skeleton, National Museum of Canada, Ottawa.

ANDERSON, J.R. and C.A. SMITH 1986 "The VAX Computing Facility" in Annual Research Report 1985 - 86, Cyclotron Laboratory, Department of Physics, University of Manitoba, Winnipeg.

AUFDERHEIDE, A.C., J.L. ANGEL, J.O. KELLEY, A.C. OUTLAW, M.A. OUTLAW, G. RAPP jr., and L.E. WITTMERS jr. 1985 "Lead in Bone III. Prediction of Social Correlates From Skeletal Lead Content in Four Colonial American Populations (Catoctin Furnace, College Landing, Governor's Land, and Irene Mound)", in American Journal of Physical Anthropology, 66:353 - 361.

BARRY, P.S.I., 1975 "A Comparison of Concentration of Lead In Human Tissue", in British Journal of Industrial Medicine, 32:119 - 139.

BASS, William M. 1971 Human Osteology, Special Publication, Missouri Archaeological Society, University of Missouri, Columbia.

BEATTIE, O. 1982 "An Assessment of X-Ray Energy Spectroscopy and Bone Trace Element Analysis for the Determination of Sex From Fragmentary Human Skeletons", in Canadian Journal of Anthropology, 2:2: 205 - 216.

BROTHWELL, D.R. 1965 Digging Up Bones, William Cloves and Sons Ltd., London.

BROTHWELL, Don and A.T. SANDISON [editors] Diseases in Antiquity,
1967
Charles C. Thomas Publishers, Springfield.

COKE, Sir Edward The Third Part of the Institutes of the Laws of England,
1628 (reprinted 1979)
Garland Publishing, New York.

CRAWFORD, M.D, and D.G. CLATON "Lead In Bones and Drinking Water In Towns With Hard And Soft Water", in British Medical Journal, 2:21 - 23.
1973

CRAWFORD, M.D. and T. CRAWFORD "Lead Content of Bone In A Soft and Hard Water Area", in Lancet, 1:699 - 701.
1969

CYBULSKI, Jerome S. "Identification of a Human Skeleton From Artillery Park, Quebec City" Unpublished Conservation Report, Ms. No. 1173 Scientific Records Section, Archaeological Survey of Canada, Ottawa.
1976

1983 "Appendix A. Identification and Analysis of an Intrusive Burial at Nottingham House", in Nottingham House: the Hudson's Bay Company in Athabasca 1802 - 1806, Parks Canada History and Archaeology No. 69.

DUROCHER, J.J.G. X-Ray Emission Analysis As A Tool In the Biomedical Sciences, Unpublished Paper.
1978

1988 Personal Communication, Accelerator Centre, University of Manitoba, Winnipeg, Manitoba.

EL-NAJJAR, Mahmond Y. and K. Robert MCWILLIAMS Forensic Anthropology: The Structure, Morphology and Variation of Human Bone and Dentition, Charles C. Thomas Publishers, Springfield.
1978

FRANCEY, K. and J.J.G. DUROCHER "Calibration of the
1986 University of Manitoba PIKXE Facility for the Study of Rubidium in Heart Tissue", in Annual Research Report 1985 - 86, Cyclotron Laboratory, Department of Physics, University of Manitoba, Winnipeg.

GILBERT, R.I. "Applications of Trace Element Research to
1977 Problems in Archaeology" in Biocultural Adaptations in Prehistoric America, Robert L. Blakely, ed. Southern Anthropological Society Proceedings, No. 11, University of Georgia Press, Athens, pp. 85 - 100.

GILBERT, B.M. and T.W. MCKERN "A New Method for Aging the
1973 Female Os Pubis", in American Journal of Physical Anthropology, 38:31 - 38.

GILES, Eugene and Orvill ELLIOT "Sex Determination by
1963 Discriminant Function Analysis of Crania, in American Journal of Physical Anthropology, 21:53 - 63.

GOVERNMENT OF CANADA Consolidated Statutes For Upper Canada,
1859 Cap. 54 - End, pp.775 - 779.

1874 "Dominion Land Survey Plan 1141" Energy Mines And Resources, Ottawa.

GOVERNMENT OF ENGLAND The Statutes at Large: From the First
1762 Year of the Reign of King James the First to the Tenth Year of the Reign of King William the Third, Mark Basker Printer to the King, London.

1764 The Statutes at Large: From the Third Year of the Reign of King George the Second to the Twentyth Year of the Reign of King George the Second, Mark Basker Printer to the King, London.

1909 The English Reports, Kings Bench Division XXIX, Vol. C, pp. 394 - 395

HAMBLEY, George Henry 1976 The Flaming Dance, D.W.Friesen & Sons Ltd., Altona, Manitoba.

HARBOTTLE, G. 1986 "Twenty-five Years Of Research In The Analysis Of Archaeological Artifacts And Works Of Art", in Nuclear Instruments and Methods In Physics Research, B14:10 - 16.

HARRIS, R. COLE and John WARKENTIN 1974 Canada Before Confederation, Oxford University Press, New York.

HUDSON'S BAY COMPANY ARCHIVES, PROVINCIAL ARCHIVES MANITOBA

A.12/L/111/1	#13 Official Survey Map 1879
A.12/L/111/1	#31 Unofficial Survey Map 1874
B.105/d/1	Fort Frances Account Book
B.105/e/1 - 11	Fort Frances District Reports

ISHII,K., S. MORITA, H. TAWARA, T. CHU, H. KAJI and T.SHIOKAWA 1975 "Quantitative Trace-Element Analysis By Proton-Induced X-Rays", in Nuclear Instruments and Methods, 126:75 - 80.

KATZENBERG, M.A. 1982 Strontium as a Dietary Indicator in Prehistoric Peoples of Southern Ontario, Manuscript no. 2048, Scientific Records Service, Archaeological Survey of Canada, National Museum of Man, Ottawa.

1984 Chemical Analysis of Prehistoric Human Bone from Five Temporally Distinct Populations in Southern Ontario, Paper # 129, Archaeological Survey of Canada, National Museum of Man, Ottawa.

KERLEY, E.R. 1970 "Estimation of Skeletal Age: After About Age 30", in Personal Identification In Mass Disaster, 1970, T.D. STEWART [Editor], Smithsonian Institution, Washington.

KNOWLES, Sir Francis H.S. 1937 Physical Anthropology of the Roebuck Iroquois with Comparative Data From Other Indian Tribes, National Museum of Canada, Bulletin # 87.

LAHANIER, Ch., F.D. PREUSSER & L. VAN ZELT 1986 "Study And Conservation Of Museum Objects: Use Of Classical Analytical Techniques", in Nuclear Instruments and Methods In Physics Research, B14 1:1 - 9.

LAMBERT, J.B., C.B. SZPUNAR and J.E. BUIKSTRA 1979 "Chemical analysis of Excavated Human Bone from Middle and Late Woodland Sites" in Archaeometry, 21 pp. 115 - 129.

LAMBERT, J.B., S.M. VLASAK, A.C. THOMETZ, and J.E. BUIKSTRA 1982 "A Comparative Study of the Chemical Analysis of Ribs and Femurs in Woodland Populations", in American Journal of Physical Anthropology, 59 pp.289 - 294

LANGENBERG, A. and J. van ECK 1979 "An Evaluation of K-shell Fluorescence Yields; Observations of Outer-shell Effects" in Journal of Physics B: Atomic Molecular Physics, Vol 12 No.8 pp.1331 - 1350.

LOVEJOY, C. Owen 1985 "Dental Wear in the Libben Population: Its Functional Pattern and Role in the Determination of Adult Skeletal Age at Death", in American Journal of Physical Anthropology, 68:47 - 56.

MALMQVIST, Klas G. 1986 "Comparison Between PIXE And XRF For Applications In Art And Archaeology" in Nuclear Instruments and Methods In Physics, B14, pp.86 - 92.

MANCHESTER, Keith
1983
The Archaeology of Disease, University of Bradford, Bradford, England.

MCKEE, J.S.C., C. LAPOINTE, J. BIRCHALL, C. PINSKY, and R. BOISE,
1981
"Analysis of Cesium in Tissue Samples Using the PIXE Technique" in Journal of Environmental Science and Health, A16(5) pp.465 - 475

MCKERN, T.W.
1970
"Estimation of Skeletal Age: From Puberty to About 30 Years of Age" in Personal Identification In Mass Disasters, 1970, T.D. Stewart [editor], Smithsonian Instition, Washington.

MCKERN, T. and T.D. STEWART
1957
Skeletal Age Changes in Young American Males, Quartermasters Research and Development Command, Technical Report EP - 45, Natick, Massachusetts.

MEINDL, R.S. and C.O. LOVEJOY
1985
"Ectocranial Suture Closure: A Revised Method for the determination of Skeletal Age at Death Based on the Lateral-Anterior Sutures", in American Journal of Physical Anthropology, 68:57 - 66.

MEINDL, R.S., C.O. LOVEJOY, R.P. MENSFORTH, and T.J. BARTON
1985
"Mulitfactorial Determination of Skeletal Age at Death: A Method and Blind Tests of Its Accuracy", in American Journal of Physical Anthropology, 68:1 - 14.

MORGAN, Catherine
1983
The Skeletal Biology of the Long Lac Site (DkIp1) Unpublished Honours Thesis, Lakehead University, Thunder Bay.

NUTE, Grace Lee 1950 Rainy River Country, The Minnesota Historical Society, St. Paul.

OKUMUSOGLU, N.T., J. BIRCHALL, A. MOUSSA, M.B. WANGO, A. ROUVAS, K. RETHA, S. BAL and R. ESENER, 1986 "Analysis of Human Gall Stone Samples Using the "PIXE" Technique" in, Annual Research Report 1985 - 86, Cyclotron Laboratory, Department of Physics, University of Manitoba, Winnipeg.

ORTNER, D. and W. PUTSCHAR 1981 Identification of Pathological Conditions in Human Skeletal Remains, Smithsonian Contributions to Anthropology, # 28, Washington, D.C..

PARKER, R.B. and H. TOOTS 1980 "Trace Elements in Bones as Paleobiological Indicators". in Fossils in the Making, A.K. Behrensmeyer and A.P. Hill, eds., Chicago: University of Chicago Press.

PFEIFFER, S. and P. KING 1983 "Cortical Bone Formation and Diet Among Protohistoric Iroquoians", in American Journal of Physical Anthropology, 60:23 - 28.

PHENICE, T.W. 1969 "A Newly Developed Visual Method of Sexing the Os Pubis", in American Journal of Physical Anthropology, 30:297 - 302.

PINSKY, C. and R. BOSE 1986 "Collaborative Applied Nuclear Physics - Pharmacology/Toxicology Research", in Annual Research Report 1985 - 86, Cyclotron Laboratory, Department of Physics, University of Manitoba, Winnipeg.

PRAKASH, R., F.C. HAWTHORNE, N.M. HALDEN and J.S.C. MCKEE
1986 "Medium Energy Analysis of Minerals' in, Annual Research Report 1985 - 86, Cyclotron Laboratory, Department of Physics, University of Manitoba, Winnipeg.

PRICE, D.T. and M. KAVANAGH "Bone Composition and the
1982 Reconstruction of Diet:Examples from the Mid-western United States", in Midcontinental Journal of Archaeology, 7 pp.61 - 79.

RAJNOVICH, Grace "Rescue Excavations of the Boise Cascade
1985 Burials (DdKi - 2) in Fort Frances, Ontario" in Ontario Conservation Archaeology Report, Northwestern Region Report #6.

RAMSAY, W.D. The (p,n) Reaction on ^{13}C, A Scintillating
1980 Liquid Argon Target, And Proton Induced K-shell Ionization Studies, Unpublished Phd Thesis, University of Manitoba.

RAMSAY, W.D., M.S.A.L. AL-GHAZI, J. BIRCHALL and J.S.C. MCKEE
1978 "Atomic K-shell Ionization Induced by 20 - 50 MeV Protons" in Physics Letters, Vol 69A, No. 4, pp.258 - 260.

RUSS, J.C. Exam Methods: Elemental X-ray Analysis of
1972 Materials, Edax Laboratories Division, Raleigh, North Carolina.

SCHROEDER, H.A. and I.H. TIPTON "The Human Body Burden
1968 of Lead", in Archives of Environmental Health, 17:965 - 978.

SIMONDS, Lord [editor] Halsbury's Laws of England, 3rd Edition,
1953 Vol. 4, pp. 102 - 103, Butterworth and Co. Ltd., London.

STEELE, D.G., 1970 — "Estimation of Stature From Fragments of Long Limb Bones" in Personal Identification in Mass Disasters, 1970 T.D. STEWART [editor], Smithsonian Institution, Washington.

STEINBOCK, R.T. 1976 — Paleopathological Diagnosis and Interpretation: Bone Diseases in Ancient Human Populations, Charles C. Thomas Publishers, Springfield.

STEWART, T.D. 1970 — Personal Identification in Mass Disaster, Smithsonian Institute, Washington, D.C..

STONEHOCKER, E.G. 1988 — Personal Communication, President, Alberta Chapter, Canadian Dentist Association.

SVENDSEN, L.G., N. HERTEL & G. SORENSEN 1981 — "Detection Of Trace Elements In Ash Samples Performed By Combining RBS And PIXE", in Nuclear Instruments and Methods In Physics Research, 191:414 - 418.

SZPUNAR, C.B., J.B. LAMBERT and J.E. BUIKSTRA 1978 — "Analysis of Excavated Bone By Atomic Absorption", in American Journal of Physical Anthropology, 48:199 - 202.

THIEME, F.R. and W.J. SCHULL 1957 — "Sex Determination From the Skeleton", in Human Biology, 29:242 - 273.

TROTTER, M. 1970 — "Estimation of Stature From Intact Limb Long Bones", in Personal Indentification in Mass Disasters, 1970, T.D. STEWART [ed], Smithsonian Institution, Washington.

TROTTER, M. and G. GLESER 1952 "Estimation of Stature From Long Bones of American Whites and Negroes", in *American Journal of Physical Anthropology*, 10:463 - 514.

1958 "A Pre-evaluation of Estimation of Stature Based On Measurements of Stature During Life And of Long Bones After Death" in *American Journal of Physical Anthropology*, 16:79 - 123.

UNIVERSITY OF TORONTO 1985 "IBM Osteology Codification Guidline" in *Department of Anthropology*, Toronto, Ontario.

WEAST, R.C. [editor] 1975 *Handbook of Chemistry and Physics*, CRC Press, Cleveland.

WEELER, R.M., R.P. CHATURVEDI, J.S. ONELLO, V. VALKOVIC, and J.KRMPOTIC 1987 "Trace Elements In Human Nasal Cavity Bones" in *Nuclear Instruments and Methods in Physics Research*, B24/25, pp.658 - 661.

WINTEMBERG, W.J. 1937 (reprinted 1972) *Roebuck Prehistoric Village Site, Grenville County, Ontario*, National Museum of Canada Bulletin # 83, Ottawa.

ZIVANOVIC, Srboljub 1982 *Ancient Diseases: The Elements of Paleopathology*, Translated by Lovett F. Edwards, Pica Press, New York.

ADDITIONAL MATERIAL CONSULTED

ANDERSON, J.E. 1963 — The People of Fairty, National Museum of Canada Bulletin # 193, Ottawa.

BALDWIN, Stuart J. 1978 — The Elk Point Burial, Occasional Paper No. 11, Archaeological Survey of Alberta, Edmonton.

BROTHWELL, D.R. [editor] 1968 — The Skeletal Biology of Earlier Human Populations, Pergamon Press, London.

BUIKSTRA, J.E. [editor] 1981 — Prehistoric Tuberculosis in the Americas, Northwestern University Archaeology Program, Evanston, Illinois.

CORRUCCINI, R. 1976 — "The Interaction Between Non-Metric and Metric Cranial Variation", in American Journal of Physical Anthropology, 44:285 - 294.

CYBULSKI, J.S. 1978 — An Earlier Population of Hesquiat Harbour, British Columbia, Cultural Recovery Paper No. 1, British Columbia Provincial Museum, Victoria.

1982 — "Human Skeletal Remains From Plum Point and Bio-temporal Identification in Ontario Prehistory" in Ontario Archaeology, No.37 pp. 17 - 28.

ERIKSON, M.F. 1982 — "Aging Changes in the Thickness of the Proximal Femoral Cortex", in American Journal of Physical Anthropology, 59:121 - 130.

EWART, William B. "Causes of Mortality in a Subarctic
1983 Settlement (York Factory, Man.), 1714 - 1946", in Canadian Medical Association Journal, 129:571 - 574

FINNEGAN, Michael "Non-Metric Variance of The Post Cranial
1973 Skeleton in Man", in American Journal of Physical Anthropology, 40:135 - 136.

HAMILTON, E.I. The Chemical Elements and Man: Measurements,
1979 Perspectives, Applications. Springfield, C.C. THOMAS Publishers.

HUGHES, M.J., M.R. COWELL and P.T. CRADDOCK "Atomic Absorption
1976 Techniques in Archaoeology", in Archaeometry, Vol 18:pp19 - 38.

KAPCHES, M. "The Interment of Infants of the Ontario
1976 Iroquois", in Ontario Archaeology, 27:29 - 39.

KNIGHT, D and J. MELBYE "Burial Patterns at the Ball Site", in
1983 Ontario Archaeology, 40:37 - 48.

LEONARD, C.H. The Concise Gray's Anatomy,
1983 Omega Books Ltd., London.

MEINDL, R.S., C.O. LOVEJOY, R.P. MENSFORTH, and L.D. CARLOS
1985 "Accuracy and Direction of Error in the Sexing of the Skeleton: Implications for Paleodemography", in American Journal of Physical Anthropology, 68:79 - 85.

MELBYE, Jerry "The People of the Ball Site", in
1983 Ontario Archaeology, 40:15 -36.

MERBS, Charles F. 1983 Patterns of Activity - Induced Pathology In a Canadian Inuit Population, Archaeological Survey of Canada, # 119, National Museum of Canada, Ottawa.

MOLTO, J.E. 1980 Biological Relationships of Southern Ontario Woodland People: The Evidence of Discontinuous Cranial Morphology, Unpublished PHD Dissertation, Department of Anthropology, University of Toronto, Toronto.

NUTE, Grace Lee 1941 Minnesota History, Vol 22, pp. 270 - 289.

OSSENBERG, N.S. 1969 Osteology of the Millar Site, Royal Ontario Museum Art and Archaeology Occasional Paper # 18.

PATTERSON, David Kingsnorth Jr. 1984 A Diachronic Study of Dental Palaeopathology and Attritional Status of Prehistoric Ontario Pre-Iroquois and Iroquois Populations, Archaeological Survey of Canada, # 122, National Museum of Canada, Ottawa.

PFEIFFER, S. 1977 The Skeletal Biology of Archaic Populations of the Great Lakes Region, Archaeological Survey of Canada, # 64, National Museum of Canada, Ottawa.

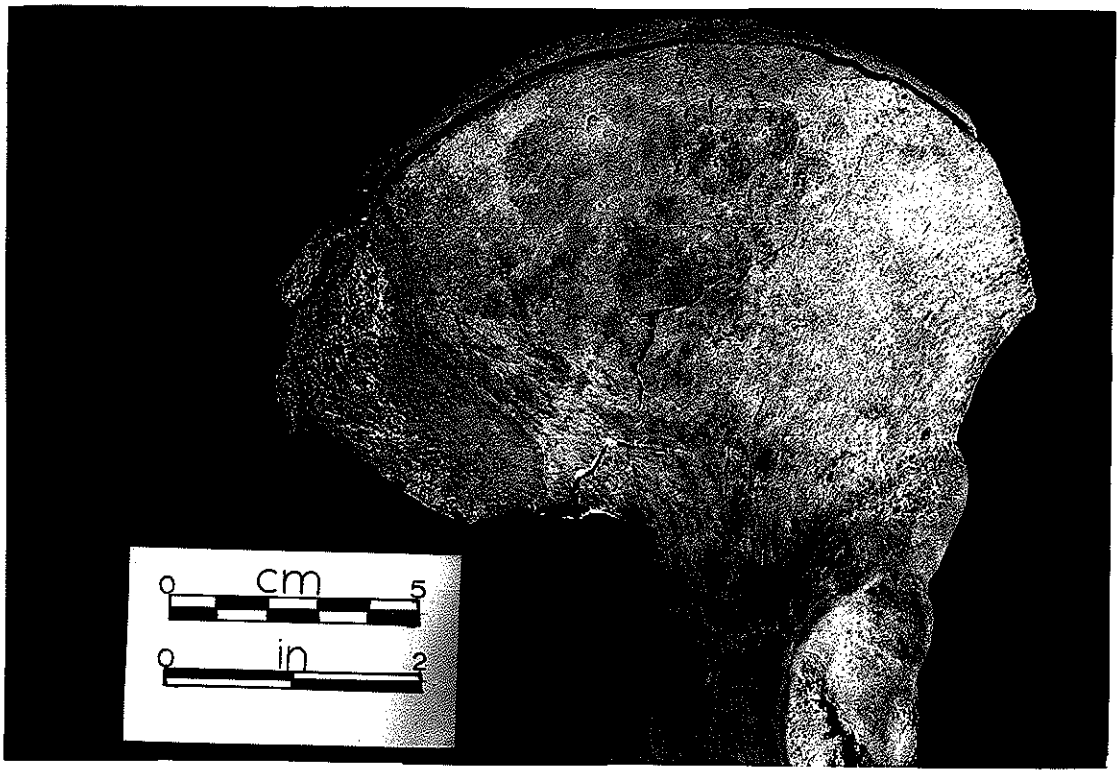
SAUNDERS, Shelley Rae 1978 The Development and Distribution of Discontinuous Morphological Variation of the Human Infracranial Skeleton, Archaeological Survey of Canada, # 81, National Museum of Canada, Ottawa.

STEWART, T.D. 1979 "Patterning of Skeletal Pathologies and Epidemiology", in The First Americans, W.S. LAUGHTIN and A.B. HARPER [editors], G. Fisher Publisher, New York, pp.257 - 274.

WILK, S.F.J., J.S.C. MCKEE and C.P. RANDELL 1977 "Pixe Work at the University of Manitoba" in Nuclear Instruments and Methods, No. 142, pp.33 - 38.

PLATE 1
Burial # 8
Right Innominate Bone With Unfused Illiac Epiphysial Crest.

PLATE 2
Burial # 2
Collapse Fracture of the Spine Involving the T10, T11 and T12 Vertebrae


0 cm 5
0 in 2

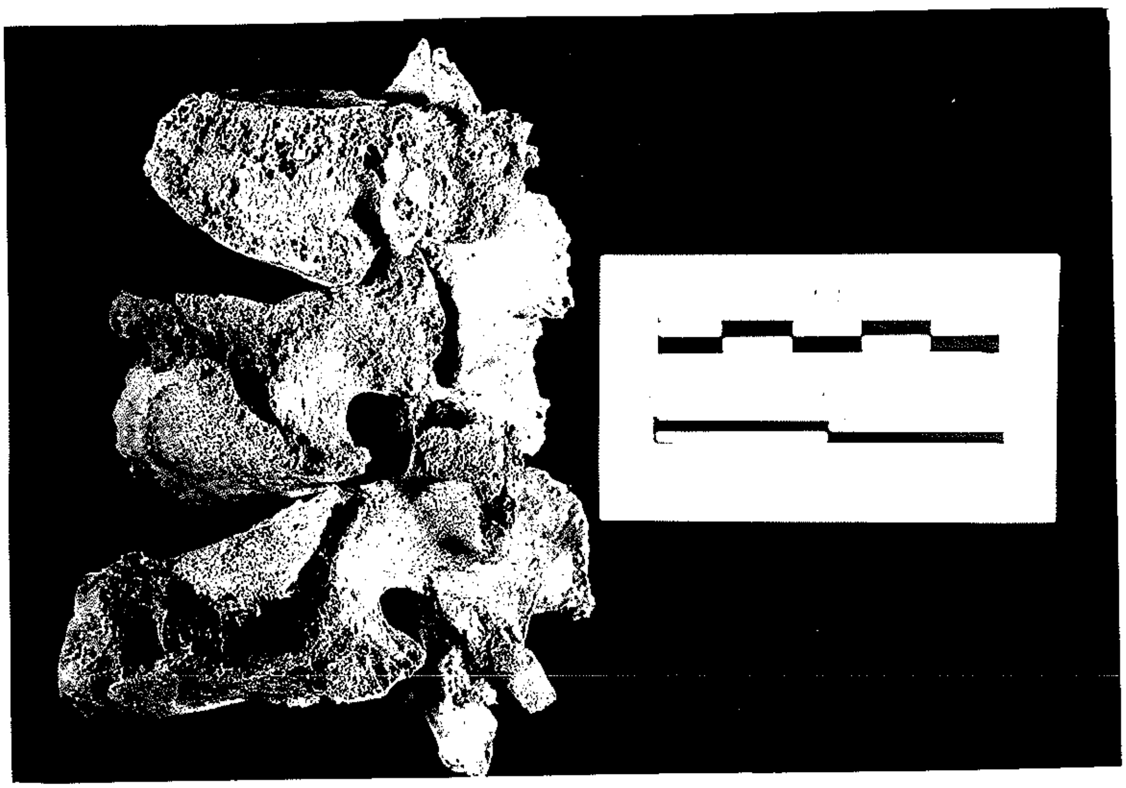
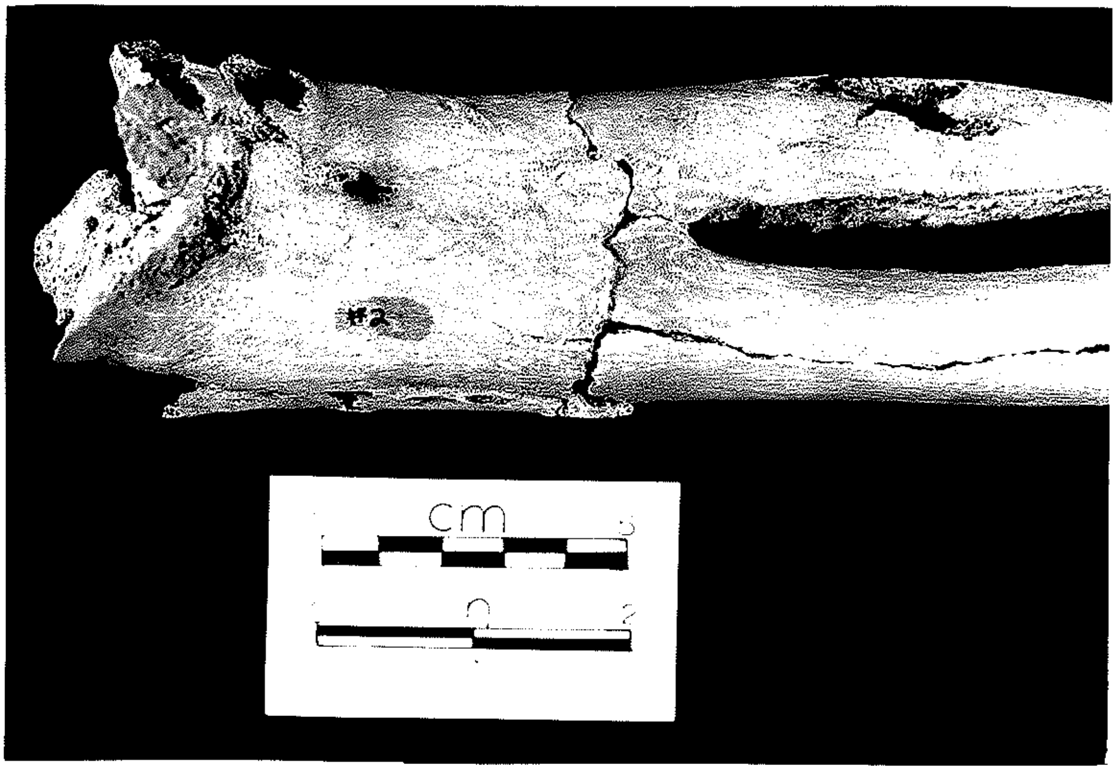


PLATE 3
Burial # 2
Union of Right Distal Tibia and Fibula
Note: Callus formation on fibula shaft and modification of distal joint capsule.

PLATE 4
Burial # 3b
Ununited Healed Fracture
Distal Right Humerus


cm

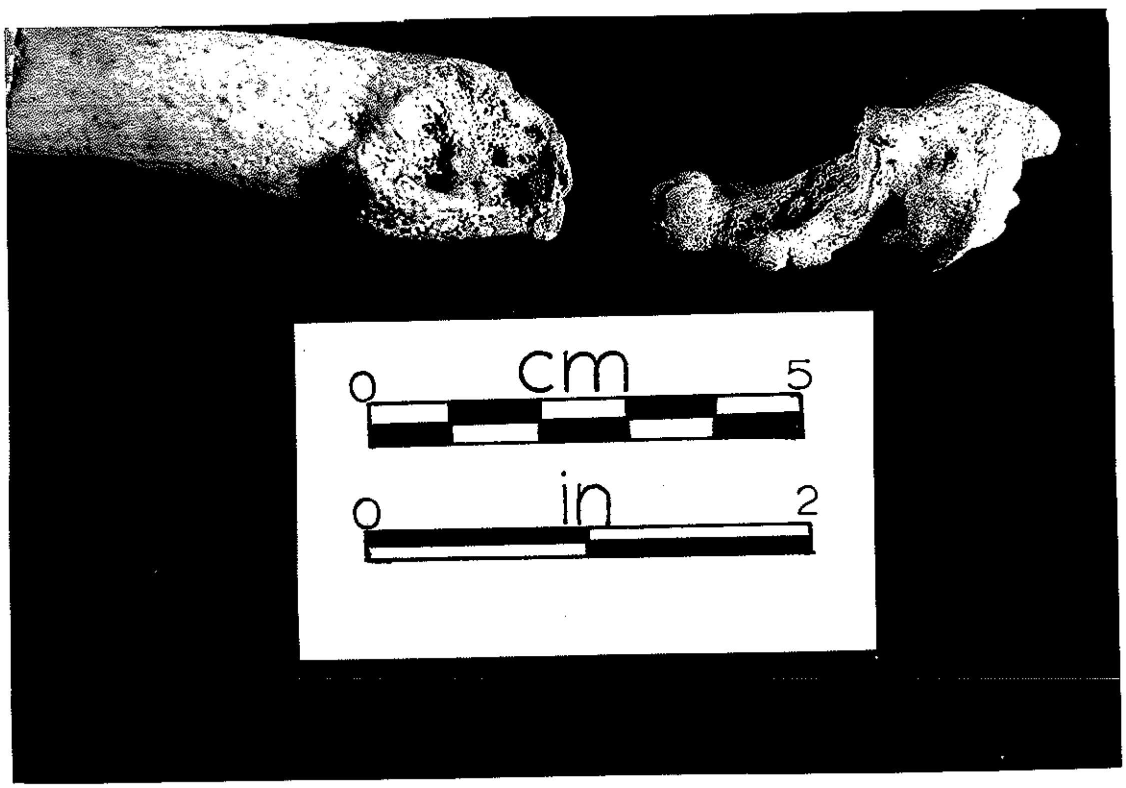
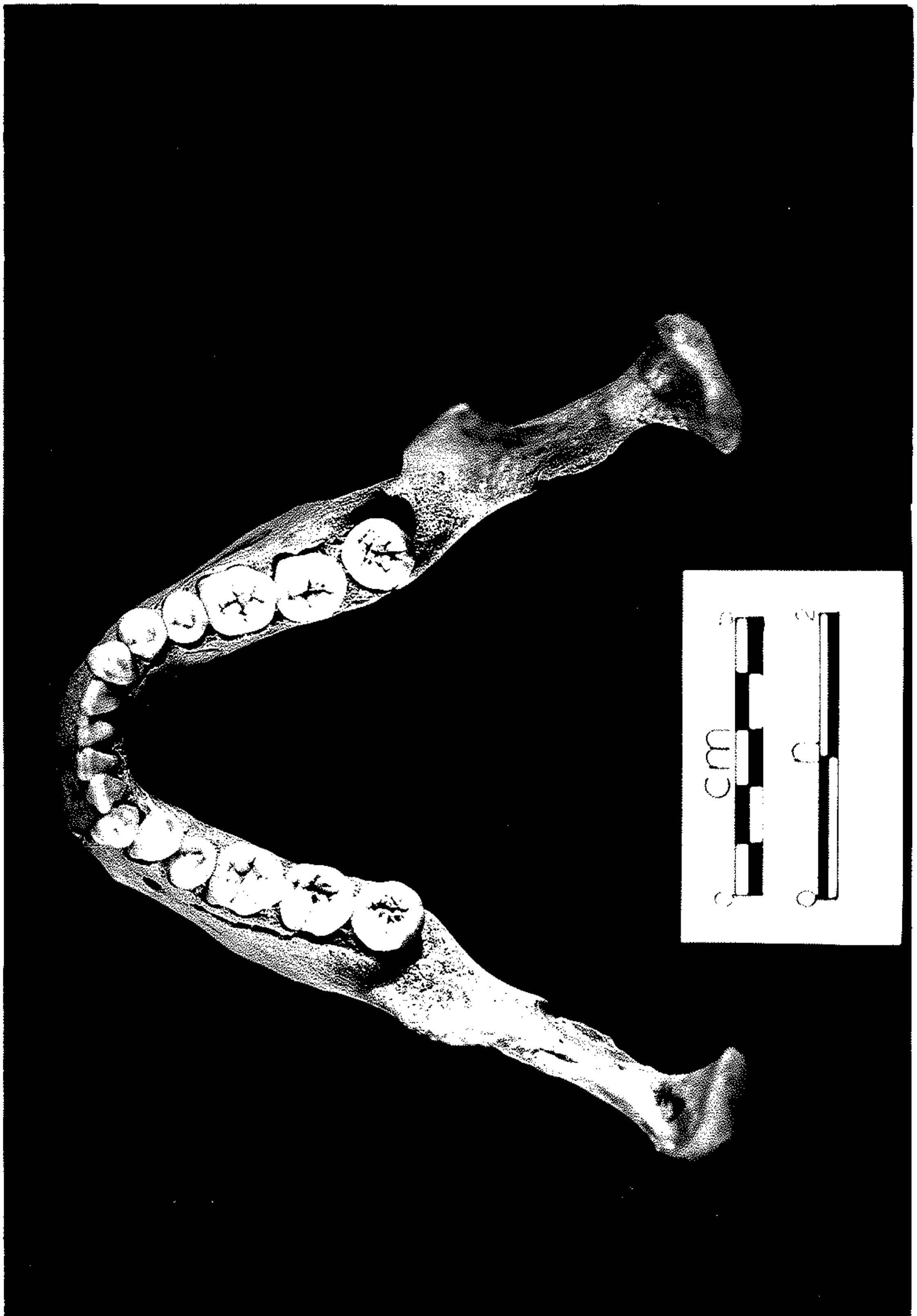

0 cm 5
0 in 2

PLATE 5
Burial # 9
Mandible
Note: occlusal surface of tooth 38 and 48


cm

APPENDICES A1 - A3

The following three appendices contain the raw osteological data collected using the methodology discussed in Chapter 1. Measurements were taken using the landmarks identified in Bass [1971], Brothwell [1965] and University of Toronto IBM codification guidelines for the recording of osteological data. The following code was used in the tables.

D = Damaged
e = Estimated
F = Fragmentary
M = Missing
NA = Not available
P = Pathological
U = Unidentified

All cranial measurements are given in millimeters [mm]. Post cranial measurements are given in centimeters [cm].

APPENDIX A1 OSTEOMETRIC DATA

BOSIE-CASCADE CRANIAL DATA	BURIAL 1 F 24-26 YRS	BURIAL 2A F 42-47 YRS	BURIAL 2B I	BURIAL 3A F 18-25 YRS	BURIAL 3B M 25-30 YRS	BURIAL 3C F 21-25 YRS	BURIAL 3 UNID U YRS	BURIAL 4 M 21-25 YRS
GLABELLO-OCCIPITAL LENGTH	M	189	F	D	191	155	D	D
MAX CRANIAL BREADTH	M	D	F	D	D	D	D	D
BASION-BREGMA HEIGHT	M	134	F	D	D	D	D	D
BASION-PROSTHION LENGTH	M	107	F	D	D	D	D	D
BASION-NASION LENGTH	M	105	F	D	D	D	D	D
MIN FRONTAL BREADTH	M	90	F	91.5	103	D	D	D
NASION-GNATHION HEIGHT	M	111.5	F	D	D	D	D	D
NASION-PROSTHION HEIGHT	M	64.7	F	D	D	D	D	D
BIZYGOMATIC BREADTH	M	D	F	D	D	D	D	D
ORBITAL HEIGHT	M	32.9	F	D	D	D	D	D
ORBITAL BREADTH	M	38.4	F	D	D	D	D	D
NASAL BREADTH	M	27.6	F	D	D	D	D	D
NASAL LENGTH	M	47.9	F	D	D	D	D	D
ALVEOLAR BREADTH	M	D	F	D	D	D	D	D
ALVEOLAR LENGTH	M	D	F	D	D	D	D	D
PALATAL BREADTH	M	37.2	F	D	D	D	D	D
PALATAL LENGTH	M	50.4	F	D	D	D	D	D
BIASTERIONIC BREADTH	M	114	F	D	97	D	D	D
BISTEPHANIC BREADTH	M	D	F	D	D	D	D	D
ECTOCONCHION BREADTH	M	97	F	93.5	93.5	D	D	D
SIMOTIC CHORD	M	6.4	F	D	D	D	D	D
BIFRONTAL CHORD	M	D	F	D	D	D	D	D
NASIO-FRONTAL SUBTENSE	M	D	F	D	D	D	D	D
BIMAXILLARY CHORD	M	D	F	D	D	D	D	D
ZYGOMAXILLARE SUBTENSE	M	D	F	D	D	D	D	D
NASION-BREGMA CHORD	M	186	F	106	119	109	105	D
NASION-BREGMA SUBTENSE	M	D	F	240	270	D	D	D
NASIO-SUBTENSE FRACTION	M	D	F	39	51	D	D	D
BREGMA-LAMBDA CHORD	M	132	F	D	116	D	D	D
BREGMA-LAMBDA SUBTENSE	M	D	F	D	200	270	D	D
BREGMA-SUBTENSE FRACTION	M	D	F	D	58	5	D	D
LAMBDA-OPISTHION CHORD	M	D	F	D	D	D	D	65
LAMBDA-OPISTHION SUBTENSE	M	D	F	D	D	D	D	85
LAMBDA-SUBTENSE FRACTION	M	D	F	D	D	D	D	24
FRONTAL ARC	M	123	F	119	133	106	123	D
PARIETAL ARC	M	135	F	D	126	103	D	D
OCCIPITAL ARC	M	25	F	D	D	D	D	D
MANDIBULAR BODY LENGTH	M	73.2	F	M	M	97	104	D
BICONDYLAR BREADTH	M	140.4	F	M	M	D	D	D
MIN RAMUS BREADTH	M	35.6	F	M	M	26	37	35.8
RAMUS HEIGHT	M	58	F	M	M	D	66	D
BIGONIAL BREADTH	M	112.5	F	M	M	D	105	D
CORONOID HEIGHT	M	63.3	F	M	M	51	66	69.7
SYMPHASIS HEIGHT	M	36.6	F	M	M	21	32	D
MANDIBULAR ANGLE	M	126	F	M	M	135	110	D

BOSIE-CASCADE

CRANIAL DATA	BURIAL 5 F 17-18 YRS	BURIAL 7 M 17-19 YRS	BURIAL 8 F 15-18 YRS	BURIAL 9 M 17-25 YRS	BURIAL 10 F 42-64 YRS	BURIAL 11 M 18-25 YRS	BURIAL 12 M 38-42 YRS
GLABELLO-OCCIPITAL LENGTH	D	D	D	D	D	M	183
MAX CRANIAL BREADTH	D	D	D	D	D	M	151
BASION-BREGMA HEIGHT	D	D	D	132	D	M	131
BASION-PROSTHION LENGTH	D	D	D	D	D	M	D
BASION-NASION LENGTH	D	D	D	D	D	M	D
MIN FRONTAL BREADTH	D	D	D	D	D	M	101
NASION-GNATHION HEIGHT	D	D	D	D	D	M	D
NASION-PROSTHION HEIGHT	D	D	D	D	D	M	D
BIZYGOMATIC BREADTH	D	D	D	D	D	M	D
ORBITAL HEIGHT	D	D	D	D	D	M	D
ORBITAL BREADTH	D	D	D	D	41	M	D
NASAL BREADTH	D	D	D	D	D	M	D
NASAL LENGHT	D	D	D	D	D	M	D
ALVEOLAR BREADTH	D	D	D	68	D	M	D
ALVEOLAR LENGTH	D	D	D	D	D	M	D
PALATAL BREADTH	D	D	D	39.8	D	M	D
PALATAL LENGTH	D	D	D	D	D	M	D
BIASTERIONIC BREADTH	D	D	108	D	D	M	114
BISTEPHANIC BREADTH	D	D	D	D	D	M	112.5
ECTOCONCHION BREADTH	D	D	D	D	D	M	D
SIMOTIC CHORD	D	D	D	D	D	M	D
BIFRONTAL CHORD	D	D	D	D	D	M	D
NASIO-FRONTAL SUBTENSE	D	D	D	D	D	M	D
BIMAXILLARY CHORD	D	D	D	D	D	M	D
ZYGOMAXILLARE SUBTENSE	D	D	D	D	D	M	D
NASION-BREGMA CHORD	D	D	D	D	D	M	D
NASION-BREGMA SUBTENSE	D	D	D	D	D	M	D
NASIO-SUBTENSE FRACTION	D	D	D	D	D	M	D
BREGMA-LAMBDA CHORD	D	D	D	110	D	M	106
BREGMA-LAMBDA SUBTENSE	D	D	D	195	D	M	200
BREGMA-SUBTENSE FRACTION	D	D	D	55	D	M	53.5
LAMBDA-OPISTHION CHORD	47	D	46	56	D	M	56
LAMBDA-OPISTHION SUBTENSE	65	D	30	40	D	M	65
LAMBDA-SUBTENSE FRACTION	38	D	25	29	D	M	25
FRONTAL ARC	D	D	115	D	D	M	D
PARIETAL ARC	D	D	D	125	D	M	117
OCCIPITAL ARC	D	D	25	60	D	M	56
MANDIBULAR BODY LENGTH	106	106	111	115	108	M	103
BICONDYLAR BREADTH	D	D	109	136	D	M	D
MIN RAMUS BREADTH	29	34.5	29	40	D	M	36
RAMUS HEIGHT	62	62	55	67	D	M	61
BIGONIAL BREADTH	D	104	88	101	D	M	105
CORONOID HEIGHT	D	61	58.6	62	D	M	D
SYMPHASIS HEIGHT	D	31	31	33	D	M	36
MANDIBULAR ANGLE	124	132	125	125	D	M	121

APPENDIX A2 OSTEOMETRIC DATA

BOSIE/CASCADE	BURIAL 1		BURIAL 2		BURIAL 3A		BURIAL 3B	
POST CRANIAL	F		F		F		M	
YRS	24-26		42-47		18-25		25-30	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
CLAVICLE LENGTH	11.9	12.10	D	D	D	D	D	D
CLAVICLE DIAMETER	1.10	0.90	D	D	1.37	1.38	1.13	1.06
SCAPULA LENGTH	D	D	D	D	D	D	D	D
SCAPULA BREADTH	D	D	D	D	D	D	10.30	D
GLENOID LENGTH	3.10	3.20	D	3.90	3.70	D	4.30	3.80
GLENOID BREADTH	2.40	1.95	D	2.80	2.60	2.60	2.92	2.85
HUMERUS LENGTH	29.50	D	D	D	M	D	D	33.50
HUMERUS PYS LENGTH	29.30	29.40	D	D	M	D	D	32.90
MAX SHAFT DIAM	2.20	2.55	2.66	2.64	M	D	D	2.53
MIN SHAFT DIAM	1.67	D	1.80	1.70	M	D	D	1.90
MAX HEAD DIAM	D	D	D	D	M	D	4.94	4.86
MIN HEAD DIAM	D	D	D	D	M	D	4.46	4.32
EPICONDYLAR BREADTH	4.91	D	5.67	D	M	D	D	6.88
LOWER ART. BREADTH	3.58	D	4.58	D	M	D	D	5.10
RADIUS LENGTH	22.00	22.30e	M	D	22.24e	22.13e	24.50	M
RADIUS PYS LENGTH	21.30	D	M	D	D	D	23.10	M
RADIUS HEAD DIA	D	D	M	D	D	D	2.70	M
RADIUS DISTAL BREADTH	D	D	M	D	D	D	3.60	M
ULNA LENGTH	24.00e	24.30	26.00	25.50	D	M	P	D
ULNA PYS LENGTH	22.00e	D	22.00	22.00	D	M	P	D
ULNA OLECRANON HEIGHT	2.75	D	3.10	2.60	D	M	3.76	D
ULNA OLECRANON BREADTH	1.93	D	D	D	D	M	3.03	D
INNOMINATE LENGTH	D	D	D	D	D	D	D	M
INNOMINATE BREADTH	D	D	D	D	D	D	D	M
SYMPHYSEAL HEIGHT	D	D	D	D	D	D	D	M
ACETABULUM-PUBIS LENGT	D	D	D	D	D	D	D	M
ACETABULUM-ISCHIUM LEN	D	D	D	D	D	D	D	M
SCIATIC NOTCH ANGLE	D	D	110	D	D	D	D	M
FEMUR LENGTH	43.37e	D	44.00	43.30	45.09e	44.16e	43.76e	45.00
FEMUR PYS LENGTH	D	D	43.10	43.00	D	D	D	44.70
PROX ANT/POST DIAMETER	2.42	D	2.85	2.70	2.80	2.75	3.00	3.06
PROX LATERAL DIAMETER	3.43	D	3.36	3.98	3.30	3.17	3.32	3.53
MID ANT/POST DIAMETER	2.60	D	2.86	3.30	2.65	2.52	2.80	2.77
MID LATERAL DIAMETER	2.51	D	3.00	2.80	2.90	2.80	3.11	3.15
MAXIMUM HEAD DIAMETER	D	4.04	4.20	4.47	D	D	D	5.03
PATELLA LENGTH	M	M	D	D	D	M	M	4.66
PATELLA BREADTH	M	M	D	4.80	D	M	M	4.96
PATELLA THICKNESS	M	M	1.96	2.05	D	M	M	2.14
TIBIA LENGTH	M	32.64e	D	D	36.90	D	36.30	M
TIBIA PYS LENGTH	M	D	31.50	D	34.70	D	34.50	M
CONDYLAR BREADTH	M	D	6.80	D	D	D	7.70	M
TRANSVERSE CNEMIC DIAM	M	2.33	2.70	D	2.56	2.57	2.46	M
SAGITTAL CNEMIC DIAMET	M	3.24	3.20	D	3.40	3.51	3.55	M
MID TRANSVERSE DIAMETE	M	1.90	D	D	2.30	2.23	2.25	M
MID SAGITTAL DIAMETER	M	2.71	D	D	2.86	2.74	3.26	M
FIBULA LENGTH	M	M	30.00	D	D	D	35.30	D
CALCANEUS LENGTH	M	M	D	D	M	M	M	M
CALCANEUS HEIGHT	M	M	D	D	M	M	M	M
TALUS LENGTH	M	M	D	5.30	M	M	D	M
TALUS BREADTH	M	M	D	4.30	M	M	D	M
TALUS HEIGHT	M	M	D	3.10	M	M	3.20	M

BOSIE/CASCADE	BURIAL 4		BURIAL 5			BURIAL 7	
POST CRANIAL DATA	M		F			M	
YRS	21-25		17-18			17-19	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	RIGHT	LEFT
CLAVICLE LENGTH	D	M	D	D		M	M
CLAVICLE DIAMETER	D	M	D	D		M	M
SCAPULA LENGTH	M	D	D	M		M	D
SCAPULA BREADTH	M	D	D	M		M	D
GLENOID LENGTH	M	D	D	M		M	D
GLENOID BREADTH	M	D	D	M		M	D
HUMERUS LENGTH	33.40	D	31.95e	31.95e	D	M	32.94e
HUMERUS PYS LENGTH	D	D	D	D	D	M	D
MAX SHAFT DIAM	2.53	2.53	D	D	D	M	D
MIN SHAFT DIAM	2.00	2.10	D	D	D	M	D
MAX HEAD DIAM	D	D	D	D	D	M	D
MIN HEAD DIAM	D	D	D	D	D	M	D
EPICONDYLAR BREADTH	D	D	D	D	D	M	D
LOWER ART. BREADTH	D	D	D	D	D	M	D
RADIUS LENGTH	M	M	18.82e	18.82e		25.09	25.20
RADIUS PYS LENGTH	M	M	D	D		D	23.90
RADIUS HEAD DIA	M	M	D	D		D	D
RADIUS DISTAL BREADTH	M	M	D	D		D	3.20
ULNA LENGTH	M	M	D	D		D	27.10
ULNA PYS LENGTH	M	M	D	D		D	23.50
ULNA OLECRANON HEIGHT	M	M	D	D		D	3.00
ULNA OLECRANON BREADTH	M	M	D	D		D	2.50
INNOMINATE LENGTH	D	M	M	M		M	19.30e
INNOMINATE BREADTH	D	M	M	M		M	11.50e
SYMPHYSEAL HEIGHT	3.90	M	M	M		M	D
ACETABULUM-PUBIS LENGT	D	M	M	M		M	D
ACETABULUM-ISCHIUM LEN	D	M	M	M		M	D
SCIATIC NOTCH ANGLE	D	M	M	M		M	D
FEMUR LENGTH	M	M	U	U		M	49.99e
FEMUR PYS LENGTH	M	M	U	U		M	D
PROX ANT/POST DIAMETER	M	M	U	U		M	2.50
PROX LATERAL DIAMETER	M	M	U	U		M	3.00
MID ANT/POST DIAMETER	M	M	U	U		M	2.40
MID LATERAL DIAMETER	M	M	U	U		M	2.50
MAXIMUM HEAD DIAMETER	M	M	U	U		M	4.60
PATELLA LENGTH	M	M	M	M		D	M
PATELLA BREADTH	M	M	M	M		D	M
PATELLA THICKNESS	M	M	M	M		D	M
TIBIA LENGTH	M	D	U	U		M	M
TIBIA PYS LENGTH	M	D	U	U		M	M
CONDYLAR BREADTH	M	D	U	U		M	M
TRANSVERSE CNEMIC DIAM	M	D	U	U		M	M
SAGITTAL CNEMIC DIAMET	M	D	U	U		M	M
MID TRANSVERSE DIAMETE	M	D	U	U		M	M
MID SAGITTAL DIAMETER	M	D	U	U		M	M
FIBULA LENGTH	M	M	U	U		U	U
CALCANEUS LENGTH	D	M	M	M		M	M
CALCANEUS HEIGHT	D	M	M	M		M	M
TALUS LENGTH	D	M	M	M		M	M
TALUS BREADTH	D	M	M	M		M	M
TALUS HEIGHT	D	M	M	M		M	M

BOSIE/CASCADE	BURIAL 8		BURIAL 9		BURIAL 10		BURIAL 11	
POST CRANIAL DATA	F		M		F		M	
YRS	15-18		17-25		42-64		18-25	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
CLAVICLE LENGTH	D	D	15.17	15.27	M	M	M	D
CLAVICLE DIAMETER	D	1.07	1.34	1.28	M	M	M	0.90
SCAPULA LENGTH	D	D	D	17.00e	D	D	M	M
SCAPULA BREADTH	D	D	11.73	11.60	D	D	M	M
GLENOID LENGTH	D	D	4.50	4.36	D	3.1e	M	M
GLENOID BREADTH	D	D	3.12	2.90	D	2.1e	M	M
HUMERUS LENGTH	33.31e	D	34.80	34.80	U	U	M	D
HUMERUS PYS LENGTH	D	D	33.80	33.40	U	U	M	D
MAX SHAFT DIAM	2.07	1.95	2.58	2.43	U	U	M	D
MIN SHAFT DIAM	1.84	D	1.95	1.85	U	U	M	D
MAX HEAD DIAM	D	D	4.94	4.76	U	U	M	D
MIN HEAD DIAM	D	D	4.56	4.67	U	U	M	D
EPICONDYLAR BREADTH	4.90e	D	6.95	6.55	U	U	M	D
LOWER ART. BREADTH	3.80	D	4.90	4.73	U	U	M	D
RADIUS LENGTH	24.00	21.67e	D	28.00	D	21.10e	M	M
RADIUS PYS LENGTH	22.90	D	D	26.10	D	D	M	M
RADIUS HEAD DIA	2.10	D	2.50	2.50	D	D	M	M
RADIUS DISTAL BREADTH	2.80	D	D	3.47	D	D	M	M
ULNA LENGTH	25.70	D	29.80	29.40	D	D	M	D
ULNA PYS LENGTH	23.20	D	26.10	25.90	D	D	M	D
ULNA OLECRANON HEIGHT	2.36	D	3.53	3.13	D	D	M	2.60e
ULNA OLECRANON BREADTH	2.02	D	2.75	2.60	D	D	M	1.80e
INNOMINATE LENGTH	21.10	20.30	22.00	22.50	M	M	D	D
INNOMINATE BREADTH	15.30e	D	15.80	15.50	M	M	D	D
SYMPHYSEAL HEIGHT	D	D	D	D	M	M	D	D
ACETABULUM-PUBIS LENGT	D	D	8.50	8.50	M	M	D	D
ACETABULUM-ISCHIUM LEN	7.20	D	7.60	D	M	M	D	D
SCIATIC NOTCH ANGLE	88.00	D	75.00	76.00	M	M	D	75.00
FEMUR LENGTH	37.19e	43.40	49.00	49.00	34.54e	35.54e	46.80	46.80
FEMUR PYS LENGTH	D	43.00	48.70	48.80	D	D	46.40	46.20
PROX ANT/POST DIAMETER	2.54	2.42	2.90	2.80	D	2.70	2.96	2.50
PROX LATERAL DIAMETER	3.10	3.10	3.56	3.57	D	3.50	3.05	3.46
MID ANT/POST DIAMETER	2.60	2.65	3.13	3.04	2.90	2.85	3.10	3.00
MID LATERAL DIAMETER	2.50	2.60	3.00	2.88	2.90	2.63	2.50	2.50
MAXIMUM HEAD DIAMETER	4.24	4.24	4.76	4.60	D	D	4.60	4.64
PATELLA LENGTH	3.90e	4.05	4.88	4.76	D	D	3.90e	D
PATELLA BREADTH	3.86	3.92	4.95	4.85	D	D	3.90e	D
PATELLA THICKNESS	1.74	1.80	2.66	2.64	1.90	D	2.00e	D
TIBIA LENGTH	31.38	D	40.30	39.90	D	36.59	D	38.50
TIBIA PYS LENGTH	D	D	38.40	37.90	D	D	D	36.50
CONDYLAR BREADTH	6.30e	6.50	8.15	8.16	D	D	6.10e	6.40e
TRANSVERSE CNEMIC DIAM	2.25	D	2.70	2.80e	D	D	2.70	2.70
SAGITTAL CNEMIC DIAMET	3.31	D	3.80	3.90e	D	D	3.60	3.52
MID TRANSVERSE DIAMETE	2.07	D	2.50	2.50	D	2.03	2.25	2.30
MID SAGITTAL DIAMETER	2.87	D	3.37	3.40	D	2.85	3.03	3.20e
FIBULA LENGTH	35.00e	D	38.80	38.70	M	D	D	D
CALCANEUS LENGTH	M	M	M	7.80	D	D	7.80e	7.60e
CALCANEUS HEIGHT	M	M	M	4.53	D	D	4.60	4.60
TALUS LENGTH	M	5.46e	M	5.70e	4.80e	D	5.30e	6.00
TALUS BREADTH	M	4.03	M	4.60	D	D	D	D
TALUS HEIGHT	M	2.90	M	3.00	2.90	D	3.30	3.30

BOSIE/CASCADE BURIAL 12 BACKHOE DI

POST CRANIAL DATA M

YRS 38-42

	RIGHT	LEFT	RIGHT	LEFT
CLAVICLE LENGTH	D	D		
CLAVICLE DIAMETER	D	M		
SCAPULA LENGTH	D	M		
SCAPULA BREADTH	D	M		
GLENOID LENGTH	M	M		
GLENOID BREADTH	M	M		
HUMERUS LENGTH	32.38	31.73	D	31.62
HUMERUS PYS LENGTH	D	D	D	D
MAX SHAFT DIAM	2.40	2.34	D	2.15
MIN SHAFT DIAM	1.74	1.73	D	1.70
MAX HEAD DIAM	D	D	D	D
MIN HEAD DIAM	D	D	D	D
EPICONDYLAR BREADTH	D	D	D	D
LOWER ART. BREADTH	D	D	D	D
RADIUS LENGTH	M	D		
RADIUS PYS LENGTH	M	D		
RADIUS HEAD DIA	M	D		
RADIUS DISTAL BREADTH	M	D		
ULNA LENGTH	D	D		
ULNA PYS LENGTH	D	D		
ULNA OLECRANON HEIGHT	D	D		
ULNA OLECRANON BREADTH	D	2.50		
INNOMINATE LENGTH	D	D		
INNOMINATE BREADTH	D	D		
SYMPHYSEAL HEIGHT	D	D		
ACETABULUM-PUBIS LENGT	D	D		
ACETABULUM-ISCHIUM LEN	D	D		
SCIATIC NOTCH ANGLE	D	D		
FEMUR LENGTH	37.51e	36.24e		
FEMUR PYS LENGTH	D	D		
PROX ANT/POST DIAMETER	2.70	2.60		
PROX LATERAL DIAMETER	3.40	3.42		
MID ANT/POST DIAMETER	3.00	3.02		
MID LATERAL DIAMETER	2.60	2.66		
MAXIMUM HEAD DIAMETER	D	4.53		
PATELLA LENGTH	M	M		
PATELLA BREADTH	M	M		
PATELLA THICKNESS	M	M		
TIBIA LENGTH	M	M		
TIBIA PYS LENGTH	M	M		
CONDYLAR BREADTH	M	M		
TRANSVERSE CNEMIC DIAM	M	M		
SAGITTAL CNEMIC DIAMET	M	M		
MID TRANSVERSE DIAMETE	M	M		
MID SAGITTAL DIAMETER	M	M		
FIBULA LENGTH	M	M		
CALCANEUS LENGTH	M	M		
CALCANEUS HEIGHT	M	M		
TALUS LENGTH	M	M		
TALUS BREADTH	M	M		
TALUS HEIGHT	M	M		

APPENDIX A3 OSTEOMETRIC INDICES

CRANIAL INDICES	BURIAL 2A		BURIAL 12	
CRANIAL INDEX	NA		81.97e	BRACHYCRANY
CRANIAL LENGTH-HEIGHT	70.9	ORTHOCRANY	71.59e	ORTHOCRANY
CRANIAL BREADTH-HEIGHT	NA		86.76e	TAPEINOCRANY
MEAN BASION-HEIGHT	NA		78.44e	LOW
FRONTO-PARIETAL INDEX	NA		66.89e	METRIOMETOPIC
NASAL INDEX	57.62	PLATYRRHINY	NA	
ORBITAL INDEX	85.68	MESOCONCHY	NA	
PALATAL INDEX	73.81	LEPTOSTAPHYLINE	NA	

POST CRANIAL INDICES	BURIAL 1		BURIAL 2A		BURIAL 3A		BURIAL 3B	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
SCAPULA INDEX	NA	NA	NA	NA	NA	NA	NA	NA
CLAVICULO-HUMERAL	40.34	NA	NA	NA	NA	NA	NA	NA
RADIO-HUMERAL	74.09	NA	NA	NA	NA	NA	73.13e	NA
FEMUR PLATYMERIC	70.55	NA	84.82	67.84	84.85	86.75	86.69	84.85
FEMUR ROBUSTICITY	NA	NA	13.6	14.19	NA	NA	NA	13.24
TIBIA PLATYCNEMIC	NA	71.91	84.38	NA	75.29	73.22	69.3	NA

	BURIAL 5		BURIAL 7		BURIAL 8		BURIAL 9	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
SCAPULA INDEX	NA	NA	NA	NA	NA	NA	NA	68.24e
CLAVICULO-HUMERAL	NA	NA	NA	NA	NA	NA	43.59e	43.88e
RADIO-HUMERAL	58.91e	58.91e	NA	76.5e	72.05e	NA	NA	80.46
FEMUR PLATYMERIC	NA	NA	NA	83.33e	81.94	78.07	81.46	78.43
FEMUR ROBUSTICITY	NA	NA	NA	NA	NA	12.21	12.59	12.13
TIBIA PLATYCNEMIC	NA	NA	NA	NA	67.98e	NA	71.05	71.8e

	BURIAL 10		BURIAL 11		BURIAL 12	
	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT
SCAPULA INDEX	NA	NA	NA	NA	NA	NA
CLAVICULO-HUMERAL	NA	NA	NA	NA	NA	NA
RADIO-HUMERAL	NA	NA	NA	NA	NA	NA
FEMUR PLATYMERIC	NA	77.14	97.05e	72.25	79.41	76.02
FEMUR ROBUSTICITY	NA	NA	12.07	11.91	NA	NA
TIBIA PLATYCNEMIC	NA	NA	75.0e	76.7e	NA	NA

APPENDIX A4 STATURE CALCULATIONS

The difficulty in identifying race has an effect upon the calculation of stature. For this reason this study used only a regression formula derived for white male and female skeletal remains.

The rationale for this is two fold. First arbritary identification of race would result in stature figures derived from the arbitary formula application. Additionally the effects of intermarrage on the stature of offspring between two different races has not been dealt with for this geographical and temporal period. Second the regression formula for mongoloid stature was based upon 68 Korean males with no formula available for females. The regression formula for white males and female was based upon a sample size of 3782 males and 63 females [Trotter 1970:p.72].

Stature estimates for complete longbones were calculated using the regression formulas for white males and females from Trotter Table XXVIII; 1970;p.77. Stature estimates utilizing incomplete long bones were based upon Steele regression formulas [Tables XXX through L;1970;p.85].

The incomplete nature of the burials did not allow for the consistant use of one regression formula based on a specific element or combination of elements for male and females stature estimates. To account for these differences the stature calculations were averaged for each burial as follows. Formulas which combined a left and right combination are indicated with an asterix.

Burial 1 Female

Hum	[right]	157.09 cm ±4.45
Rad	[right]	159.21 cm ±4.24
	[left]	160.63 cm ±4.24
Ulna	[right]	160.63 cm ±4.3
	[left]	161.52 cm ±4.3
Fem	[right]	161.22 cm ±3.72
Tib	[left]	156.19 cm ±3.66
Fem/Tib*		158.85 cm ±3.55
Averaged Stature		159.37 cm ±4.06

Burial 2 Female

Ulna	[right]	168.78 cm ±4.3
	[left]	166.65 cm ±4.3
Fem	[right]	162.78 cm ±3.72
	[left]	161.05 cm ±3.72
Fib	[right]	147.51 cm ±3.57
Averaged Stature		161.35 cm ±3.92

Burial 3A Female

Rad	[right]	160.35 cm ±4.24
	[left]	159.83 cm ±4.24
Fem	[right]	165.47 cm ±3.72
	[left]	163.18 cm ±3.72
Tib	[right]	168.54 cm ±3.66
Fem/Tib	[right]	167.17 cm ±3.55
Fem/Tib*		165.87 cm ±3.55
Averaged Stature		164.34 cm ±3.81

Burial 3B Male

Hum	[left]	173.63 cm ±4.05
Rad	[right]	171.62 cm ±4.32
Fem	[right]	165.56 cm ±3.27
	[left]	168.51 cm ±3.27
Tib	[right]	170.10 cm ±3.66
Fib	[right]	166.38 cm ±3.29
Fem/Tib	[right]	167.37 cm ±2.99
Fem/Tib*		168.98 cm ±2.99
Averaged Stature		169.02 cm ±3.48

Burial 4 Male

Hum	[right]	173.32 cm ±4.05
Averaged Stature		173.32 cm ±4.05

Burial 5 Female

Hum	[right]	165.3 cm ±4.45
	[left]	165.3 cm ±4.45
Rad	[right]	144.14 cm ±4.24
	[left]	144.14 cm ±4.24
Averaged Stature		154.72 cm ±4.35

Burial 7 Male

Hum	[left]	171.91 cm ±4.05
Rad	[right]	173.85 cm ±4.32
	[left]	174.27 cm ±4.32
Ulna	[left]	174.32 cm ±4.32
Fem	[left]	180.39 cm ±3.72
Averaged Stature		174.95 cm ±4.06

Burial 8 Female

Hum	[right]	169.89 cm ±4.45
Rad	[right]	168.69 cm ±4.24
	[left]	157.65 cm ±4.24
Ulna	[right]	167.50 cm ±4.3
Fem	[right]	145.96 cm ±3.72
	[left]	161.30 cm ±3.72
Tib	[right]	152.53 cm ±3.66
Fib	[right]	162.16 cm ±3.57
Fem/Tib	[right]	148.51 cm ±3.55
Fem/Tib*		157.14 cm ±3.55
Averaged Stature		159.13 cm ±3.84

Burial 9 Male		
Hum	[right]	177.63 cm ±4.05
	[left]	177.63 cm ±4.05
Rad	[left]	184.84 cm ±4.24
Ulna	[right]	184.31 cm ±4.32
	[left]	182.83 cm ±4.32
Fem	[right]	178.03 cm ±3.27
	[left]	178.03 cm ±3.27
Tib	[right]	180.18 cm ±3.66
	[left]	179.17 cm ±3.66
Fib	[right]	175.76 cm ±3.29
	[left]	175.76 cm ±3.29
Fem/Tib	[right]	179.38 cm ±2.99
	[left]	178.86 cm ±2.99
Averaged Stature		179.42 cm ±3.65

Burial 10 Female		
Rad	[left]	154.94 cm ±4.24
Fem	[right]	139.41 cm ±3.72
	[left]	139.41 cm ±3.72
Tib	[left]	167.64 cm ±3.66
Fib/Tib*		152.07 cm ±3.55
Fib/Tib	[left]	152.07 cm ±3.55
Averaged Stature		150.92 cm ±3.74

Burial 11 Male		
Fem	[right]	172.79 cm ±3.27
	[left]	172.79 cm ±3.27
Tib	[left]	175.64 cm ±3.66
Tib/Fib*		174.18 cm ±2.99
Tib/Fib	[left]	174.18 cm ±2.99
Averaged Stature		173.92 cm ±3.24

Burial 12 Male		
Hum	[right]	170.18 cm ±4.05
	[left]	168.18 cm ±4.05
Fem	[right]	150.68 cm ±3.27
	[left]	147.66 cm ±3.27
Averaged Stature		159.18 cm ±3.66

APPENDIX A5 DENTITION RECOVERED

The information in this appendix is based upon Brothwell's notation system detailed in Digging Up Bones [1965;p.65] with the addition of the quadrant indicators from the International Tooth Identification System (ITIS) [Stonehocker 1988] and using the modified symbols listed in the following index.

Index of Symbols

Tooth missing but Socket Present	=	\
Tooth present but Socket missing	=	-
Tooth lost ante-mortum [pathological]	=	XP
Tooth lost ante-mortum [cause unkown]	=	XU
Tooth with pit or fissure cavity	=	Cp
Tooth with approximal cavity	=	Ca
Tooth with both types of caries	=	Cb
Tooth with Fracture	=	F
Alveolar abcess	=	A
Area missing	=	----

Burial 2

Quadrant 1									Quadrant 2							
8	X	X	X	X	\	2	\	:	\	\	3	4	X	6	X	X
	P, A	P	P	P				:					P	F, A	P	U

Quadrant 4									Quadrant 3							
8	7	X	5	4	3	2	1	:	1	2	3	4	5	X	7	8
Cp	F	U						:					Ca	P		

Burial 3C

Quadrant 1									Quadrant 2							
---	7	---	5	4	---	2	---	:	---	2	3	4	5	6	7	---
				Cp				:						Cp		

Quadrant 4									Quadrant 3							
X	7	6	X	4	X	X	X	:	X	X	X	X	5	6	7	X
U		Cp	P		P	P	P	:	P	P	P	P		Cp		U

Burial 3U

Quadrant 1								Quadrant 2							
8	7	6	5	4	3	X	X	1	X	3	4	5	6	7	X
Cp		Cp				U	U		U						U
Quadrant 4								**Quadrant 3**							
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8

Burial 4

Quadrant 1								Quadrant 2							
\	\	\	\	\	\	\	\	\	\	\	4	5	6	\	\
													Cb		
Quadrant 4								**Quadrant 3**							
X	X	X	X	X	X	X	X	X	X	X	X	X	X	7	8
P	P	P	P	P	P	P	P	P	P	P	P	P	P		Cp

Burial 5

Quadrant 1								Quadrant 2							
\	\	\	\	\	\	\	\	1	\	\	\	\	\	\	\
Quadrant 4								**Quadrant 3**							
------------------------------------								---	2	3	4	5	6	7	8

Burial 7

Quadrant 1								Quadrant 2							
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
		Cp											Cp		
Quadrant 4								**Quadrant 3**							
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
		Cp	Cp										Cp		

Burial 8

Quadrant 1								:	Quadrant 2							
8	7	6	5	4	3	2	1	:	\	2	\	\	5	6	7	8
								:						Cp		
Quadrant 4								:	Quadrant 3							
8	7	6	5	4	3	2	1	:	1	2	3	4	5	6	7	8
		Cp						:						Cp		

Burial 9

Quadrant 1								:	Quadrant 2							
8	7	6	5	4	3	2	1	:	1	2	3	4	5	6	7	8
Cp								:								Cp
Quadrant 4								:	Quadrant 3							
8	7	6	5	4	3	2	1	:	1	2	3	4	5	6	7	8
	Cp							:							Cp	

Burial 10

Quadrant 1								:	Quadrant 2							
X	X	X	X	X	3	\	\	:	----	----	----	4	5	6	----	----
U	P	P	P	P				:				Cp	Cp	Cp		
Quadrant 4								:	Quadrant 3							
----	----	----	X	X	\	\	\	:	\	2	3	X	X	X	X	X
			P	P				:				P	P	P	P	U

Burial 12

Quadrant 1								:	Quadrant 2							
----	----	----	----	----	----	----	----	:	----	----	----	----	----	----	----	----
Quadrant 4								:	Quadrant 3							
8	X	6	X	4	3	2	1	:	1	2	3	4	5	X	7	8
	P		P	Ca				:						P	Ca	

APPENDIX A6 TRACE ELEMENT RAW DATA

Appendix A6 contains the raw data for both Atomic Absorption [AA] and Proton Induced X-Ray Emission [PIXE] spectroscopy. The following abbreviations are present in this appendix.

RN	- Run number
DA	- Data area
T	- Target
DET	- Detector type
Ge	- Germanium
Si	- Silicon
PIXE VIA	- PIXE vial
AA VIAL	- AA vial
PIXE PPM	- PIXE parts per million
AA PPM	- AA parts per million
AGE	- Mean estimated age of burial
Uniden	- Unidentified

APPENDIX A6 TRACE ELEMENTS

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
1	As	5	3	1	Ge	740.67	1.21		60.42		Female	25
1	Ca	5	4	1	Si	3924037.25	1457.01	920.00	72850.49	46000.00	Female	25
1	Co	5	3	1	Ge	457.36	0.20		10.12		Female	25
1	Cu			1				0.90		45.00	Female	25
1	Dy	5	3	1	Ge	1265.81	50.00		2500.00		Female	25
1	Fe	5	4	1	Si	133344.83	56.89	22.30	2844.27	1115.00	Female	25
1	Mg			1				25.00		1250.00	Female	25
1	Mn	5	4	1	Si	240238.67	97.74	1.56	4887.10	78.00	Female	25
1	Na			1				29.60		1480.00	Female	25
1	Ni	5	4	1	Si	4877.73	2.25	0.40	112.71	20.00	Female	25
1	P	5	4	1	Si	29082.67	25.50		1275.14		Female	25
1	Pb			1				2.33		116.50	Female	25
1	Sr	5	4	1	Si	807.76	0.90		44.99		Female	25
1	Zn	5	4	1	Si	9729.65	5.19	45.90	259.42	2295.00	Female	25
1	Ca	5	6	2	Si	5273794.20	2218.26	973.00	110912.98	48650.00	Female	25
1	Cu			2				0.70		35.00	Female	25
1	Dy	5	5	2	Ge	1117.40	50.00		2500.00		Female	25
1	Fe	5	6	2	Si	55018.44	26.59	4.60	1329.42	230.00	Female	25
1	Mg			2				28.00		1400.00	Female	25
1	Mn	5	6	2	Si	432391.75	199.29	1.05	9964.28	52.50	Female	25
1	Na			2				30.30		1515.00	Female	25
1	P	5	6	2	Si	46035.70	45.73		2286.54		Female	25
1	Pb			2				2.35		117.50	Female	25
1	Sr	5	6	2	Si	1064.60	1.34		67.17		Female	25
1	Zn	5	6	2	Si	13986.23	8.45	32.60	422.44	1630.00	Female	25
2	As	5	8	3	Si	305.07	0.33		16.55		Female	45
2	As	5	7	3	Ge	634.00	1.63		81.62		Female	45
2	Br	5	7	3	Si	377.00	0.48		24.21		Female	45
2	Ca	5	8	3	Si	2607907.10	1528.23	958.00	76411.56	47900.00	Female	45
2	Cu	5	8	3	Si	9038.19	6.99	0.38	349.34	19.00	Female	45
2	Dy	5	7	3	Ge	802.05	50.00		2500.00		Female	45
2	Fe	5	8	3	Si	89771.61	60.44	22.70	3022.05	1135.00	Female	45
2	Mg			3				40.00		2000.00	Female	45
2	Mn	5	8	3	Si	138548.76	88.96	1.57	4448.15	78.50	Female	45
2	Mo	5	8	3	Si	118.60	0.36		17.78		Female	45
2	Na			3				32.10		1605.00	Female	45
2	P	5	8	3	Si	14191.00	19.64		981.99		Female	45
2	Pb			3				2.69		134.50	Female	45
2	Rb	5	7	3	Ge	821.60	2.71		135.47		Female	45
2	Sr	5	8	3	Si	802.14	1.41		70.51		Female	45
2	Sr	5	7	3	Ge	642.60	2.34		117.18		Female	45
2	Zn	5	8	3	Si	16629.30	14.00	54.50	699.76	2725.00	Female	45
2	As	5	10	4	Si	1499.44	0.93		46.75		Female	45
2	Ca	5	10	4	Si	4963508.15	1672.03	1025.00	83601.53	51250.00	Female	45
2	Cu	5	10	4	Si	3765.60	1.67	0.77	83.67	38.50	Female	45
2	Dy	5	9	4	Ge	1395.22	50.00		2500.00		Female	45
2	Fe	5	10	4	Si	227464.65	88.04	30.60	4401.85	1530.00	Female	45
2	Mg			4				42.00		2100.00	Female	45
2	Mn	5	10	4	Si	288952.49	106.66	1.25	5332.87	62.50	Female	45
2	Na			4				35.30		1765.00	Female	45
2	Nb	5	10	4	Si	250.18	0.36		17.84		Female	45
2	Ni			4				0.40		20.00	Female	45
2	P	5	10	4	Si	36123.37	28.74		1436.94		Female	45

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
2	Pb			4				4.06		203.00	Female	45
2	Sr	5	9	4	Ge	939.97	1.97		98.53		Female	45
2	Sr	5	10	4	Si	2352.30	2.38		118.86		Female	45
2	Y	5	10	4	Si	534.00	0.59		29.66		Female	45
2	Zn	5	10	4	Si	22484.56	10.88	49.50	543.90	2475.00	Female	45
2	Zr	5	10	4	Si	564.60	0.72		35.81		Female	45
3 BAG	Ca	5	12	5	Si	5308118.70	4423.41	1060.00	221170.44	53000.00	Uniden	
3 BAG	Cu			5				0.32		16.00	Uniden	
3 BAG	Dy	5	11	5	Ge	564.00	50.00		2500.00		Uniden	
3 BAG	Fe	5	12	5	Si	98457.79	94.27	11.20	4713.38	560.00	Uniden	
3 BAG	Mg			5				36.00		1800.00	Uniden	
3 BAG	Mn	5	12	5	Si	335027.71	305.92	2.13	15295.95	106.50	Uniden	
3 BAG	Na			5				34.50		1725.00	Uniden	
3 BAG	Ni			5				0.40		20.00	Uniden	
3 BAG	P	5	12	5	Si	35015.16	68.91		3445.62		Uniden	
3 BAG	Pb			5				1.94		97.00	Uniden	
3 BAG	Sr	5	11	5	Ge	629.14	3.26		163.14		Uniden	
3 BAG	Sr	5	12	5	Si	2866.08	7.17		358.26		Uniden	
3 BAG	Zn	5	12	5	Si	23657.54	28.31	53.20	1415.67	2660.00	Uniden	
3 BAG	Zr	5	12	5	Si	205.97	0.65		32.32		Uniden	
3 BAG	Zr	5	11	5	Ge	234.74	1.47		73.46		Uniden	
3 BAG	Ca	5	14	6	Si	2052320.90	1624.16	891.00	81208.19	44550.00	Uniden	
3 BAG	Cu			6				0.24		12.00	Uniden	
3 BAG	Dy	5	13	6	Ge	593.90	50.00		2500.00		Uniden	
3 BAG	Fe	5	14	6	Si	69231.69	62.95	25.20	3147.42	1260.00	Uniden	
3 BAG	Mg			6				37.00		1850.00	Uniden	
3 BAG	Mn	5	14	6	Si	127728.59	110.76	1.91	5537.99	95.50	Uniden	
3 BAG	Na			6				29.90		1495.00	Uniden	
3 BAG	Ni			6				0.40		20.00	Uniden	
3 BAG	P	5	14	6	Si	17811.40	33.29		1664.48		Uniden	
3 BAG	Pb			6				2.31		115.50	Uniden	
3 BAG	Ru	5	14	6	Si	66.70	0.33		16.37		Uniden	
3 BAG	Ru	5	13	6	Ge	207.53	1.53		76.26		Uniden	
3 BAG	Sr	5	14	6	Si	1261.20	2.99		149.71		Uniden	
3 BAG	Zn	5	14	6	Si	8976.86	10.20	59.70	510.13	2985.00	Uniden	
3 BAG	Zr	5	14	6	Si	269.30	0.80		40.13		Uniden	
3 B	Ca	5	16	7	Si	2655631.08	1267.44	936.00	63371.85	46800.00	Male	28
3 B	Cu			7				0.35		17.50	Male	28
3 B	Dy	5	15	7	Ge	984.78	50.00		2500.00		Male	28
3 B	Fe	5	16	7	Si	44384.77	24.34	11.40	1216.91	570.00	Male	28
3 B	Mg			7				36.00		1800.00	Male	28
3 B	Mn	5	16	7	Si	156023.68	81.59	1.91	4079.70	95.50	Male	28
3 B	Na			7				33.40		1670.00	Male	28
3 B	Ni	5	16	7	Si	3813.72	2.27	0.40	113.28	20.00	Male	28
3 B	P	5	16	7	Si	22753.30	25.65		1282.33		Male	28
3 B	Pb			7				1.83		91.50	Male	28
3 B	Sr	5	16	7	Si	1030.00	1.47		73.74		Male	28
3 B	Zn	5	16	7	Si	19567.44	13.41	65.90	670.61	3295.00	Male	28
3 B	Ca	5	18	8	Si	2045923.54	868.17	1014.00	43408.45	50700.00	Male	28
3 B	Cu	5	18	8	Si	9527.68	5.33	0.36	266.66	18.00	Male	28
3 B	Dy	5	17	8	Ge	1107.60	50.00		2500.00		Male	28
3 B	Fe	5	18	8	Si	89618.48	43.69	14.60	2184.63	730.00	Male	28
3 B	Mg			8				39.00		1950.00	Male	28
3 B	Mn	5	18	8	Si	156476.89	72.76	2.73	3637.85	136.50	Male	28
3 B	Na			8				32.60		1630.00	Male	28
3 B	Ni			8				0.40		20.00	Male	28

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
3 B	P	5	18	8	Si	18786.54	18.83		941.36		Male	28
3 B	Pb			8				1.41		70.50	Male	28
3 B	Sr	5	18	8	Si	1341.30	1.71		85.38		Male	28
3 B	Zn	5	18	8	Si	19964.74	12.17	64.70	608.35	3235.00	Male	28
3 B	Zr	5	18	8	Si	738.10	1.18		58.98		Male	28
4	As	5	19	9	Ge	336.82	1.67		83.45		Male	23
4	Ca	5	20	9	Si	1413797.30	1594.48	1200.00	79724.14	60000.00	Male	23
4	Cu	5	20	9	Si	3038.37	4.52	0.46	226.01	23.00	Male	23
4	Dy	5	19	9	Ge	416.74	50.00		2500.00		Male	23
4	Fe	5	20	9	Si	30774.93	39.88	14.40	1993.86	720.00	Male	23
4	Mg			9				37.00		1850.00	Male	23
4	Mn	5	20	9	Si	104880.61	129.61	1.34	6480.48	67.00	Male	23
4	Na			9				28.70		1435.00	Male	23
4	Ni			9				0.40		20.00	Male	23
4	P	5	20	9	Si	11194.06	29.82		1490.79		Male	23
4	Pb			9				1.98		99.00	Male	23
4	Sr	5	19	9	Ge	194.37	1.36		68.21		Male	23
4	Sr	5	20	9	Si	770.70	2.61		130.38		Male	23
4	Zn	5	20	9	Si	11912.00	19.29	66.00	964.70	3300.00	Male	23
4	Ca	5	22	10	Si	2192998.58	1568.72	983.00	78435.81	49150.00	Male	23
4	Cu			10				0.29		14.50	Male	23
4	Dy	5	21	10	Ge	657.04	50.00		2500.00		Male	23
4	Fe	5	22	10	Si	41119.16	33.79	9.90	1689.73	495.00	Male	23
4	Mg			10				36.00		1800.00	Male	23
4	Mn	5	22	10	Si	172884.22	135.51	1.48	6775.49	74.00	Male	23
4	Na			10				32.50		1625.00	Male	23
4	Ni	5	22	10	Si	3238.90	2.88	0.40	144.19	20.00	Male	23
4	P	5	22	10	Si	20029.20	33.84		1691.86		Male	23
4	Pb			10				1.31		65.50	Male	23
4	Sr	5	22	10	Si	1180.00	2.53		126.61		Male	23
4	Zn	5	22	10	Si	13493.90	13.86	53.60	693.14	2680.00	Male	23
4	Ca	6	4	11	Si	4234794.15	1568.81	952.00	78440.66	47600.00	Male	23
4	Cu			11				0.19		9.50	Male	23
4	Dy	6	3	11	Ge	1268.70	50.00		2500.00		Male	23
4	Fe	5	4	11	Si	36528.44	15.55	4.80	777.38	240.00	Male	23
4	Mg			11				32.00		1600.00	Male	23
4	Mn	6	4	11	Si	243410.85	98.81	0.55	4940.36	27.50	Male	23
4	Na			11				26.40		1320.00	Male	23
4	Ni	6	4	11	Si	5236.00	2.41	0.40	120.72	20.00	Male	23
4	P	6	4	11	Si	39603.69	34.65		1732.49		Male	23
4	Pb			11				1.35		67.50	Male	23
4	Sr	6	4	11	Si	1110.36	1.23		61.70		Male	23
4	Sr	6	3	11	Ge	1752.11	4.04		201.98		Male	23
4	Yb	6	3	11	Ge	352.12	113.31		5665.57		Male	23
4	Zn	6	4	11	Si	10941.67	5.82	35.30	291.07	1765.00	Male	23
4	Zr	6	4	11	Si	291.78	0.41		20.35		Male	23
5	Ca	6	6	12	Si	2781806.08	1296.07	913.00	64803.47	45650.00	Female	18
5	Cu			12				0.44		22.00	Female	18
5	Dy	6	5	12	Ge	1008.78	50.00		2500.00		Female	18
5	Fe	6	6	12	Si	24115.32	12.91	21.90	645.45	1095.00	Female	18
5	Mg			12				41.00		2050.00	Female	18
5	Mn	6	6	12	Si	165896.48	84.69	0.71	4234.65	35.50	Female	18
5	Na			12				31.90		1595.00	Female	18
5	Nb	6	6	12	Si	229.76	0.45		22.66		Female	18
5	Ni	6	6	12	Si	860.83	0.50	0.50	24.96	25.00	Female	18
5	P	6	6	12	Si	30385.77	33.43		1671.73		Female	18

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
5	Pb			12				0.92		46.00	Female	18
5	Sr	6	6	12	Si	1437.93	2.01		100.49		Female	18
5	Zn	6	6	12	Si	7946.89	5.32		265.87		Female	18
5	Zr	6	6	12	Si	382.50	0.67		33.56		Female	18
5	As	6	7	13	Ge	529.12	1.55		77.49		Female	18
5	Ca	6	8	13	Si	3630139.33	2419.99	879.00	120999.50	43950.00	Female	18
5	Cu	6	8	13	Si	10847.51	9.54	0.50	476.96	25.00	Female	18
5	Dy	6	7	13	Ge	705.03	50.00		2500.00		Female	18
5	Fe	6	8	13	Si	89109.79	68.25	10.00	3412.57	500.00	Female	18
5	Ga	6	8	13	Si	488.45	0.51		25.46		Female	18
5	Mg			13				34.00		1700.00	Female	18
5	Mn	6	8	13	Si	212223.10	155.02	0.40	7751.08	20.00	Female	18
5	Na			13				29.30		1465.00	Female	18
5	Ni			13				0.40		20.00	Female	18
5	P	6	8	13	Si	37200.15	58.57		2928.40		Female	18
5	Pb			13				0.98		49.00	Female	18
5	Sr	6	8	13	Si	1755.90	3.51		175.58		Female	18
5	Zn	6	8	13	Si	14905.10	14.27	38.50	713.51	1925.00	Female	18
7	Ca	6	10	14	Si	3894212.33	1744.94	1162.00	87246.75	58100.00	Male	18
7	Cu			14				0.88		44.00	Male	
7	Dy	6	9	14	Ge	1048.91	50.00		2500.00		Male	18
7	Fe	6	10	14	Si	107314.93	55.25	14.80	2762.39	740.00	Male	18
7	Mg			14				35.00		1750.00	Male	18
7	Mn	6	10	14	Si	189787.21	93.18	0.98	4659.14	49.00	Male	18
7	Na			14				21.80		1090.00	Male	18
7	Ni			14				0.50		25.00	Male	18
7	P	6	10	14	Si	42176.91	44.63		2231.67		Male	18
7	Pb			14				1.26		63.00	Male	18
7	Sr	6	9	14	Ge	790.04	2.20		110.16		Male	18
7	Sr	6	10	14	Si	1947.19	2.62		130.88		Male	18
7	Zn	6	10	14	Si	21652.34	13.93	59.60	696.69	2980.00	Male	18
7	Zr	6	10	14	Si	424.60	0.72		35.82		Male	18
7	Ca	6	12	15	Si	3847756.33	1702.84	963.00	85141.78	48150.00	Male	18
7	Cu			15				0.38		19.00	Male	
7	Dy	6	11	15	Ge	1062.02	50.00		2500.00		Male	18
7	Fe	6	12	15	Si	93687.47	47.64	12.50	2381.84	625.00	Male	18
7	Mg			15				36.00		1800.00	Male	18
7	Mn	6	12	15	Si	203208.93	98.54	0.86	4927.05	43.00	Male	18
7	Na			15				27.50		1375.00	Male	18
7	Ni	6	12	15	Si	7387.90	4.07	0.50	203.48	25.00	Male	18
7	P	6	12	15	Si	41021.57	42.87		2143.74		Male	18
7	Pb			15				1.06		53.00	Male	18
7	Sr	6	12	15	Si	1798.58	2.39		119.40		Male	18
7	Zn	6	12	15	Si	19783.83	12.57	59.60	628.71	2980.00	Male	18
7	Zr	6	12	15	Si	326.40	0.54		27.20		Male	18
8	Ca	6	14	16	Si	3465637.58	2476.96	824.00	123848.06	41200.00	Female	17
8	Cu	6	14	16	Si	3301.70	3.11	1.83	155.65	91.50	Female	17
8	Dy	6	13	16	Ge	657.60	50.00		2500.00		Female	17
8	Fe	6	14	16	Si	63076.97	51.80	7.60	2589.84	380.00	Female	17
8	Mg			16				36.00		1800.00	Female	17
8	Mn	6	14	16	Si	193752.33	151.74	1.09	7586.87	54.50	Female	17
8	Na			16				28.80		1440.00	Female	17
8	Ni	6	14	16	Si	4558.23	4.05	0.40	202.75	20.00	Female	17
8	P	6	14	16	Si	31786.81	53.65		2682.74		Female	17
8	Pb			16				0.62		31.00	Female	17
8	Sr	6	14	16	Si	1456.82	3.12		156.18		Female	17

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
8	Zn	6	14	16	Si	9068.32	9.31	31.20	465.41	1560.00	Female	17
8	Ca	6	16	17	Si	2683386.33	886.45	916.00	44322.32	45800.00	Female	17
8	Cu	6	16	17	Si	1458.02	0.64	0.93	31.77	46.50	Female	17
8	Dy	6	15	17	Ge	1422.75	50.00		2500.00		Female	17
8	Fe	6	16	17	Si	49700.76	18.86	7.70	943.19	385.00	Female	17
8	Mg			17				35.00		1750.00	Female	17
8	Mn	6	16	17	Si	191180.88	69.20	2.50	3460.14	125.00	Female	17
8	Na			17				29.30		1465.00	Female	17
8	Ni	6	16	17	Si	1926.32	0.79	0.50	39.60	25.00	Female	17
8	P	6	16	17	Si	25087.91	19.57		978.65		Female	17
8	Pb			17				0.77		38.50	Female	17
8	Sr	6	16	17	Si	1780.39	1.76		88.22		Female	17
8	Zn	6	16	17	Si	10859.44	5.15	34.40	257.60	1720.00	Female	17
8	Ca	6	18	18	Si	4164757.83	2199.86	1009.00	109993.04	50450.00	Female	17
8	Cu	6	18	18	Si	11997.21	8.36	3.05	417.97	152.50	Female	17
8	Dy	6	17	18	Ge	889.80	50.00		2500.00		Female	17
8	Fe	6	18	18	Si	110447.15	67.03	10.10	3351.40	505.00	Female	17
8	Mg			18				36.00		1800.00	Female	17
8	Mn	6	18	18	Si	234278.87	135.60	1.36	6779.82	68.00	Female	17
8	Na			18				26.20		1310.00	Female	17
8	Ni	6	18	18	Si	2767.04	1.82	0.50	90.96	25.00	Female	17
8	P	6	18	18	Si	41409.26	51.66		2582.84		Female	17
8	Pb			18				1.01		50.50	Female	17
8	Sr	6	18	18	Si	2530.09	4.01		200.46		Female	17
8	Zn	6	18	18	Si	55891.94	42.40	83.10	2119.97	4155.00	Female	17
8	Zr	6	18	18	Si	546.69	1.09		54.37		Female	17
9	Ca	6	20	19	Si	5055309.65	2093.89	922.00	104694.31	46100.00	Male	21
9	Cu	6	20	19	Si	4313.40	2.36	0.41	117.84	20.50	Male	21
9	Dy	6	19	19	Ge	1134.73	50.00		2500.00		Male	21
9	Fe	6	20	19	Si	138035.80	65.69	10.90	3284.45	545.00	Male	21
9	Mg			19				37.00		1850.00	Male	21
9	Mn	6	20	19	Si	224797.76	102.03	0.48	5101.25	24.00	Male	21
9	Na			19				21.40		1070.00	Male	21
9	Ni	6	20	19	Si	7282.82	3.75	0.40	187.73	20.00	Male	21
9	P	6	20	19	Si	58809.10	57.53		2876.37		Male	21
9	Pb			19				0.87		43.50	Male	21
9	Sr	6	20	19	Si	2460.54	3.06		152.87		Male	21
9	Zn	6	20	19	Si	17419.96	10.36	39.60	518.12	1980.00	Male	21
9	Ca	6	22	20	Si	3979708.33	2042.39	971.00	102119.57	48550.00	Male	21
9	Cu			20				0.38		19.00	Male	21
9	Dy	6	21	20	Ge	915.82	50.00		2500.00		Male	21
9	Fe	6	22	20	Si	84167.35	49.63	8.70	2481.40	435.00	Male	21
9	Mg			20				35.00		1750.00	Male	21
9	Mn	6	22	20	Si	193924.05	109.05	0.39	5452.54	19.50	Male	21
9	Na			20				23.70		1185.00	Male	21
9	Ni	6	22	20	Si	6215.63	3.97	0.40	198.52	20.00	Male	21
9	P	6	22	20	Si	40543.79	49.14		2457.01		Male	21
9	Pb			20				0.91		45.50	Male	21
9	Sr	6	22	20	Si	1723.19	2.65		132.65		Male	21
9	Zn	6	22	20	Si	12968.45	9.56	40.80	477.92	2040.00	Male	21
9	Zr	6	22	20	Si	381.56	0.74		36.87		Male	21
10	Ca	7	4	21	Si	3654444.33	1665.19	859.00	83259.27	42950.00	Female	42
10	Cu			21				0.52		26.00	Female	42
10	Dy	7	3	21	Ge	1031.47	50.00		2500.00		Female	42
10	Fe	7	4	21	Si	67490.74	35.33	5.80	1766.65	290.00	Female	42
10	Mg			21				32.00		1600.00	Female	42

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
10	Mn	7	4	21	Si	244986.80	122.32	1.95	6115.94	97.50	Female	42
10	Na			21				25.90		1295.00	Female	42
10	Ni	7	4	21	Si	5333.03	3.02	0.40	151.23	20.00	Female	42
10	P	7	4	21	Si	38417.87	41.34		2067.14		Female	42
10	Pb			21				0.99		49.50	Female	42
10	Sr	7	3	21	Ge	600.36	1.70		85.12		Female	42
10	Sr	7	4	21	Si	2005.98	2.74		137.11		Female	42
10	Yb	7	3	21	Ge	472.61	187.06		9353.16		Female	42
10	Zn	7	4	21	Si	26030.49	17.03	60.80	851.73	3040.00	Female	42
10	Ca	7	6	22	Si	2947878.08	4580.48	868.00	229023.85	43400.00	Female	42
10	Cu	7	6	22	Si	1958.50	4.01	0.34	200.72	17.00	Female	42
10	Dy	7	5	22	Ge	302.48	50.00		2500.00		Female	42
10	Fe	7	6	22	Si	65334.61	116.64	12.40	5831.90	620.00	Female	42
10	Mg			22				33.00		1650.00	Female	42
10	Mn	7	4	22	Si	170737.14	290.70	1.90	14534.78	95.00	Female	42
10	Na			22				26.90		1345.00	Female	42
10	Ni	7	6	22	Si	3287.23	6.36	0.40	317.88	20.00	Female	42
10	P	7	6	22	Si	27961.99	102.61		5130.56		Female	42
10	Pb			22				0.98		49.00	Female	42
10	Sr	7	6	22	Si	1155.38	5.39		269.29		Female	42
10	Zn	7	6	22	Si	12250.88	27.34	40.90	1366.92	2045.00	Female	42
11	As	7	7	23	Ge	373.00	1.76		88.18		Male	22
11	Ca	7	8	23	Si	2667281.08	2870.34	948.00	143517.13	47400.00	Male	22
11	Cu	7	8	23	Si	5391.23	7.65	0.29	382.66	14.50	Male	22
11	Dy	7	7	23	Ge	436.75	50.00		2500.00		Male	22
11	Fe	7	8	23	Si	34280.57	42.38	3.80	2119.23	190.00	Male	22
11	Mg			23				23.00		1150.00	Male	22
11	Mn	7	8	23	Si	177879.13	209.75	4.51	10487.44	225.50	Male	22
11	Na			23				25.50		1275.00	Male	22
11	Ni	7	8	23	Si	1832.39	2.45	0.40	122.72	20.00	Male	22
11	P	7	8	23	Si	26193.78	66.57		3328.57		Male	22
11	Pb			23				1.25		62.50	Male	22
11	Sr	7	8	23	Si	1482.21	4.79		239.26		Male	22
11	Zn	7	8	23	Si	12536.21	19.37	44.70	968.74	2235.00	Male	22
11	As	7	9	24	Si	372.50	0.30		15.10		Male	22
11	Ba	7	9	24	Ge	172.19	2.53		126.58		Male	22
11	Ca	7	10	24	Si	3916075.83	1714.86	954.00	85742.83	47700.00	Male	22
11	Cu			24				0.35		17.50	Male	22
11	Dy	7	9	24	Ge	1073.30	50.00		2500.00		Male	22
11	Fe	7	10	24	Si	86153.61	43.35	11.80	2167.29	590.00	Male	22
11	Mg			24				23.00		1150.00	Male	22
11	Mn	7	10	24	Si	207496.16	99.56	2.57	4978.13	128.50	Male	22
11	Na			24				23.40		1170.00	Male	22
11	Ni	7	10	24	Si	2992.71	1.63	0.40	81.56	20.00	Male	22
11	P	7	10	24	Si	41620.89	43.04		2152.20		Male	22
11	Pb			24				1.32		66.00	Male	22
11	Sn	7	10	24	Si	271.62	2.15		107.37		Male	22
11	Sr	7	10	24	Si	2184.16	2.87		143.47		Male	22
11	Zn	7	10	24	Si	17687.89	11.12	45.50	556.20	2275.00	Male	22
12	Ca	7	12	25	Si	2844666.33	1793.32	974.00	89666.09	48700.00	Male	40
12	Cu			25				0.26		13.00	Male	40
12	Dy	7	11	25	Ge	745.54	50.00		2500.00		Male	40
12	Fe	7	12	25	Si	55634.92	40.30	13.00	2014.84	650.00	Male	40
12	Mg			25				35.00		1750.00	Male	40
12	Mn	7	12	25	Si	177801.61	122.82	0.88	6141.04	44.00	Male	40
12	Na			25				27.20		1360.00	Male	40

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
12	Ni	7	12	25	Si	2487.49	1.95	0.40	97.59	20.00	Male	40
12	P	7	12	25	Si	27953.89	41.62		2080.96		Male	40
12	Pb			25				1.18		59.00	Male	40
12	Sr	7	11	25	Ge	308.12	1.21		60.44		Male	40
12	Sr	7	12	25	Si	2210.38	4.18		209.02		Male	40
12	Zn	7	12	25	Si	7185.94	6.51	45.20	325.30	2260.00	Male	40
12	Zr	7	12	25	Si	458.40	1.08		54.18		Male	40
12	Ca	7	14	26	Si	3531471.83	2313.30	798.00	115664.93	39900.00	Male	40
12	Cu			26				0.28		14.00	Male	40
12	Dy	7	13	26	Ge	717.50	50.00		2500.00		Male	40
12	Fe	7	14	26	Si	117178.05	88.19	18.70	4409.49	935.00	Male	40
12	Mg			26				32.00		1600.00	Male	40
12	Mn	7	14	26	Si	188585.47	135.36	1.24	6768.05	62.00	Male	40
12	Na			26				27.30		1365.00	Male	40
12	Ni	7	14	26	Si	5730.80	4.67	0.40	233.62	20.00	Male	40
12	P	7	14	26	Si	36935.71	57.14		2857.05		Male	40
12	Pb			26				1.24		62.00	Male	40
12	Sr	7	14	26	Si	2431.35	4.78		238.90		Male	40
12	Sr	7	13	26	Ge	1879.69	7.66		383.14		Male	40
12	Yb	7	13	26	Ge	307.20	174.80		8740.00		Male	40
12	Zn	7	14	26	Si	24026.18	22.60	57.80	1130.15	2890.00	Male	40
12	Zr	7	14	26	Si	637.93	1.57		78.69		Male	40
X61	Ca	7	16	27	Si	4862276.65	2071.08	1400.00	103553.95	70000.00	Uniden	
X61	Cu			27				0.21		10.50	Uniden	
X61	Dy	7	15	27	Ge	1103.42	50.00		2500.00		Uniden	
X61	Fe	7	16	27	Si	95529.78	46.75	9.60	2337.55	480.00	Uniden	
X61	Ho	7	15	27	Ge	222.87	11.33		566.46		Uniden	
X61	Mg			27				16.00		800.00	Uniden	
X61	Mn	7	16	27	Si	207595.47	96.89	4.00	4844.56	200.00	Uniden	
X61	Na			27				23.30		1165.00	Uniden	
X61	Ni	7	16	27	Si	6593.40	3.50	0.50	174.78	25.00	Uniden	
X61	P	7	16	27	Si	50293.25	50.59		2529.66		Uniden	
X61	Pb			27				0.72		36.00	Uniden	
X61	Sr	7	16	27	Si	1201.74	1.54		76.78		Uniden	
X61	Zn	7	16	27	Si	4617.27	2.82	8.70	141.23	435.00	Uniden	
X63	Ca	7	18	28	Si	4161276.08	2520.10	1400.00	126005.04	70000.00	Uniden	
X63	Cu	7	18	28	Si	2627.20	2.10	0.29	104.94	14.50	Uniden	
X63	Dy	7	17	28	Ge	776.08	50.00		2500.00		Uniden	
X63	Fe	7	18	28	Si	72469.03	50.42	10.50	2521.21	525.00	Uniden	
X63	Gd	7	17	28	Ge	228.39	11.38		569.22		Uniden	
X63	Mg			28				16.00		800.00	Uniden	
X63	Mn	7	18	28	Si	184270.66	122.28	2.94	6114.02	147.00	Uniden	
X63	Na			28				21.90		1095.00	Uniden	
X63	Ni	7	18	28	Si	2102.40	1.58	0.50	79.24	25.00	Uniden	
X63	P	7	18	28	Si	48168.81	68.89		3444.71		Uniden	
X63	Pb			28				0.00			Uniden	
X63	Sr	7	17	28	Ge	496.97	1.87		93.65		Uniden	
X63	Sr	7	18	28	Si	1274.56	2.32		115.78		Uniden	
X63	Zn	7	18	28	Si	3670.19	3.19	12.90	159.61	645.00	Uniden	
2SOIL	Ca	8	22	29	Si	84261.86	42.79	57.00	2139.34	2850.00	Soil	
2SOIL	Cr	8	22	29	Si	1389.98	0.75		37.54		Soil	
2SOIL	Cu			29				0.16		8.00	Soil	
2SOIL	Dy	8	21	29	Ge	925.59	50.00		2500.00		Soil	
2SOIL	Fe	8	22	29	Si	205221.86	119.73	32.10	5986.44	1605.00	Soil	
2SOIL	K	8	22	29	Si	12683.61	7.54		376.84		Soil	
2SOIL	Mg			29				21.00		1050.00	Soil	

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
2SOIL	Mn	8	22	29	Si	82389.39	45.84	0.91	2292.08	45.50	Soil	
2SOIL	Na			29				1.50		75.00	Soil	
2SOIL	Nb	8	22	29	Si	111.45	0.24		11.98		Soil	
2SOIL	Ni	8	22	29	Si	5678.90	3.59	0.40	179.46	20.00	Soil	
2SOIL	P	8	22	29	Si	558.92	0.67		33.51		Soil	
2SOIL	Pb			29				0.00			Soil	
2SOIL	Rb	8	22	29	Si	301.44	0.41		20.44		Soil	
2SOIL	Sr	8	22	29	Si	236.18	0.36		17.99		Soil	
2SOIL	Ti	8	22	29	Si	11128.13	5.71		285.49		Soil	
2SOIL	Zn	8	22	29	Si	6162.49	4.49	0.40	224.70	20.00	Soil	
3SOIL	Ca	8	20	30	Si	60197.32	58.79	78.00	2939.32	3900.00	Soil	
3SOIL	Cu			30				0.19		9.50	Soil	
3SOIL	Dy	8	19	30	Ge	481.28	50.00		2500.00		Soil	
3SOIL	Fe	8	20	30	Si	165742.16	185.96	40.90	9298.20	2045.00	Soil	
3SOIL	K	8	20	30	Si	15691.80	17.93		896.62		Soil	
3SOIL	Mg			30				21.00		1050.00	Soil	
3SOIL	Mn	8	20	30	Si	89150.78	95.40	3.59	4769.85	179.50	Soil	
3SOIL	Na			30				1.90		95.00	Soil	
3SOIL	Ni	8	20	30	Si	2514.55	3.06	0.40	152.82	20.00	Soil	
3SOIL	P	8	20	30	Si	408.35	0.94		47.09		Soil	
3SOIL	Pb			30				0.00			Soil	
3SOIL	Rb	8	20	30	Si	484.13	1.26		63.12		Soil	
3SOIL	Sb	8	20	30	Si	75.78	1.67		83.65		Soil	
3SOIL	Sr	8	20	30	Si	307.15	0.90		44.99		Soil	
3SOIL	Ti	8	20	30	Si	8970.62	8.85		442.68		Soil	
3SOIL	Zn	8	20	30	Si	3960.37	5.55	2.40	277.72	120.00	Soil	
3SOIL	Zr	8	20	30	Si	225.16	0.83		41.40		Soil	
10SOIL	Ca	8	18	31	Si	381488.23	213.14	260.00	10657.11	13000.00	Soil	
10SOIL	Cu	8	18	31	Si	8864.39	5.06	0.36	252.96	18.00	Soil	
10SOIL	Dy	8	17	31	Ge	841.22	50.00		2500.00		Soil	
10SOIL	Fe	8	18	31	Si	384076.59	246.55	75.70	12327.41	3785.00	Soil	
10SOIL	K	8	18	31	Si	54616.50	35.71		1785.45		Soil	
10SOIL	Mg			31				31.00		1550.00	Soil	
10SOIL	Mn	8	18	31	Si	118095.50	72.30	4.59	3614.94	229.50	Soil	
10SOIL	Na			31				4.20		210.00	Soil	
10SOIL	Ni			31				0.40		20.00	Soil	
10SOIL	P	8	18	31	Si	2248.59	2.97		148.35		Soil	
10SOIL	Pb			31				1.26		63.00	Soil	
10SOIL	Rb	8	18	31	Si	415.53	0.62		31.00		Soil	
10SOIL	Sr	8	18	31	Si	851.68	1.43		71.38		Soil	
10SOIL	Ti	8	18	31	Si	45983.35	25.96		1298.24		Soil	
10SOIL	Zn	8	18	31	Si	9639.38	7.73	11.00	386.73	550.00	Soil	
10SOIL	Zr	8	18	31	Si	1312.08	2.76		138.04		Soil	
12SOIL	Ca	8	16	32	Si	158885.07	118.74	104.00	5937.22	5200.00	Soil	
12SOIL	Cr	8	16	32	Si	902.78	0.72		35.89		Soil	
12SOIL	Cu	8	16	32	Si	2698.39	2.66	0.55	132.92	27.50	Soil	
12SOIL	Dy	8	15	32	Ge	628.88	50.00		2500.00		Soil	
12SOIL	Fe	8	16	32	Si	447488.51	384.24	110.00	19212.23	5500.00	Soil	
12SOIL	K	8	16	32	Si	48748.51	42.63		2131.70		Soil	
12SOIL	Mg			32				26.00		1300.00	Soil	
12SOIL	Mn	8	16	32	si	118487.99	97.03	1.78	4851.59	89.00	Soil	
12SOIL	Na			32				3.30		165.00	Soil	
12SOIL	Ni			32				0.40		20.00	Soil	
12SOIL	P	8	16	32	Si	1109.62	1.96		97.93		Soil	
12SOIL	Pb			32				0.97		48.50	Soil	
12SOIL	Sn	8	15	32	Ge	307.35	4.10		204.90		Soil	

BURIAL	ELEMENT	RN	DA	T	DET	NETCOUNTS	PIXE VIA	AA VIAL	PIXE PPM	AA PPM	SEX	AGE
12SOIL	Sn	8	16	32	Si	350.36	4.73		236.36		Soil	
12SOIL	Sr	8	16	32	Si	725.30	1.63		81.31		Soil	
12SOIL	Sr	8	15	32	Ge	818.41	3.81		190.33		Soil	
12SOIL	Ti	8	16	32	Si	41875.27	31.63		1581.44		Soil	
12SOIL	Y	8	16	32	Si	145.73	0.36		17.96		Soil	
12SOIL	Zn	8	16	32	Si	4432.40	4.76	6.60	237.87	330.00	Soil	
12SOIL	Zr	8	16	32	Si	628.12	1.77		88.39		Soil	