Above, Beneath, and Within: Collaborative and Community-Driven Archaeological Remote Sensing Research in Canada

by

William Thomas Dowler Wadsworth

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Department of Anthropology
University of Alberta

ABSTRACT

This thesis investigates the application of geophysics and remote sensing techniques in community-driven and collaborative archaeology research in Canada. While these techniques have become common among some archaeologists, they have yet to be extensively used within the lens of Indigenous archaeology. In the introductory chapters, I present the current Canadian context and review the theory, method and application of these techniques to archaeology. I argue for a reconsideration of how these techniques are applied and interpreted within Indigenous contexts, specifically, where these applications have fallen short and how these techniques impact and are shaped by modern Indigenous communities. I propose a methodological approach that incorporates multiple lines of evidence, Indigenous knowledge, and Indigenous archaeology principles, as a potential 'middle range' solution. To illustrate how this approach can be applied with Indigenous communities in Canada, I present the methods and results of three community-driven unmarked grave surveys and two collaborative archaeology projects. Drawing on these case studies, I demonstrate 1) that these techniques are effective at contributing to common community-based research goals in a wide range of sites and environments, 2) there are unique factors present when working with Indigenous communities that need to be reflected in and balanced by research designs, 3) the incorporation of multiple lines of evidence and collaborations with Indigenous communities will result in more holistic, meaningful, and co-produced narratives for communities and researchers, and 4) when framed and designed in an engaged and respectful way, archaeological remote sensing can contribute to modern Indigenous communities' needs and objectives.

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LIST OF ABBREVIATIONS

AB	Alberta
ARS	Archaeological Remote Sensing
BC	British Columbia
CPFN	Chipewyan Prairie First Nation
CRM	Cultural Resource Management
ECN	Enoch Cree Nation
EM	Electromagnetic
EMITA	Exploring Métis Identity Through Archaeology Project
GIS	Geographic Information System
GPR	Ground-penetrating Radar
HBC	Hudson's Bay Company
LRT	Light Rail Transit
MAG	Magnetic Gradiometry
MS	Multi-spectral
NDVI	Normalized Difference Vegetation Index
NWMP	North-West Mounted Police
NWC	Northwest Coast
PFN	Papaschase First Nation
PRH	Prince Rupert Harbour
RTK/GNSS	Real-time Kinematic /Global Navigation Satellite System
SK	Saskatchewan
TSC	Taylor Seminary and College
TWTT	Two-way Travel Time
UAV	Unmanned Aerial Vehicle (otherwise known as a 'drone')

CHAPTER 1:

INTRODUCTION AND RESEARCH FRAMING

Archaeology is currently in a state of transition (Nicholas 2019). While technological advancements have enabled us to generate incredible amounts of information and answer fundamental questions at an exponential pace, many people (whether archaeologists or Indigenous community members) are becoming disassociated from their pasts (Lyons and Supernant 2020; Policy Horizons 2018). The belief in science and technology as the ultimate form of knowledge is not new (Tuhiwai-Smith 2012), but recently its dispassion and rationality has been called into question. To reconnect people to their pasts, encourage relationships between modern people and ancestors, and protect cultural landscapes, archaeological practice, methodology, and theory need to change. Remote sensing applications in archaeology have contributed to this problem in the past but can also directly contribute to these new ethical objectives. To accomplish this, however, a new methodological approach is needed for the discipline to be practiced ‘with, for, and by’ Indigenous communities, in a heart-centered and engaged way (Lyons and Supernant 2020).

Traditional archaeological excavation is destructive, and it is often debated in boardrooms, classrooms, and lecture halls about whether archaeologists should excavate sites at all (or at least only when necessary)! In recent years, Indigenous archaeologies have sought to address the colonial issues of the discipline by shifting conversations away from widespread excavation and toward active participation in Indigenous goals (Atalay 2012; Nicholas and Markey 2015; Supernant 2018a; Tuck et al. 2012). Often times, this includes the development of long-term relationships with Indigenous communities, changing traditional archaeological excavation methods to better fit Indigenous beliefs, needs, and values, and being open and inclusive in knowledge co-production while recognizing the impact of narratives. Attuned with Indigenous values and methods, practitioners of this new paradigm have often employed a 'least impact' philosophical approach (Gonzalez 2016), yet surprisingly, my research has found that the inclusion of non-destructive remote sensing techniques in this application has yet to be exploited to any great extent.

This trend goes beyond Indigenous archaeology, and while using geophysical and remote sensing techniques have become common practice for many archaeologists around the world, North American researchers have been criticized as not wholeheartedly incorporating the methods (Thompson 2015). Canada, specifically, has been slow to contribute to their applications in archaeology. When they have been applied, they have not been consistently used "with, for, and by" Indigenous communities (Atalay 2012; Nicholas and Andrews 1997: 3). In this thesis, I set out to understand how geophysical/ remote sensing techniques could be applied to collaborative and community-driven archaeology in Canada. I was particularly interested in which applications and survey designs lend themselves best to the goals outlined by Indigenous communities, and how, as researchers, we can be attentive to the impacts of our research on modern peoples. Over the course of this thesis, I will draw on five case studies that demonstrate how I have applied remote sensing techniques in community contexts and consider their results. Based upon these surveys, I consider the trajectory of archaeological remote sensing in Indigenous contexts and describe a new engaged methodological approach that is informed by Indigenous archaeologies. It will be shown that Indigenous and settler-colonial nations inhabiting the same physical landscapes require different methodological approaches to knowledge production, which in turn impacts archaeological remote sensing research and its results.

An impetus for this project has been the changing economic and political climate in Canada, which has further endangered Indigenous communities' heritage and has created nuanced impacts on Indigenous life, varying by province. Across Canada, economic development has impacted Indigenous territories (Oil Sands Monitoring Operational Task Team 2018), but the majority of development has been focused in Canada's western provinces (Alberta, Saskatchewan, and British Columbia) (Hertzberg and Argitis 2018). In Alberta and Saskatchewan, there is little community engagement as cultural resource management (CRM) archaeologists and corporations are not necessarily required to consult with specific Indigenous communities (Province of Alberta 2013, Province of Saskatchewan 2010). Governments and larger development projects often deal with Indigenous groups as a top-down process or Treaty organizations (e.g., Treaty 8 Nations of Alberta), sometimes infringing upon individual community rights (Aboriginal Affairs and Northern Development Canada 2012). Meanwhile in B.C., there is much more engagement, but many communities have less say in opposing development compared to nations with asserted title, often infringing upon their sovereignty (Jang 2020). Simply, consultant archaeologists are bound by provincial regulation and may or may not adhere to ethical guidelines set by external organizations (e.g., Canadian Archaeological Association 2019) and current trends towards engaged practice (Nicholas 2019). In contrast, fields outside archaeology (i.e., conservation biology) have reoriented to this new ethics and created community-based programs for their application in Canada, such as multiple-evidence based approaches and structures to incorporate Indigenous knowledge (Oil Sands Monitoring Operational Task Team 2018; Raygorodetsky and Chetkiewicz 2017). These frameworks and approaches have been created to work with communities rather than work around them, indirectly affirming their rights and sovereignty.

As a prime example of heritage-threatening development, Canada has nationalized the twinning of the $7.4 billion Trans-Mountain (TMX) oil pipeline, spanning from Edmonton, AB to Burnaby, BC. The pipeline has either been opposed by Indigenous groups who do not want it to interfere with their land and heritage, or cautiously supported if adequate mitigation and consultation procedures are followed (e.g., Sterritt 2019). In Alberta, these large-scale economic projects create high demand for archaeological mitigation but do not require extensive Indigenous collaboration according to provincial law (Province of Alberta 2013). In an attempt to have more control over the pipeline's trajectory and management, many Indigenous groups have banded together in an attempt to bid for part-ownership of the project, such as the Iron Coalition and Project Reconciliation (Reuters 2019). In contrast, many nations in B.C. have outright opposed the pipeline. TMX is just one of many ongoing threats to Indigenous culture and heritage in Canada. A new paradigm of archaeological practice is needed in order to immediately respond to this growing heritage crisis (Nicholas 2019; Supernant 2018a).

My goal in this thesis is to provide positive examples of community-driven and collaborative archaeological remote sensing projects to demonstrate their efficacy in contributing to community defined goals. My research questions are:

1. How are geophysical and remote sensing techniques best applied to community defined goals?
2. Which techniques and survey strategies are most appropriate for locating specific archaeological features and/or targets (i.e., unmarked graves, house features, and artifacts)?
3. What are the unique factors of community-driven and collaborative work that need to be considered when designing remote sensing research?

4. How can geophysical interpretations be balanced and augmented with other research components to derive more meaningful and easily translated conclusions for the communities? In turn, can a new Indigenous methodological approach help ARS contribute to larger anthropological research questions?
5. What is the impact of ARS research on community relationships and political aspirations?

A general history of remote sensing theory and applications in Canada is presented in Chapter 2. Fundamental principles behind ground-penetrating radar (GPR), magnetic gradiometry, unmanned aerial vehicle (UAV)-mounted multispectral imaging, magnetic susceptibility, and conductivity, along with their successes and limitations, are reviewed. I close the chapter with a review of standards and guidelines available to archaeological remote sensing professionals in Canada and find that no serious attempts have been made to standardize the practice.

In Chapter 3, I review and expand on previous frameworks that have been employed by archaeological geophysicists and propose a new approach to the discipline. Drawing on current trends in anthropological research, the incorporation of Indigenous knowledge, imagined landscapes, and community-based archaeology, I describe an *archaeological remote sensing* (ARS) methodological approach that better prepares researchers and specialists to investigate the unique problems inherent in Indigenous archaeological applications. I then apply this framework over five case studies presented in the subsequent chapters (Figure 1.1). These surveys span three provinces, many cultures, and different objectives, but each demonstrate the efficacy of the techniques for Indigenous communities. As the chapters progress, the case studies shift away from community-driven to collaborative work but increase in their multi-component nature.

Chapter 4 details three community-driven GPR surveys that I conducted to locate unmarked graves. I describe the process and outcome of the surveys for the Chipewyan Prairie First Nation, Papaschase First Nation, and Enoch Cree Nation. Consideration will also be given to the surveys' residual impacts on community politics.

Shifting the focus to traditional archaeological research, in Chapter 5, I present the results of remote sensing surveys conducted at three different sites in Prince Rupert Harbour, BC. The objective of these surveys was to locate Tsimshian architecture as part of the ongoing Prince Rupert Harbour archaeology project. I describe my initial efforts to resolve these architectural patterns and discuss its potential and limitations in and around Prince Rupert Harbour.

In the last case study, presented in Chapter 6, I present a multi-component survey of the Chimney Coulee Métis site in southwestern Saskatchewan. I describe a brief history of the site, as well as the current implications of the research for present-day Métis communities. GPR, magnetic gradiometry, conductivity/ magnetic susceptibility, and multispectral imagery results are presented and discussed in light of their ability to locate Métis cabins.

Finally, in Chapter 7, I answer the research questions and discuss the case studies in light of their method, methodological, theoretical, and applied contributions. I close the thesis with where I believe the field needs to go in the future to ensure proper techniques, collaboration, and engaged practice is maintained.

N

0 270 540 1,080 Kilometers

Figure 1.1 A map of community surveys/archaeological sites presented in this thesis.

CHAPTER 2:

THEORY, METHOD, AND PRACTICE IN REMOTE SENSING

This chapter reviews the general history, theory and method behind remote sensing techniques that will appear as part of case studies in subsequent chapters. I present a brief history of the field of remote sensing and fundamental principles prior to discussing individual techniques. Ground-penetrating radar, magnetic gradiometry, unmanned aerial vehicle (UAV)-mounted multispectral imaging, magnetic susceptibility, and conductivity approaches will be reviewed and their applications in archaeology highlighted. The chapter will close with a review of standards and guidelines available to archaeological remote sensing professionals, and whether there are differences in practice between North America and Europe. I will argue that Canada lags behind both the U.S. and Europe in any serious attempts to standardize the practice. This chapter will ultimately establish the background necessary for how remote sensing has been applied in Canada in the past, and how future projects could be structured.

2.1 What is Remote Sensing?

There are many names used to describe the application of geophysical, UAV, satellite, and photographic methods within archaeology, such as archaeological geophysics (Kvamme 2003b), archaeological prospection (Linford 2006), remote sensing, and space/satellite archaeology (Parcak 2009). Its many names and subfields have led to some confusion over the field and its relationship to archaeology. When reduced to its most basic definition, remote sensing can be defined as,

> the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation [Lillesand et al. 2015].

Under this definition, any technique or technology that acquires information non-invasively can be considered a remote sensing technique, including the human eye (Campbell and Wynne 2011; Lillesand et al. 2015). More commonly, this field is defined by the application of geophysical techniques, drones, and satellites. Archaeology has long been interested in applying ground-based geophysical tools in archaeological site surveys to characterise the site before excavation (Linford 2006). Increasingly, archaeologists have begun to adopt unmanned aerial vehicle (UAV) or 'drone' -mounted geophysical techniques to increase the speed and breadth of these field surveys (Barber 2017; Hamilton 2017). Furthermore, despite its long history, increased access to aerial and satellite imagery in recent years has allowed more researchers the ability to locate and conduct multi-scale analysis on archaeological sites (Parcak 2009). The widespread application of these techniques is transforming how archaeologists conceive of space and forcing the profession to reconsider traditional survey strategies.

There are many considerations that must be evaluated with each survey. First, geophysical techniques do not locate artifacts, features, or structures. Rather, by their definition, these surveys attempt to identify changes in physical properties of the subsurface (e.g., dielectric permittivity, magnetic susceptibility, conductivity) related to cultural and natural (chemical, biological) disturbance events (Reynolds 1998). These disturbance events, such as, the inhumation of human remains, may produce anomalies (in the form of radar reflections, magnetic dipoles, etc.) which are interpreted as potential features. Therefore, results should always be expressed in technique-specific terminology (e.g., GPR reflections) or otherwise referred to as locating 'anomalies', to better characterize the observed results (Conyers 2013).

Second, there is a clear distinction between active (provides their own energy source) and passive (only detect naturally occurring energy) remote sensing techniques (Lillesand et al. 2015). Third, techniques are dependent on environmental context and the target's characteristics (Ruffell and McKinley 2008). Some contexts provide advantages or disadvantages that preclude or enhance data acquisition for particular techniques. Lastly, many remote sensing techniques have not been ubiquitously employed in archaeology due to a knowledge and operating cost barrier (Kvamme 2018; Rindfuss and Stern 1998).

There are many types of remote sensing techniques, but this thesis will focus on ground and UAV-based methods. Specifically, the case studies highlighted in Chapters 4-6 will present data from ground-penetrating radar, magnetic gradiometry, multi-spectral imagery, magnetic susceptibility, and conductivity techniques. The following section will summarize the theory behind these techniques and challenges to their implementation.

2.2 Ground-penetrating Radar (GPR)

Ground-penetrating radar is an active geophysical technique that transmits high-frequency radar pulses from an antenna to image the subsurface (Conyers 2013). It also has a reputation as being one of the more complicated geophysical techniques in the archaeologists' toolkit (Conyers 2013). In reality, the basic components of a GPR system are quite simple (Conyers 2013; Goodman and Piro 2013). RADAR (RAdio Detection And Ranging) works by using two antennas to send electromagnetic energy (specifically along the radiowave spectrum) (Figure 2.1) into the ground and then record the resulting reflected wave and its two-way travel time (TWTT). TWTT is the time it takes for the energy to be reflected and picked up by the receiver antenna (Figure 2.2), and can be converted to depth using the following equations (Papadimitrios et al. 2019):

$$v = c/\sqrt{\varepsilon}$$

$$d = (1/2t)v$$

Radarwave velocity (v) is calculated using the speed of light constant (c) and the square-root of the relative dielectric permittivity value (measure of a material's ability to store a charge from an applied electromagnetic (EM) field) for the subsurface (ε). The velocity can be multiplied by one half of the two way time (t) to get distance (d) (Papadimitrios et al. 2019). These equations can be re-arranged to solve for velocity and the dielectric constant using collected TWTT and depths measured through excavation (as seen in Chapter 5.3). There are also ways to estimate radar velocity using computer software rather than real measurements. A common method, and the one used in this thesis, is hyperbola fitting estimation. This involves point reflection geometry, where a computer generated reflection with known velocity, dielectric permittivity, and environmental values is compared to a real reflection to infer its variables (Conyers 2013). There are various

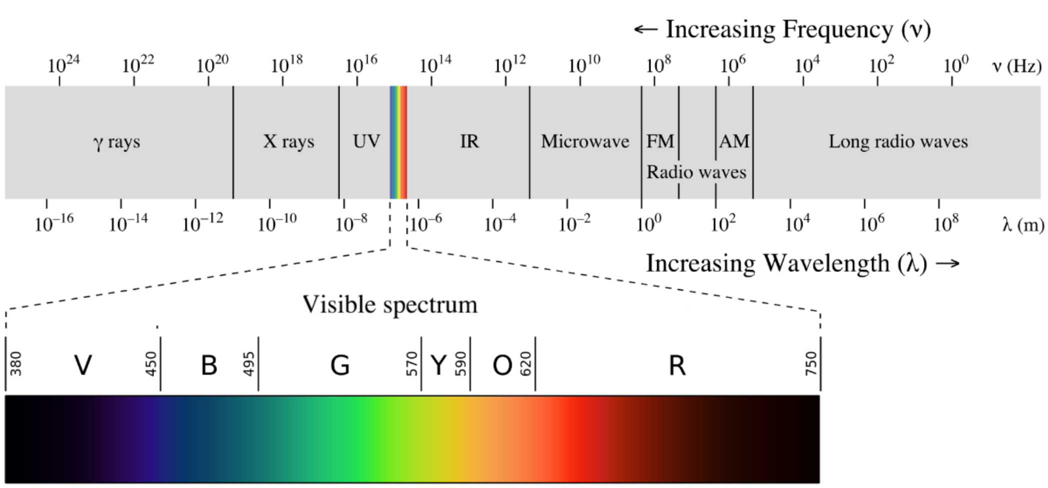


Figure 2.1 The electromagnetic spectrum, taken from wikipedia commons (labelled for reuse under creative commons).

other ways of estimating velocity (Conyers 2013), but this exceeds the confines of this thesis and is best suited for a more in-depth discussion of the technique.

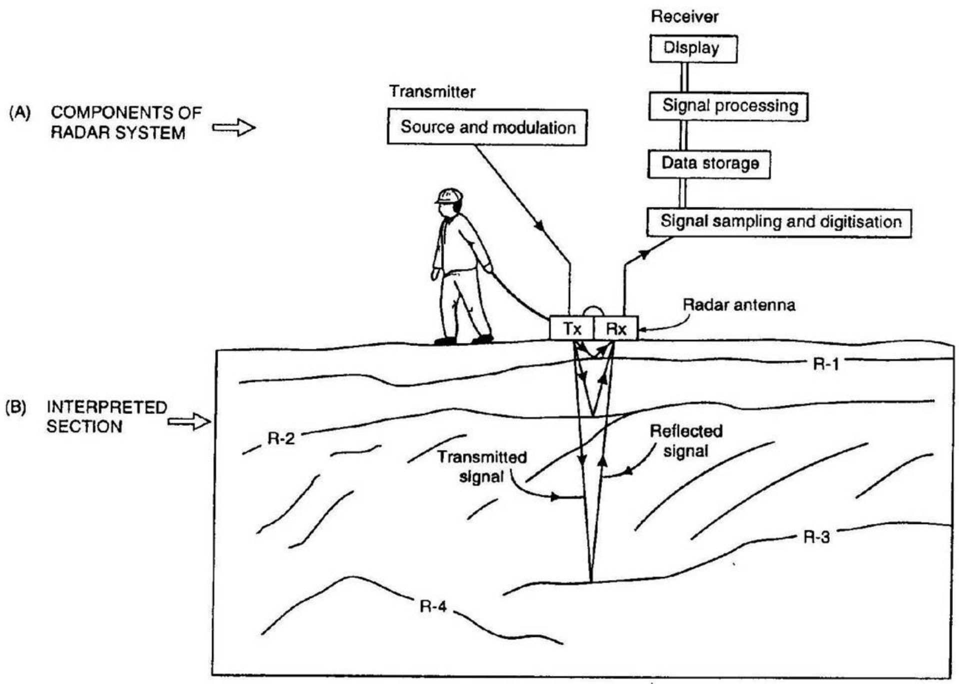


Figure 2.2 Schematic diagram of a ground-penetrating radar (GPR) system. Taken from the open source website, Geophysics for Practicing Geoscientists (Oldenburg et al. 2017)

When radiowaves pass through the ground, any physical or chemical change in the subsurface will cause some energy to reflect back towards the surface, while the remaining energy is refracted or propagated deeper to be reflected again (Conyers 2013; Goodman and Piro 2013; Papadimitrios et al. 2019). The receiving antenna at the surface collects the reflected data and stores, then visualizes, the information in a computer console (Figure 2.3) (Conyers 2013; Reynolds 1998). The GPR collects data in profiles; however, when the data is collected in a grid, 3D cubes of data can be constructed using computer scripts and software (Figure 2.4). This is particularly useful as it allows the interpreter to see a 'bird's eye' view of the area and look through depth layers known as 'timeslices'. Although useful, some researchers have rightly

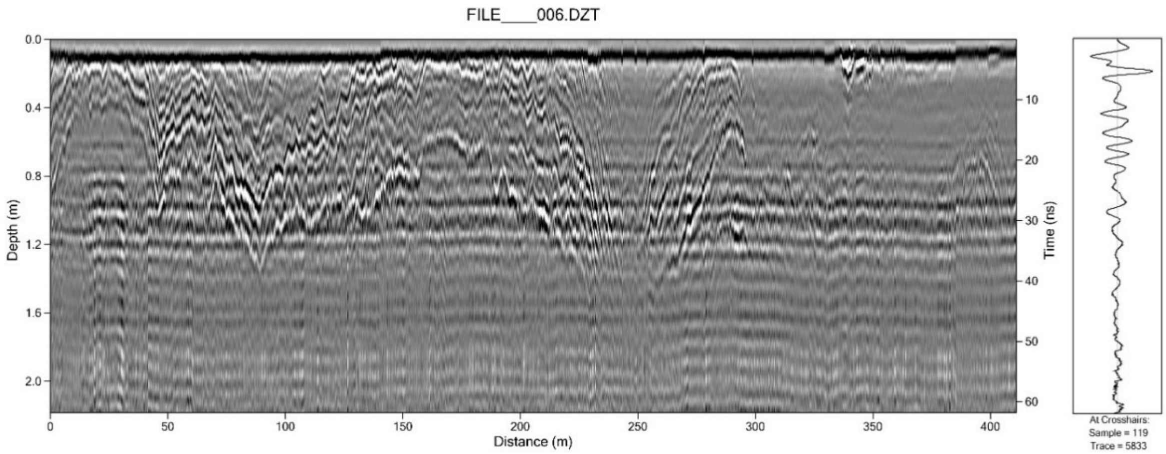


Figure 2.3 Example radargram data visualized on a GPR console. Data from a site I worked on in Southern Alberta. Displayed using GPRviewer (Conyers and Lucius 2016).

called attention to the issue with creating timeslices as they sample different areas of the subsurface when the data was collected in an area with substantial surface topography (Conyers 2013; Goodman and Piro 2013). These timeslices or amplitude maps should be used with caution and the majority of interpretations should be made from the GPR profiles.

Field data often has traits that obscure interpretation (e.g., noise and interference). A number of processing steps have been developed to aid interpretation of less than ideal profiles, so that the technique can be used on a wide range of projects (Conyers 2013; Goodman and Piro 2013). Some of the more common processing techniques that have been applied in this thesis' case studies are time-zero correction, horizontal background/banding removal, removal of high-frequency noise, and changing the gain curve. First, it is important to subtract the time difference between the GPR's initial 'zero' from when the first reflection was recorded by the ground surface (Conyers 2013). That way the time zero and the recorded first reflection are the same, which results in the subsequent GPR reflections being placed at their correct TWTT. Second, many antennas produce a 'ringing' affect in the data which is displayed as horizontal bands in

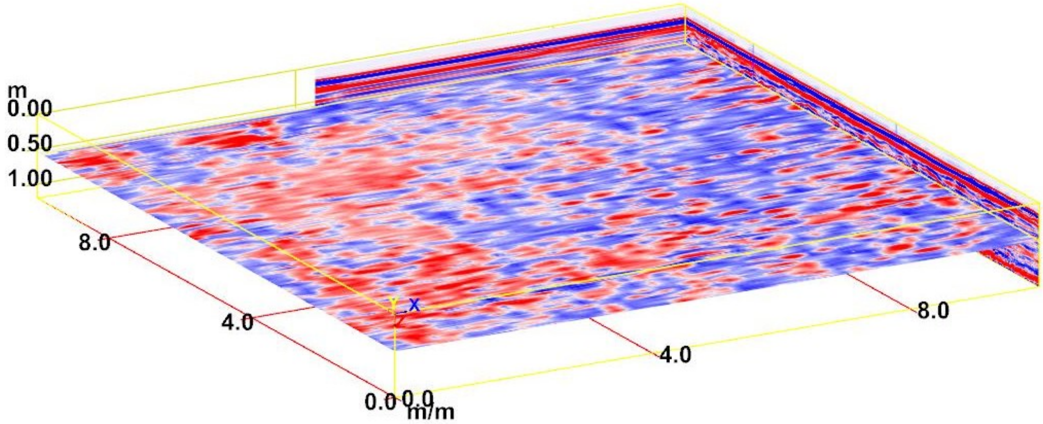


Figure 2.4 Example of GPR timeslices and amplitude maps (constructed in RADAN 7). The creation of timeslices or amplitude map using computer scripts and software can be a powerful tool but also misleading. This data was collected at the Chimney Coulee site in southwestern Saskatchewan (Chapter 6).

the collected profiles (Conyers 2013; Goodman and Piro 2013). These horizontal bands may also be produced by surface objects. Horizontal banding can obscure important subsurface reflections and can be easily removed in most processing programs by subtracting the average background noise signal. Third, the most complex processing technique mentioned, high-frequency noise removal, which typically results from interference from other radio transmitters, can be removed with additional frequency filters (Conyers 2013). Finally, the last processing strategy is to influence the gain curve to increase the visibility of subtle reflections. The user can increase the gain range at certain TWTTs to increase the amplitudes of the reflected signal in a profile. Although a powerful visualization tool, one has to be careful not to 'create' reflections with this processing technique (Reynolds 1998; Schmidt et al. 2015). There are many processing techniques (e.g., migration, stacking, wave-phase transformations) that were not described here that have been useful in GPR interpretation, however each additional, more complicated post-processing step has the potential of distorting GPR data and should be used with caution (Conyers 2013).

History and Application of GPR in Archaeology

Like most technologies, the first sophisticated RADAR system was developed by the military in World War II; however, the first attempt at ‘ground-penetrating’ radar came in the 1920s when scientists tried to use the technique to map glacier thickness (Conyers 2013; Stern 1929). Military experiments continued until 1967 when the National Aeronautics and Space Administration (NASA) sent a GPR system to the moon to survey its surface ahead of the Apollo 11 mission (Conyers 2013). After this noteworthy endeavour, GPR’s widespread applicability to locate objects and subsurface phenomena was quickly realized in the 1970s and was being experimented with across scientific, industrial, military fields (Conyers 2013). Soon, archaeologists would also begin to use GPR in both contact and pre-contact archaeology (Conyers 2013).

There is a plethora of early examples from American and European archaeologists experimenting with GPR, but there is much more limited literature on its early applications in Canada. The first examples of GPR being used in Canadian archaeological contexts came when Vaughan (1986) surveyed a site in Red Bay, Labrador and another in Gatineau, Quebec. The first survey used a GPR system with a 350 MHz antenna in an attempt to locate 16th century Basque graves and buried artifacts on Saddle Island, Labrador. Despite a somewhat wide transect spacing (1 m), Vaughan (1986) reported good correlation between the GPR reflections identified as graves and archaeological remains excavated. The second survey was designed to assess ‘prehistory impacts’ relating to the construction of the new Museum of Man (now, the Canadian Museum of History) in Gatineau. Visible in the radar was the remains of a stone wall, however the high level of clay led to fairly inconclusive results. Despite this, Vaughan (1986) concluded this technique showed promise for future applications in Canadian archaeology.

The next significant GPR study came from Bauman and colleagues (1994) who attempted to map the rooms and palisades of the 19th century HBC Fort at Rocky Mountain House and locate its associated burials. GPR was used in conjunction with magnetic gradiometry and terrain conductivity, however, GPR was determined to be the most successful at locating both the structures and the burials. Bauman and colleagues (1994) concluded, however, that GPR used by itself provided a limited view of the subsurface and must be combined with the other two techniques to draw more accurate conclusions.

Despite these surveys' early successes, in the subsequent decades, GPR studies in Canadian archaeology were rarely published and primarily exist as CRM and consultant reports (e.g., Altamira Consulting Ltd 1998; Cross 1996; Kalman et al. 2004), principally conducted by geophysicists or cross-appointed researchers in physics and archaeology faculties (as was the case with Dr. Larry Pavlish at the University of Toronto). It was not until the mid-2000s that GPR began to re-enter mainstream Canadian archaeology and the technique began to be found more frequently in academic publications (e.g., Prentiss et al. 2008; Sisk et al. 2005). While it is more common for today's Canadian archaeologists to be specialized and include GPR on their projects, there has yet to be research conducted across the country, and current studies recommend more work be done in this field (e.g., Landry et al. 2018; Wadsworth et al. 2020).

This paucity of research is confusing considering its applicability to archaeological questions currently being asked by Canadian archaeologists, but previously investigated by American and European researchers. For example, GPR has already been used to map many American archaeological sites and identify their structures (e.g., Bevan 2006; Conyers 2016a; Whittaker 2009). Furthermore, much research has been devoted to the question of whether GPR can identify unmarked graves (Bevan 1991; Bigman 2014; Conyers 2006; Jones 2008; King et al. 1993) and the technique has become a main tool in forensic investigation (Ruffell and McKinley 2008).

While the technique continues to show great promise for its incorporation into Canadian archaeology, it still has a number of limitations that must be considered. First, the interpretation of reflections corresponding to stratigraphic changes, buried topography or archaeological features is limited by the previous archaeological/geological knowledge needed to understand these changes (Conyers 2013). While GPR is useful in identifying reflections of interest, often times, they remain ambiguous until they are excavated or compared to other known examples. Second, GPR is, theoretically and mechanically speaking, best suited for dry, sparsely vegetated, and sandy soils (Conyers 2013; McLay et al. 2009). Similarly, varying topography (although not impossible to correct) also obscures data collection and interpretation. While these considerations should not preclude the application of GPR in places like the Northwest Coast (Chapter 5), it helps to explain differences in data quality between sites across Canada.

2.3 Magnetometry/ Magnetic Gradiometry

Magnetic geophysical techniques are far more common and familiar than GPR for most archaeologists (Aspinall et al. 2008; Gibson 1986; Kvamme 2003a). These passive remote sensing techniques monitor changes in the earth's magnetic field and model theoretical anomalies given known or estimated magnetic variables (Scollar 1990). The technique is predicated on the earth's strong global magnetic field magnetizing subsurface materials in a fairly consistent way (Oswin 2009). Once an object is heated or subjected to a new magnetic field, depending on the magnetic susceptibility of the object, this can result in a change in an object's remnant magnetization which will differ from the global magnetic field. A basic magnetometry setup typically refers to measuring the total magnetic field at a location, which would need to be corrected for diurnal variation using another 'base' magnetometer. Magnetic gradiometer surveys locate 'anomalies' in the earth's magnetic field by finding deviations (e.g., magnetic dipoles), which may indicate objects or subsurface changes that were magnetized through different processes (Figure 2.5) (Aspinall et al. 2008; Oswin 2009; Scollar 1990). A magnetic gradiometer consists of two sensors, one that records the overall magnetic field, and another that records near-surface anomalous magnetic fields. Taking the difference between these sensors' measured values results in a map of the magnetic anomalies at a site, which often best represents what archaeologists are hoping to find (Oswin 2009). The manual equation that represents this calculation is presented below:

$$Magnetic\ Gradient\ (nT/m) = \frac{FIELD\ lower\ sensor\ (nT) - FIELD\ upper\ sensor\ (nT)}{Distance\ between\ sensors\ (m)}$$

After the total field and gradient data are downloaded, a simple anomaly map can be constructed from the XYZ data (Figure 2.6). Archaeologists have typically used this as a magnetic 'map' of a site to interpret possible areas to test using excavation (Hargrave 2006). There are, however, various processing steps that need to be considered before interpreting and

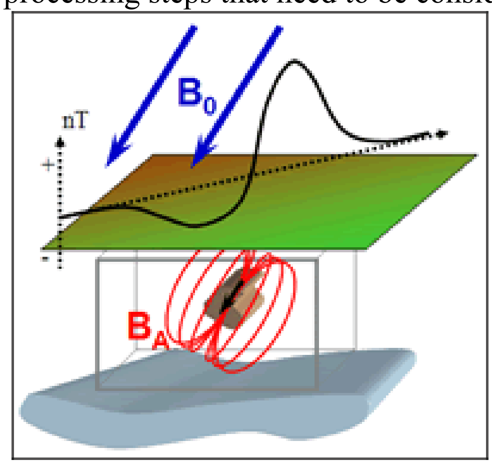


Figure 2.5 A recorded magnetic dipole (+/- black line) results from a subsurface object's magnetic field (B_A) that differs from the earth's overall magnetic field (B_0). Taken from the open source website, Geophysics for Practicing Geoscientists (Oldenburg et al. 2017)

excavating magnetic anomalies. First, like gain ranges with the GPR, magnetic scales can influence the visibility of magnetic anomalies. A small scale (e.g., -2 to +2 nT/m) will highlight more subtle changes in the magnetic field, where large scales (e.g., -40 to +40 nT/m) will dampen these subtle effects. A comprehensive magnetic survey would investigate the same anomalies at multiple scales to be able to make more inferences of their magnetic characters. Second, when possible, researchers must correct for magnetic drift across grids and to remove striping effects (Oswin 2009). This can be accomplished using different methods. This thesis uses a zero-mean traversing correction, which alters each line or traverse so that its mean is zero (Figure 2.6). This specific correction used is currently in development and thus is likely not the best way to remove striping effects in this thesis' data, however, the technique is well-researched and commonly deployed (Kvamme 2006b). This correction can also introduce error by reducing the visibility of smaller archaeological objects (Linford 2004). Other ways to fix these errors and increase interpretation include, high/low pass filtering and changing the interpolation algorithm (Kvamme 2006b). Similarly, de-spiking (the removal of high value noise) procedures are also an important step in preparing magnetic data (Kvamme 2006b). Finally, the last processing step that is infrequently employed by archaeologists is object estimation and depth analysis of magnetic

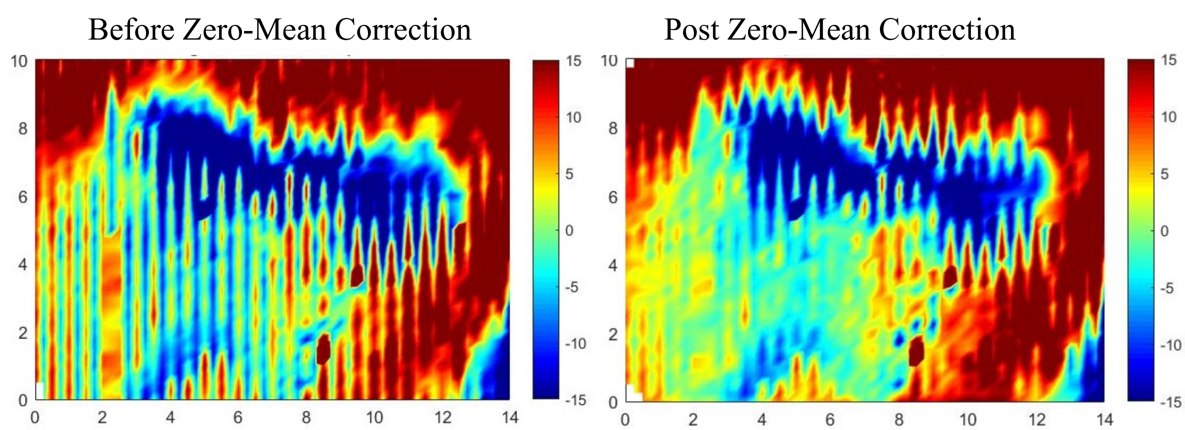


Figure 2.6 Examples of magnetic gradiometry (nT/m) maps and the effects of the zero-mean traversing script. This specific script is currently in development and was not able to remove all the striping and drift errors. Magnetic data presented here is from House 16 at the Kitandach site in Prince Rupert Harbour (Chapter 6).

anomalies. Using computer modelling scripts, researchers can approximate the size, depth and magnetic character of anomalies (Singh 2002). These generated computer models are estimates but provide archaeologists with more information to interpret the cause of the anomaly or evaluate it as a possible target for ground-truthing. Again, this thesis used an in-development method of estimating two-dimensional magnetic models based on visual characteristics rather than quantitative criteria. In the future, I am hoping to quantitatively model magnetic anomalies using a newer and more robust magnetic algorithm (i.e., Kravchinsky et al. 2019). Other ways to extract distance from magnetic anomalies include Gaussian and Fourier transformations (Papadimitrios et al. 2019).

History and Application of Magnetic Gradiometry in Canadian Archaeology

Applications of magnetic techniques have been very common among North American archaeologists for their utility in identifying precontact and historic structural remains (Garrison 1996; Hargrave 2006; Wiewel and Kvamme 2014, 2016; Lynch 2008; Patton 2013; Prentiss et al. 2008). As the most popular remote sensing technique used in archaeology, it is important to review some of the more notable Canadian applications of the technique.

On a site in the interior of British Columbia, Prentiss and colleagues (2008) were able to identify the magnetic signatures of hearths inside pit houses in order to be radiocarbon dated. Magnetic gradient data accurately mapped the structure of pithouse walls across the site and located internal negative areas. When excavated, these negative areas produced fire-cracked rock, charcoal, and burnt bone, and thus were determined to be hearths. Radiocarbon dates from each house's hearth allowed Prentiss and colleagues (2008) to reconstruct the chronology of the village.

Another magnetic gradiometer survey from British Columbia was successful at identifying plank house architecture at the Dionisio Point site (Dolan et al. 2017). The authors propose that the magnetic anomalies identified are associated with internal features within the house, such as floors, hearths, benches, and sleeping areas. These patterns were consistent with sled-roof house architecture known ethnographically from the region and allowed the authors to make inferences on house social organization (Dolan et al. 2017).

Hodgetts and colleagues (2011) found magnetometry useful in the survey of arctic sites and were able to identify activity patterns within stone dwellings and other archaeological features. The project is notable as they tested their findings against a periglacial non-cultural site, which produced noise from igneous erratics. Interestingly, Hodgetts and colleagues (2011) were unable to locate hearths with magnetic gradiometry, but this was attributed to the sandy soils and low temperatures the fires could reach in the cold environment. Magnetometry was able to distinguish between house and front depressions as well as locate internal house artifacts and features. This study was noteworthy as it drew equal attention to both the limitations and strengths of the technique when being applied in a challenging environment.

It is important to note that these published studies are good examples of magnetic gradiometry being employed successfully in Canada, given the techniques' popularity, many more studies exist as part of CRM reports. The late Terrance Gibson, a noted CRM archaeologist, spent much of his career magnetically surveying many sites across Alberta and Saskatchewan, and as such, many prairie archaeologists are familiar with the techniques (Finnigan 2019; Gibson 1986). Similarly, Jason Jeandron, a CRM archaeologist from New Brunswick, has applied the techniques at archaeological sites since the early 2000s (Jeandron

2003a, 2003b, 2003c). These reports are harder to find but hold more region-specific information about the application of magnetic gradiometry.

While many archaeologists believe the technique to be a ‘flake finder’ or “nature’s gift to archaeology” (Kvamme 2006a), Hodgetts and colleagues' (2011) reminder of the limitations of the technique begs us to consider magnetic gradient data. First, the technique creates magnetic maps of the subsurface which archaeologists typically interpret as artifacts or features, without necessarily interrogating these anomalies. Many types of rocks have magnetic signatures that can create noise or false positive results in gradient data, and a knowledge of the common types of rocks in the region is necessary. Similarly, this technique’s results are distorted by metal, limiting its use in urban areas or areas with high historic metal deposition (i.e., farmer’s fields). Second, less obviously, is that the Earth’s magnetic field is constantly variable and, when possible, diurnal corrections from a base station magnetometer must be applied to lengthy surveys (Riddihough 1970). Finally, many researchers do not take the additional step to estimate the size and depth of the object producing the magnetic field (Singh 2002), or even examining the magnetic profile (Conyers 2018), reducing the magnetic gradient results to strictly a problematic plan view.

Due to these limitations, many archaeologists remain somewhat divided whether the technique can locate unmarked graves or archaeological features, however, the technique does provide other useful information for these investigations (Bauman et al. 1994; Gaffney et al. 2015; Wadsworth et al. 2020). The technique, when applied appropriately, has been shown to be very successful across Western Canada in the location of archaeological sites and should be considered a valid technique to be used in conjunction within research designs.

2.3 Unmanned Aerial Vehicle (UAV) Remote Sensing Techniques

Applications of commercial unmanned aerial vehicles ('drones') within archaeology are quickly changing how surveys are conducted, which archaeological sites can be accessed, and what data we can produce from different sensors (Barber 2017; Campana 2017; Hanus 2018; Ostrowski and Hanus 2016). While satellite or space archaeology (Parcak 2009) also deserves credit in the changing attitudes towards remote sensing survey in archaeology, the improved and lower cost of UAVs have been shown to produce comparable results at a higher resolution, without the need to correct for atmospheric effects (Campana 2017). Consumer grade UAVs capturing orthographic photography seem to be fairly ubiquitous across modern archaeological projects (Hamilton 2017). Complicated sensors and techniques continue to be more rarely employed, but more and more archaeologists are investigating these techniques' utility in the location, characterization and protection of sites.

In this thesis, I incorporate UAV-mounted multispectral (MS) imaging, a passive remote sensing technique, to better understand the Chimney Coulee site (Chapter 6). MS sensors acquire data by sampling data across different 'spectral bands' (usually 0.3-0.9 µm in length) in the electromagnetic spectrum (typically in the range of 0.3 to 14 µm) (Lillesand et al. 2015). In the past, MS imaging was primarily used in agriculture and biology, often studying vegetation health and distribution. To do this, multispectral sensors typically sample from around the red edge (around 0.7 µm) , near infrared (0.7-1.3 µm) and middle infrared (1.3-3 µm) areas of the electromagnetic spectrum (Lillesand et al. 2015). The red edge is particularly important as it shows differences in plant species' reflectance and whether or not they are stressed (which causes vegetation to reflect shorter wavelengths) (Doneus et al. 2014). These infrared bands, along with visible light bands, can allow researchers to create false colour images and calculate vegetative indexes to see differences otherwise invisible in regular orthophotography. These generated images are of particular interest to archaeologists as differences in surface vegetation have been shown as a correlate of buried archaeological remains in some contexts (Lasaponara and Masini 2006).

While commercial multispectral imaging continues to focus on vegetation differences for the purpose of precision agriculture (Micasense 2019), archaeologists have slowly begun to recognize its advantages in picking up subtle changes in vegetation. While there has yet to be a notable application of the technique in Western Canadian archaeology, American and European authors have provided a few case studies demonstrating its efficacy in dry grassland environments, where biomass is low and vegetation can be differentiated.

Bennett and colleagues (2013) found multispectral imaging was suitable for the detection of archaeological materials from pasture and grassland environments in the United Kingdom. The authors used data already collected for agricultural management purposes via airborne multi-spectral imagery, in an attempt to differentiate structural patterns. They quickly realized the combination of different seasons and wavelengths produced different results and used principal component analysis to evaluate the result. They found that the technique proved the most effective in January when biomass was low.

Similarly, Winterbottom and Dawson (2005) also used airborne multispectral data to locate sites on two sand-dominated islands in the Scottish Hebrides. After applying a range of processing techniques, the authors investigated their interpretations in the field, rather than through statistical analysis. They concluded that the methods were able to successfully detect enclosures, cairns, relict field boundaries, buried walls and buried structures.

In a review article, Casana (2011) discussed some of the limitations of using multispectral satellite imagery in the discovery of sites. He purported that the reason for the technique's mixed success stems from the problematic notion of the 'archaeological site,' and how soil types, ground cover and seasonal changes are the chief influencers in multispectral signal response.

While these articles discussed the potential benefits and limitations to conducting multispectral research, the majority of limitations surround its application by satellite and airborne imaging systems. As such, I do not contest the idiosyncratic nature and mixed results of the technique when optimizing and interpreting data that was originally intended for a different purpose (lower resolution, different collection strategies). Despite this, all of the examples presented positive results from dry environments and therefore support the techniques' application in the northern Tundra regions or Prairie regions in Canada. Furthermore, in Chapter 6, a case will be made for the systematic use of a much higher resolution UAV-MS surveys to manually identify specific structures at a site.

2.4 Magnetic Susceptibility, EM Conductivity and Other Techniques

As magnetic susceptibility and EM conductivity only played a small role in the Chimney Coulee project (Chapter 6), their inclusion does not warrant an expanded discussion of the techniques. Magnetic susceptibility is the measurable property which describes the ability for an object to be magnetized by an induced field, rather than the study of the magnetic field itself (magnetometry) (Dalan et al. 2010; Patton 2013). Extended human occupation and activity can change a soil's magnetic susceptibility, as well as, the displacement of soils through building activities (Patton, 2013). Fires and chemical reactions can also concentrate iron or magnetite molecules increasing magnetic susceptibility (Dalan et al. 2010). Organic waste from human occupation also increases magnetic susceptibility by promoting bacterial growth (Wiewel and Kvamme 2014).

Recently, Daniel Bigman (2014) showed the utility of magnetic susceptibility when delineating site boundaries. He showed that artifacts have fairly characteristic magnetic susceptibility signatures, and that he could use the technique to evaluate disturbed plow zones and whether or not they contained artifacts. Henry, Mink II, and McBride (2017) have also found magnetic susceptibility to be useful in the mapping of historic battlefields. While purely archaeological applications have been positive for the incorporation of magnetic susceptibility, authors seem to be divided whether magnetic susceptibility can locate unmarked graves (Gaffney et al. 2015). Despite the technique providing incredible site information on historic and prehistoric sites, Weiwel and Kvamme (2014) believed the technique to be underutilized in comparison to magnetic gradiometry. In a notable Canadian example, Hodgetts and colleagues (2016) showed that in forested environments, which precludes other linear traverse-based geophysical techniques, magnetic susceptibility mapping was extremely useful in the archaeological investigation of a precontact site in southern Quebec. They recommended the adoption of magnetic susceptibility approaches to limit the cost and impact of archaeological assessments (Hodgetts et al. 2016).

Electromagnetic (EM) conductivity or induction measures variation in apparent soil conductivity. The technique relies on Ampere's and Faraday's laws. Ampere's Law states that an electrical current applied to a metal coil will produce a magnetic field perpendicular to the plane, and Maxwell expanded this to include time variance within magnetic fields (Maxwell 1890).Whereas, Faraday's law proves the inverse, a conductive object that enters a magnetic field will be electrically induced (Maxwell 1890). Similar to a metal detector, conductivity meters have two coiled wires that transmit and receive EM energy through the subsurface (Bevan 2006). The conductivity sensor generates magnetic field that induces conductive objects to produce their own magnetic fields, which is reflected in an increase or decrease apparent soil conductivity by the receiver coil (Bevan 2006; Bigman 2012). An EM conductivity system typically generates data quickly as the surveyor collects data as they walk, however, the distance between these two coils and their distance from the ground impacts depth penetration (Gaffney et al. 2015).

EM conductivity has a much longer history of application in archaeology than magnetic susceptibility and has long been favoured in the hot dry portions of North America over other geophysics techniques. Many authors have found conductivity useful in detecting earthworks, stonework, fired features, and metals (Patton 2013). Bevan (2006) found that conductivity was extremely useful in locating areas of rubble and debris from historic buildings. Prentiss et al. (2008) conducted conductivity surveys at a prehistoric winter village site in the interior of B.C, and the authors found conductivity to be very useful at identifying pit house walls and floors. EM conductivity has also been used to locate archaeological grave shafts and tombs (Ruffell and McKinley, 2008). A study from Jordan found that the fill of the shaft determined the success rate for the identification of voids (Ruffell and McKinley, 2008). Recently, some authors have found that EM conductivity surveys to be useful in the detection of graves due to the high contrast offered by the disturbed soil of the grave fill (Bigman 2012; Gaffney et al. 2015). Bauman and colleagues (1994) found coffins using conductivity at an HBC fur trade post near Rocky Mountain House. According to Ruffell and McKinley (2008), EM conductivity alongside conventional geophysical strategies (e.g., radar) has also shown to be useful in identifying buried forensic victims.

Over the course of this chapter, I have summarized the theory and application of a number of geophysical techniques. While there are many more that I did not mentioned, these too have helped archaeologists survey sites for decades. Electrical resistivity, gravity, and seismic refraction techniques are among a few of these common techniques. Regardless of the technique, there is no standard for their adoption in Canada which has resulted in their inconsistent use.

2.5 Review of Geophysical Practice Standards and Requirements

Currently, the most comprehensive set of archaeological geophysics guidelines were commissioned by the European Archaeological Council in response to the high level of geophysical survey work undertaken on the continent (Schmidt et al. 2015). These included recommendations and standards for how each technique should be conducted and how the data should be best interpreted, stored, and presented in reports. In addition to this document, many of its authors co-founded and run the International Society for Archaeological Prospection, an organization which created a large network of archaeological geophysicists from around the world. In contrast, the United States has less cohesion when it comes to geophysical standards, and in response some authors have described the country as lagging behind the Europeans (Thompson 2015). The U.S. Department of Defense released their own archaeological geophysics standards document as part of their Environmental Security Technology Certification Program (Ernenwein and Hargrave 2009). Similar to their European counterparts, Ernenwein and Hargrave (2009) provided detailed descriptions and recommendations on how these techniques can and should be used. They also discussed the use of a standardized software, known as *ArchaeoMapper*.

Unfortunately, there are no real standards concerning the adoption and implementation of geophysical/ remote sensing techniques in Canada. Moreover, archaeologists do not necessarily have to even consider the possibility of using these techniques as most legislation does not require or even recommend the practice. In Canada, archaeology is principally regulated by the provincial governments that legislate heritage acts and guidelines for archaeologists to follow. In the country's ten provinces and three territories, only three provinces' guidelines mention the incorporation of non-invasive techniques; Nova Scotia, Ontario, and British Columbia. Nova Scotia does not require or recommend non-invasive investigation, but the government requires you to mention in your permit application whether you plan to use geophysical techniques (Nova Scotia Department of Communities, Culture and Heritage 2014). Beyond directly addressing the discipline by name, this does not differ from the other provinces which would require the researcher to submit a detailed survey plan to receive a permit. Ontario recommends that geophysical and/or remote sensing techniques be considered in conjunction with traditional archaeological survey methods as part of their 'Stage 2: Property Assessment' and 'Stage 3: Site-specific assessments' (Ontario Ministry of Tourism and Culture 2011). Again, these are included as 'guidelines' rather than standards and do not go into specifics of how these techniques should be applied. Finally, although British Columbia does not technically require remote sensing according to their heritage legislation, the impact assessments of heritage sites may require geophysical techniques to evaluate site protection (Province of British Columbia 1998). The lack of inclusion within different provincial archaeology frameworks is disappointing considering that both Parks Canada (Canada's only federal organization with an archaeology mandate) and the

Canadian Archaeological Association (the national professional organization) both ethically require archaeology to be no more invasive than determined by the circumstances (Canadian Archaeological Association 2019; Parks Canada 2005).

Over the course of this chapter, I have described different geophysical techniques and attempted to demonstrate how they have been and can be applied to Canadian archaeology. While magnetometry remains the most common technique among Canadian archaeologists, most geophysical techniques are not even considered during project planning. Moreover, only external standards exist for the application of these techniques and provincial regulations rarely mention their incorporation. As I will demonstrate in the coming chapters, this is disappointing as many archaeological problems have been and could be solved by more holistically implementing the practice in order to prevent the unnecessary destruction of archaeological remains. To facilitate the wider application of these techniques, in the next chapter, I discuss a new theoretical framing that will help to incorporate the techniques into archaeological projects and interpret the results while working with Indigenous communities.

CHAPTER 3:

ARCHAEOLOGICAL REMOTE SENSING - THEORY AND PRACTICE IN INDIGENOUS CONTEXTS

In this chapter, I expand on theoretical frameworks that have previously been employed by archaeological geophysicists. First, I will discuss the western epistemological origins of landscape archaeology and how notions of space/place have impacted archaeology, GIS, and remote sensing. This will be followed by a reconceptualization of geophysical information to be more aligned with current trends in anthropological research, specifically the incorporation of Indigenous knowledge and imagined landscapes. Once I have established that geophysics and remote sensing techniques can be reorganized for more engaged and ethical practice, I will give a brief review of the current state of community-based archaeology in Indigenous/settler-colonial contexts. Drawing on multiple evidence-based approaches, imagined worlds and Indigenous archaeology, I describe a new methodological approach called *archaeological remote sensing* (ARS) that better prepares researchers and specialists to approach the unique problems inherent in applications of remote sensing to archaeology.

3.1 Space and Place within Archaeology, GIS, and Geophysics

All archaeological studies typically fall into one of two camps when investigating different landscapes and spatial relationships; space or place (following, Casey 2008). The former argues for the strict implementation of cartesian principles and employing an objective ("scientific") framework to studying landscapes (Branton 2009; Thomas 2012). While the latter, focuses on finding cultural meaning within these spatial relationships to investigate particular cultures, challenge political realities, and study past landscapes and places (Bender 1993; Hodder

1984; Ingold 1993; Tilley 1994). Although this division strongly evokes the 1980s/90s debates between processual and post-processual archaeologies (Hodder 1985), researchers continue to employ either space or place methodologies. Today, frameworks that investigate the social aspects of space ('place') and recognize that landscapes cannot be disentangled from their historically, ideologically and politically contingent realities (Pauketat 2001; Swenson 2015; Gillings et al. 2018), can be broadly grouped under the umbrella of 'landscape archaeology'(Trigger 2006).

> It is becoming increasingly clear that all events—human and nonhuman alike—occur nowhere else than in place. Each event has its own most appropriate, indeed unique, place—whether this is a microscopic spot where molecules collide or the mega-place of a galaxy. In between, there are the many places that suit the scale of human perception: hot tubs and houses, temples and tents, counties and countries. These constitute a veritable landscape of places that are at once situational and consolidating, challenging and orienting [Casey 2008:1].

Long after the post-processual critique and beginnings of landscape archaeology, mapping and geospatial archaeology continued to investigate spatial/cartesian understanding of physical landscapes. Until the 1990s and early 2000s, geospatial technologies (specifically GIS) were not subject to criticism for their disconnected and 'scientific' views of landscape (Thomas 2012; Lake and Woodman 2003; Wheatley and Gillings 2000). After these problems were realized, increased emphasis was placed on the integration of social theory within GIS archaeology (Supernant and Cookson 2014; Anemone and Conroy 2018). However, even today, the most common research questions in GIS continue to draw heavily from these cartesian foundations, such as the differential access to resources, visibility, and the management of built and natural environments (Branton 2009). The social critique of GIS and spatial studies exposed the assumptions, inequalities, and western, androcentric, and disengaged views of the past created through its practice (Thomas 2012). As a result, the reception, creation, and interpretation of maps and spaces have begun to be interrogated and archaeologists have begun to explore critical cartographies (Gillings et al. 2018).

Despite this new subjective understanding of maps and places (Gillings et al. 2018), geophysical/ remote sensing data continues to be presented as neutral or 'scientific' information (Kvamme 2003b; Thomas 2012). A literature review of geophysical and remote sensing applications in archaeology demonstrated that the field is still waiting for a more anthropologically focused paradigm. The majority of publications and journals remain focused on methods-driven studies that attempt to locate and characterize archaeological remains in cartesian terms (Conyers and Leckebusch 2010; Thompson 2015). Therefore, many geospatial research projects continue to perpetuate a processual/western understanding of space, and a more reflexive/ anthropological form of remote sensing and geophysics has been relatively understudied. Before I can appropriately critique these studies and change our approach to geophysical representations of space, I have to deconstruct and reconceptualize the production of knowledge and the outcomes of projects.

3.2 Imagined Cartographies, Re-thinking Remote Sensing

The theoretical distance between the fields of anthropology and remote sensing have resulted in few specialists and limited diversity between fields, especially when compared to other branches of specialization within archaeology (Rindfuss and Stern 1998). Few researchers have contributed to this paucity in research and much of the anthropological theory in remote sensing has focused on persistent places (McKinnon and Haley 2017; King et al. 2011). These studies typically end at the re-use of place and beg the question of their contributions to identity and landscape investigations. Henry and colleagues (2017) provide a persistent placehood study of a civil war battlefield. Differing from other studies, they discussed the implications of their geophysics research to the modern community and developed their study around anthropological place-making events (Henry et al. 2017). Rooted in the notion that the subjective conceptualization of places, events, and narratives (Portelli 1991) impact modern communities (Tuhiwai-Smith 2012), the next section deals with reconstructing a different conceptualization of place. In North America and other settler-colonial contexts, physical landscapes cannot be disentangled from the cultural weight of thousands of years of Indigenous stories and events (Atalay 2006; Patterson 2010; Swenson 2015). Similarly, this conceptualization cannot exist without acknowledging the historical and contemporary political realities of these groups.

Indigenous Knowledge and Indigenous Landscapes

Place is predicated on the meaning and memory that is situated in a landscape that represents a history of interaction (van Dyke 2008). In 1996, Basso published his work surveying Ndee (Western Apache) places using their native language. The Apache elders explained to Basso (1996) that place names were more than just a reference, they quote their ancestors and allow the Western Apache to relive their stories. These places allowed the Apache to communicate with their ancestors, recreate cultural knowledge, and instruct each successive generation through interaction with the landscape and its stories (Basso 1996). If people are removed from their place, they begin to lose their original culture, identity, and sense of reality (Basso 1996; Cannon 2002; Swenson 2015). Therefore, the physical landscape contains a more meaningful component that impacts present-day people, and it cannot be studied using traditional spatial investigations. Spaces are physical, but places are empowered through the agency of past people which is embedded in social memory of modern peoples and combined with imagination to create new cultural landscapes. These cultural landscapes exist in all settler-colonial contexts, where Indigenous communities define their world through stories (Atalay 2012). Given the complex histories that exist in these landscapes, a new synthesis between Indigenous knowledge, remote sensing techniques, and anthropological theory is necessary in order to holistically study these places.

In the past, some authors have preferred the term 'traditional knowledge' to describe Indigenous peoples' knowledge of their environment, landscape, and culture (Stevenson 1996). This term is typically used haphazardly, lacks in specificity, and does not include the diverse traditional and contemporary knowledge systems that exist in Indigenous epistemologies (Figure 3.1). In this thesis, I follow Stevenson (1996) in his use of the term, Indigenous Knowledge, to include traditional/ non-traditional and ecological/ non-ecological (social, cultural and spiritual) knowledges. While still restrictive, the term is far more inclusive than traditional knowledge in allowing Indigenous peoples to make contributions in research (Stevenson 1996).

The last few decades have seen much debate over the incorporation of oral histories and Indigenous knowledge within archaeology (Mason 2000; Echo-Hawk 2000; Nicholas and Markey 2015; Schmidt 2006). While many researchers have accepted Indigenous knowledge within archaeological interpretation, some archaeologists still believe it to be incongruous with archaeological "fact" (McGhee 2008), and it continues to be framed as either proving or denying archaeological hypotheses. Nicholas and Markley (2015) exposed archaeology for its aforementioned selective use of Indigenous knowledge (i.e., when it advances archaeological goals). The belief that one worldview is superior than another is rooted in western science culture (Tuhiwai-Smith 2012) and explains why western researchers typically seek to evaluate different

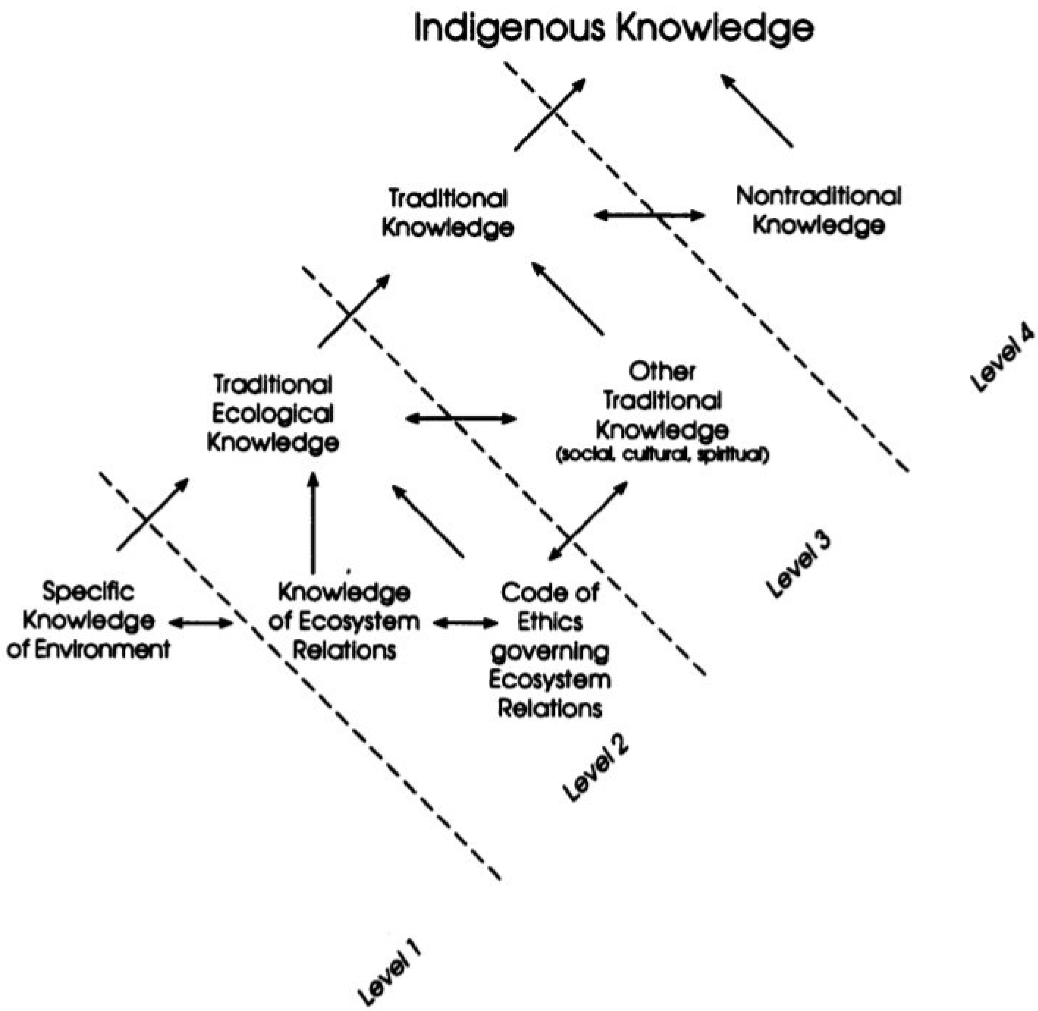


Figure 3.1 Schematic diagram of different knowledges within Indigenous Knowledge (Taken from Stevenson 1996).

forms of information with inappropriate criterion. In reality, stories exist everywhere as part of a human social world (Linde 1993), and many stories of the same places, histories, or ideas can co-exist without evaluating each other's validity (Cruikshank 2005; Yellowhorn 2002).

An increasing number of archaeological studies have recognized the value of Indigenous knowledge and incorporated it within the study of past cultural landscapes. On the northern Northwest Coast, Tsimshian families pass down their Indigenous knowledge through oral histories (collectively known as the *adawx*) (Martindale 2006a). Archaeological investigations of these oral histories have shown that they accurately represent Tsimshian events and periods up to

3000 years ago (Edinborough, Porčić, et al. 2017). In the Arctic, Stewart and colleagues (2004) found that Kivallirmiut (Caribou Inuit) passed down Indigenous knowledge through families and encoded their stories on the physical landscape. Not only did this grant informative chronologies, but also allowed for a more in-depth interpretation of the landscape and its archaeology by linking places to specific families and their relationships. These were only two examples of the potential of incorporating Indigenous knowledges in archaeology, while other 'scientific' fields have also started to realized its utility (e.g., biology (Bonta et al. 2017), chemistry (Bannister 2000), health studies (McAuley et al. 2016), and ecology (Raygorodetsky and Chetkiewicz 2017)). These examples continue to demonstrate the accuracy and interpretative power of incorporating Indigenous knowledge to aid 'scientific' methodologies in drawing more meaningful conclusions. I argue that this new synthesis has challenged the general understanding of Indigenous landscapes and what types of knowledges can be co-produced when working with communities.

Imagined Landscapes and Critical Cartography

> Landscapes are always available to their seasoned inhabitants in more than material terms. Landscapes are available in symbolic terms as well, and so, chiefly through the manifold agencies of speech, they can be "detached" from their fixed spatial moorings and transformed into instruments of thought and vehicles of purposive behavior. Thus transformed, landscapes and the places that fill them become tools for the imagination, expressive means for accomplishing verbal deeds, and also, of course, eminently portable possessions to which individuals can maintain deep and abiding attachments, regardless of where they travel. In these ways, as N. Scott Momaday (1974) has observed, men and women learn to appropriate their landscapes, to think and act "with" them as well as about and upon them, and to weave them with spoken words into the very foundations of social life [Basso 1996, 75].

Landscapes are indistinguishably linked with their communities, their cultures and their stories, because any event that happens, happens 'in place' (Basso 1996; Casey 2008; Nuttall 1992). These representations of landscape are shared between people through stories of experience and can create maps or imagined landscapes (Basso 1996; Legat 2012; Snow 2005; Palmer 2005). Indigenous cultures' identity, worldview, and political aspirations are often intertwined with their physical landscapes (Nuttall 1992). Landscapes can also be created and ordered through cultural systems, such as memory (Nuttall 1992) or kinship (Snow 2005). These imagined places create different 'views' of the same landscape (Meinig 1979), and I would argue are more important than their physical character to the Indigenous communities. Now that I have deconstructed finite understandings of landscape, typically employed in archaeological research, I will now review the concept of imagined worlds within anthropology and propose its incorporation in archaeological remote sensing.

Imagined landscapes are not a new concept to anthropology; however, they have not been widely incorporated in archaeology. Arjun Appadurai (1996), a seminal theorist in imagination, proposed a system of contemporary global cultural flow which included the construction of 'imagined worlds' that were created by historically situated actors in far-flung places. Appadurai's (1996) work illustrated two important concepts in the construction of imagined landscapes, 1) imagined landscapes have real spatial and temporal aspects; and 2) individuals do not need to physically experience landscapes to 'live' them. In other words, an individual can experience or live imagined worlds without physical space. Therefore, individuals can 'visit' imagined landscapes everyday through representations of these places through stories, and in turn, Indigenous knowledge and oral histories could be thought of as vehicles to imagined worlds. This concept is currently undertheorized in archaeology, however, Russell (2010) argued that imagined landscapes and their relationships must be treated as an integral parts of place-making events.

It has become common practice in recent years to interrogate the process of mapping and creation of maps as subjective representations of the world (Gillings et al. 2018). As previously mentioned, most researchers in geography have accepted that many assumptions go into map creation and design in order to convey a particular message. Instead of being an objective view of the world, maps are therefore subjective representations created by their author and are embedded with subjective beliefs (Gillings et al. 2018). I would argue that maps are partial imagined worlds often times lacking the inclusion of stories and experiences. Virtual and digital representations of space have been defined as the intersection between imagination and reality, and have begun to be explored and interrogated in archaeology (Harrison 2009; Morgan 2009). Two digital examples of how Canadian mapping have been trying to include Indigenous landscapes are the Inuvialuit Living History Project (Hennessey and Lyons 2016) and the NWT Place Names project (Prince of Wales Northern Heritage Center 2018), both of which are trying to re-inscribe the landscape with its original Indigenous names and stories. While these are only a few examples of many such initiatives, I am hopeful that with more powerful computing technology, storied landscapes can continue to be visualized to aid their inclusion in anthropological discussions.

This same reflexivity has yet to be applied to geophysics and remote sensing techniques, despite interrogating the creation and use of virtual worlds and maps. This suite of techniques has primarily been used to create prospection maps of the subsurface. The archaeological geophysicist's interpretations are either accepted or discussed with other members of their field, but regular archaeologists, government agencies, and community members must choose to believe the interpretations or not. This is due to an embedded belief in 'science' as the 'correct' representation of landscapes and a large disconnect between our particular subfield, the overall discipline (Kvamme 2018; Rindfuss and Stern 1998), and partnered Indigenous communities. This will not come as a surprise to those versed in geophysics theory, as 'anomalies' are just apparent variability in the subsurface given changeable conditions and times (Reynolds 1998). Treating any model of the subsurface as a 'true' model is inherently wrong. Remote sensing techniques create representations of subsurface landscapes given a host of natural and cultural factors, and thus create imagined landscapes.

By accepting that these techniques create an independent and equal landscape narrative, researchers can combine these narratives with other co-existing lines of evidence (Cruikshank 2005; Yellowhorn 2002). By doing so, it allows researchers the ability to tackle deeper anthropological questions and co-produce more meaningful remote sensing results with and for Indigenous communities. The rest of this chapter is devoted to the framing of a methodology for the reflexive use of remote sensing techniques in community-based Indigenous contexts.

3.3 From the Ground Up: Theory and Practice with Indigenous Communities

> "The road we travel is equal in importance to the destination we seek. There are no shortcuts. When it comes to truth and reconciliation, we are all forced to go the distance."
>
> -Senator Murray Sinclair, former Chair of the Truth and Reconciliation Commission of Canada, to the Canadian Senate Standing Committee on Aboriginal Peoples, September 28, 2010 (as cited in Truth and Reconciliation Commission 2012).

As an arm of colonization and colonialism, archaeologists have plagued Indigenous peoples for centuries (Deloria 1969; Tuhiwai-Smith 2012). Starting in the 1950s and 60s, Indigenous critiques of archaeology and anthropology had begun (e.g., Deloria 1969) but were largely ignored by archaeologists. While some early authors had acknowledged Indigenous concerns about representation and voice (Trigger 1980; Tuhiwai-Smith 2012), it was not until the late 1990s and early 2000s that a new emphasis was finally being placed on Indigenous issues within archaeology (Atalay 2006; Nicholas and Andrews 1997; Colwell-Chanthaphonh and Ferguson 2008). This timing is in part due to the implementation of legislation, such as the *Native American Graves Protection and Repatriation Act* (1990) in the United States, and legal decisions, such as *Delgamuukw v. the Queen* (1997) in Canada, that required changes to archaeological practice. These changes helped legitimize Indigenous knowledge in classrooms and courtrooms, and students began to be educated with new perspectives on the past (Colwell-Chanthaphonh and Ferguson 2010; Martindale 2014). Until that time, archaeology in North America had featured a colonial-centric view of the Americas which delegitimized Indigenous sovereignty, culture, and practice by co-opting physical objects as artifacts (Ferris et al. 2014; Flexner 2014). This was then used to justify unequal power relations and colonization (Cipolla 2013; Martindale and Nicholas 2014). As Tuhiwai-Smith (2006: 121) noted,

> The objects of research do not have a voice and do not contribute to research or science. In fact, the logic of the argument would suggest that it is simply impossible, ridiculous even, to suggest that the object of research can contribute to anything. An object has no life force, no humanity, no spirit of its own, so therefore 'it' cannot make an active contribution… Thus, indigenous Asian, American, Pacific and African forms of knowledge, systems of classification, technologies and codes of social life, which began to be recorded in some detail by the seventeenth century, were regarded as 'new discoveries' by Western science. These discoveries were commodified as property belonging to the cultural archive and body of knowledge of the West.

In the late 20th and early 21st century, two theoretical frameworks were and have begun to be drawn upon to address growing Indigenous concerns with archaeology: post-colonial and decolonization theory.

Both bodies of theory share some central tenets. First, they argue that archaeology, as a process and result is inherently political (Cipolla 2013; Flexner 2014), and continues to have an impact on modern communities and political realities (Silliman 2008). Second, a fundamental focus for these camps are issues of power (Atalay 2006; Jordan 2009). The difference between the approaches, and the reasons for my advocacy for decolonized methodologies, stem from the theory being rooted in advocacy, engagement, and social justice for modern communities (Atalay 2012; Tuhiwai-Smith 2012). In this way, decolonization is a step beyond the mere acknowledgment of past issues through post-colonial approaches, and seeks to rectify these issues for modern communities through recognizing their sovereignty and concerns, and seeking to contribute to 'reconciliation' by unsettling the dominant discourse (Tuck et al. 2012).

While decolonial frameworks attempt to change the overarching narratives, community-driven and collaborative approaches are critical in the dismantling of the current top-down colonial structure (Atalay 2012). When descendant communities approach researchers to address a particular problem, or are involved as research partners in the process, it disrupts the dominant way research has been conducted in the past (i.e., the researcher approaching a community to answer a particular question) (Atalay 2012; Tuhiwai-Smith 2012). Communities control how and why the research is conducted, and the archaeology often addresses community needs. When community-based research is practiced in Indigenous contexts, it drastically changes research focuses, often to the more recent and remembered past (Greer et al. 2010). The results of these projects are often more meaningful to the individuals, families, and communities closely connected to this history, and investigations may parallel personal journeys of identity for community members (Lyons 2013). As Tuhiwai-Smith (2012: 355) argued,

> A large part of the research stories that need to be told are small stories from local communities across time and space, in other words the stories that map devastation across generations and across landscapes, or the stories of transformation and hope that can also be tracked in this.

While seen as crucial components, Indigenous methodologies go beyond decolonized and community-based theories by actively incorporating Indigenous worldviews and values into research structures (Gonzalez 2016; Harris 2005; Tuhiwai-Smith 2012; Wilson 2008; Yellowhorn 2002). Projects are grounded in respect, community-based practice, and low-impact approaches that recognize and incorporate Indigenous knowledge and community perspectives on their past (Gonzalez 2016). Research is also treated as ceremony and includes Elders and knowledge keepers to ensure culturally sensitive practice is maintained (Gonzalez et al. 2006; Wilson 2008).

Decolonized, community-based, and Indigenous archaeologies have been thought of as having a profound effect on archaeological theory, practice, and ethics over the last few decades (Hart et al. 2012). In Canada, archaeological projects and field schools are increasingly run in collaboration with Indigenous and local communities and seek to achieve collaborative goals (Nicholas 2008). While these positive transformations can be seen in some sections of Canadian academic, government and CRM archaeology, widespread transition to these new ethics has yet to take place. Currently, Canadian archaeology is regulated by its provinces and few have standards and guidelines for Indigenous collaboration and the application of non-destructive approaches (see Chapter 2). While the national association for Canadian archaeologists, *Canadian Archaeological Association* or *Association canadienne d'archaeologie*, recommends proper consultation with Indigenous peoples and the recognition of United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and the Truth and Reconciliation Committee's Calls to Action (Canadian Archaeological Association 2019), provincial regulations have yet to be altered beyond notification and invitation to Indigenous monitoring of archaeological research (Nicholas 2019).

I propose a reorganization of both archaeological practice and remote sensing to both recognize Indigenous rights and sovereignty while addressing Canadian issues. Such a reorganization would carry many benefits for both Indigenous communities and archaeological research. Geophysical techniques have long been employed by government and industry archaeologists as time and cost saving measures compared to traditional excavation (e.g., Gibson 1986, 2016). The techniques' speed and efficacy in locating archaeological materials make them ideal for initial archaeological assessment in the face of rapid development (e.g., Alberta's oil sands region). Furthermore, these techniques are non-invasive which make them ideal for sensitive contexts, such as surveys of sacred areas and unmarked burial grounds. In less urgent applications, remote sensing techniques can also provide a unique dataset that can be combined with Indigenous knowledge, oral histories, and archaeological evidence to develop new narratives, help to answer anthropological questions, and contribute to engaged practice and reconciliation. Going forward, I propose a new *archaeological remote sensing* (ARS) rooted within Indigenous archaeology and decolonization theory to address Indigenous community needs in a changing world.

3.4 “Archaeological Remote Sensing”: A multiple evidence-based Indigenous Archaeology approach to geophysical and remote sensing data.

The term, archaeological remote sensing, has been applied as a less common alternative to archaeo-geophysics in the past (e.g., Challis and Howard 2006; Cross 1996). This use of the term principally describes the study of geophysical techniques as methods applied to archaeological contexts. Until now, it has yet to be used to describe a methodology that combines the technical methods with multiple lines of evidence and Indigenous archaeology principles to draw more holistic anthropological interpretations.

The first step in developing ARS as an active part of anthropological research is its acceptance as a distinct line of inquiry within archaeology and including it alongside other interdisciplinary evidence in interpretations (Whitley 2017). Conyers and Leckebusch (2010) recognized that geophysical datasets were becoming increasingly acknowledged as primary evidence in understanding the past. However, a quote by Aspinall and colleagues (2008:45, as cited in McKinnon and Haley 2017:2, emphasis added) exemplified the danger in going too far towards ‘geophysics essentialism’, “prospection alone need not be the ultimate goal . . . even more exciting is the use of [geophysical] results to help explain aspects of ancient cultures *that can be known in no other way.”* Similar to the aforenoted issue with scientific superiority, believing geophysics is the correct way to know the past is also wrong. Archaeologists must acknowledge the utility of using geophysical techniques as a separate complimentary line of evidence. Remote sensing specialists must also consider the previous archaeological work and theoretical baggage of the projects to which they contribute. An archaeological remote sensing study acts as the interface between these different fields, and possibly, worldviews.

The creation of an ARS framework necessitates a multi-component approach to survey design and data interpretation. Recently, it has become common practice for geophysical studies to incorporate and recommend multiple instrument surveys (Gaffney et al. 2015; Wiewel and Kvamme 2016). For example, Cheetham (2008) advocated for a multi-instrument perspective that incorporates more diverse instrumentation (i.e., aerial and geochemical techniques) rather than simply ground-based geophysics techniques, in order to obtain a higher accuracy in archaeology prospection. While multiple forms of geophysical evidence are a benefit to many ARS studies, I contend that increasing the number of geophysical techniques does not increase the interpretive potential of the project beyond a geophysical narrative. In *Watching, Listening and Learning to Understand Change*, the authors proposed a Indigenous knowledge informed-multiple evidence based approach to conservation biology and monitoring in northern Ontario (Raygorodetsky and Chetkiewicz 2017). This approach, which was developed out of a United Nations multiple evidence-based framework (Tengö et al. 2014), helped create and implement locally relevant monitoring protocols, consider wider and diverse cumulative impacts, inform decision making, and increase collaboration within and between the community, government agencies, and industry stakeholders. Following this example, and recognizing that different lines of evidence provide diachronic information (Ames and Martindale 2014), the incorporation of diverse 'narratives' or lines of evidence should be considered a crucial part of archaeological research going forward and the development of an engaged ARS framework.

To change interpretations, one must change how knowledge is produced (Atalay 2012; Gaventa 1993). Furthermore, the perpetuation and control of particular knowledge by experts contributes to nothing but the continued false superiority of expertise (Gaventa 1993). Atalay (2012) rightly equates Gaventa's (1993) point to Indigenous critiques of archaeology which demonstrated that knowledge had been being produced for the archaeologist rather than the communities they are supposed to serve. My ARS framework draws largely from Indigenous archaeology principles of knowledge co-production. As has been discussed at length over the use of oral histories within archaeology, Indigenous knowledge cannot be directly compared to scientific knowledge as they are based in different worldviews and histories (Nicholas and Markey 2015; Tuhiwai-Smith 2012). When used in collaboration with one another, and knowledge is evaluated within rather than across worldviews, narratives are co-produced and consistent interpretations can be formed that benefit all parties (Million 2005; Raygorodetsky and Chetkiewicz 2017). Raygorodetsky and Chetkiewicz (2017:14) outlined five key elements in knowledge co-production:

> "**1) Mobilization** includes articulating knowledge in forms that can be shared with others.
>
> **2) Translation** implies interactions between knowledge systems based on mutual comprehension of the shared knowledge.
>
> **3) Negotiation** means joint assessment of convergence, divergence and conflicts across knowledge contributions.
>
> **4) Synthesis** shapes a broadly accepted common knowledge that maintains the integrity of each knowledge system, rather than integrating' one into another.
>
> **5) Application** emphasizes knowledge that is useful for decision making that in turn feeds back into respective knowledge systems."

It is with these elements in mind that ARS seeks to Indigenize survey design within archaeology and aid in the transfer of knowledge and the fostering of community relationships.

Research Design

Prior to designing a research project, a researcher must be reflexive of their own theoretical 'baggage' as it limits the results of the project (Ames and Martindale 2014). Tuhiwai-Smith (2012) underscored the ethical importance of reconfiguring research goals to suit

Indigenous communities. The top priority for research should be to counteract the denial of humanity to Indigenous peoples, encourage capacity building, and respect Indigenous peoples' right to self determination (Tuhiwai-Smith 2012). To visualize this, Colwell (2016:117) created the 'collaborative continuum' which placed archaeological projects along a scale of collaboration which spanned from 'colonial-led' to 'Indigenous-led' projects. Given the current political situation (Supernant 2018), a central question should be: how does this study promote decolonization and meaningful impacts for the Indigenous/local communities?

The most important part of research design is to establish and maintain productive community relationships (Atalay 2012). Therefore, the most ethical form of archaeology is community-driven or community-based projects (Atalay 2012; Lyons 2013). Once relationships are established and knowledge has been exchanged, these projects will often lead to more collaborative archaeology projects. If the researcher must initially approach the community, efforts should be made to co-create goals and reciprocal partnerships with the intention of building community capacity and incorporating multiple knowledge systems (Atalay 2012). As part of this thesis, a consent form was created to facilitate discussion over the collection and use of case study data from the community-driven projects (Appendix A; Chapter 4). This simple dialogue allowed the community to have complete control over the project, establish boundaries, and deepen relationships.

Once community relationships and the goals of the project are established, planning the field project can begin (Gonzalez et al. 2006; Gonzalez 2016; Zimmerman 2005). Gonzalez (2016) rightly points out that projects that are sensitive to community goals must be partially designed around impact. She recommended that projects incorporate Indigenous principles and minimally invasive field techniques (such as remote sensing or 'catch-and-release' collection strategies) into their research methods (Gonzalez 2016). In line with Tuhiwai-Smith (2012) and Atalay (2012), Gonzalez and colleagues (2006) demonstrated that field methods can (and must) also reflect reconfigured/decolonized archaeological goals. The authors restructured their archaeological field school to focus on community identified goals and to teach local Indigenous students. Throughout the entirety of the field school, the team engaged in ongoing consultation with local Elders who visited the site and helped direct the students' education and excavation. Although I recognize these as important contributions going forward, I also propose that all community-driven ARS research should be designed with the consideration of four variables/ forces; urgency, community need, multiple evidence, and interpretive potential (Figure 3.2). As will be shown in subsequent chapters, the community's need for and urgency of the project (which might be environmentally or politically motivated) should take precedence but will affect the breadth and interpretative potential of the surveys conducted. If time is not restricted, this study falls into the current trend towards incorporating diverse, low-impact evidence to draw more meaningful conclusions.

The Research Process and Interpretation

This study takes a multiple-evidence based approach to remote sensing surveys, requiring the researcher to draw on cross-disciplinary evidence to make meaningful interpretations for both Indigenous and research communities. Although different geophysical techniques provide unique information specific to different research questions, it is also important to accept that different lines of evidence will provide different information that will form parts of research narratives. To better combine these multiple lines of evidence, I conceptualize them as different narratives to be “woven” (Ames and Martindale 2014:155-156) or “braided” together into larger synthesized narratives (Atalay 2012: 173-174).

> Rather than a multivocal model in which a cacophony of voices can emanate from numerous, unspecified locations, and focused in no specific direction, a model of “braiding knowledge” brings distinct forms of knowledge together. Research partners engage in situated weaving to create complex histories that are grounded in specific locations [Atalay 2012: 174].

It is important to briefly consider how and why narrative and, subsequently, discourse makes sense as a theoretical tool for ARS. Narratives are modes of storytelling that recapture and transmit past events and experiences organized in a verbal sequence that reflects a temporal ordering (Labov 1993; Palmer 2005). They often convey senses of ourselves, our places, our relations to others, and histories of how these things came into being (Linde 1993). In this way all ‘utterances’ with temporal components can be considered narratives, no matter their length or matter. As aforementioned with the discussion on imagined landscapes, archaeology might be considered one way to listen and record the (hidden) narratives imbedded in the artifacts, sites, and landscapes. Now consider that these stories cannot be separated from discourse (Sherzer 1987). I use discourse on two levels, both in the linguistic anthropological and Foucauldian senses. Discourse is made up of narratives and is always created between two subjects (e.g., two peers, researcher and subject, researcher and self). It is a level or component of language use in which narratives are culturally encoded and situates narratives within their natural-cultural context (Sherzer 1987). Discourse also references the systems of power and histories of communication that created these language systems (Foucault 1972) and the coherence created for individuals who share this contextual background (Linde 1993). As doctors communicate through and operate within a discourse imbedded in medicine (Foucault 1972: 52-55), geophysicists must construct and communicate scientific results through a discourse of physics. While still overlapping, ambiguous and "slippery" terms (Palmer 2005: 13), when talking about discourses I am recognizing the systems of power and coherence that created this 'separateness' between lines of inquiry. This interdiscursivity, working within and between competing discourses, allows for the inclusion of Indigenous knowledge alongside scientific results. Approaching this interpretive space with a heart-centered and Indigenous archaeology framework (Lyons and Supernant 2020) creates opportunities for meaningful and holistic narratives to be braided.

> I could hand you a braid of sweetgrass, as thick and shining as the plait that hung down my grandmother's back. But it is not mine to give, nor yours to take. Wiingaashk [sweetgrass] belongs to herself. So I offer, in its place, a braid of stories meant to heal our relationship with the world… It is an intertwining of science, spirit, and story- old stories and new ones that can be medicine for our broken relationship with earth, a pharmacopoeia of healing stories that allow us to imagine a different relationship, in which people and land are good medicine for each other [Kimmerer 2013: x].

Framing lines of evidence in this way encourages the link between, and reciprocally informs, low- and high-order interpretations, thus creating a general model for a multiple evidence-based remote sensing project (Figure 3.3). As well, I am hoping to use this model to open up opportunities for further discursive interactions. In other words, treating lines of evidence as narratives and acknowledging discourse allows researchers to decolonize their methods by recognizing unequal power relationships, better incorporating Indigenous knowledge, and more appropriately including Indigenous communities and knowledge keepers in the interpretive process (Atalay 2012; Kimmerer 2013). Turning towards application of this methodology and the generation of these braided narratives, the most likely narratives to be included when

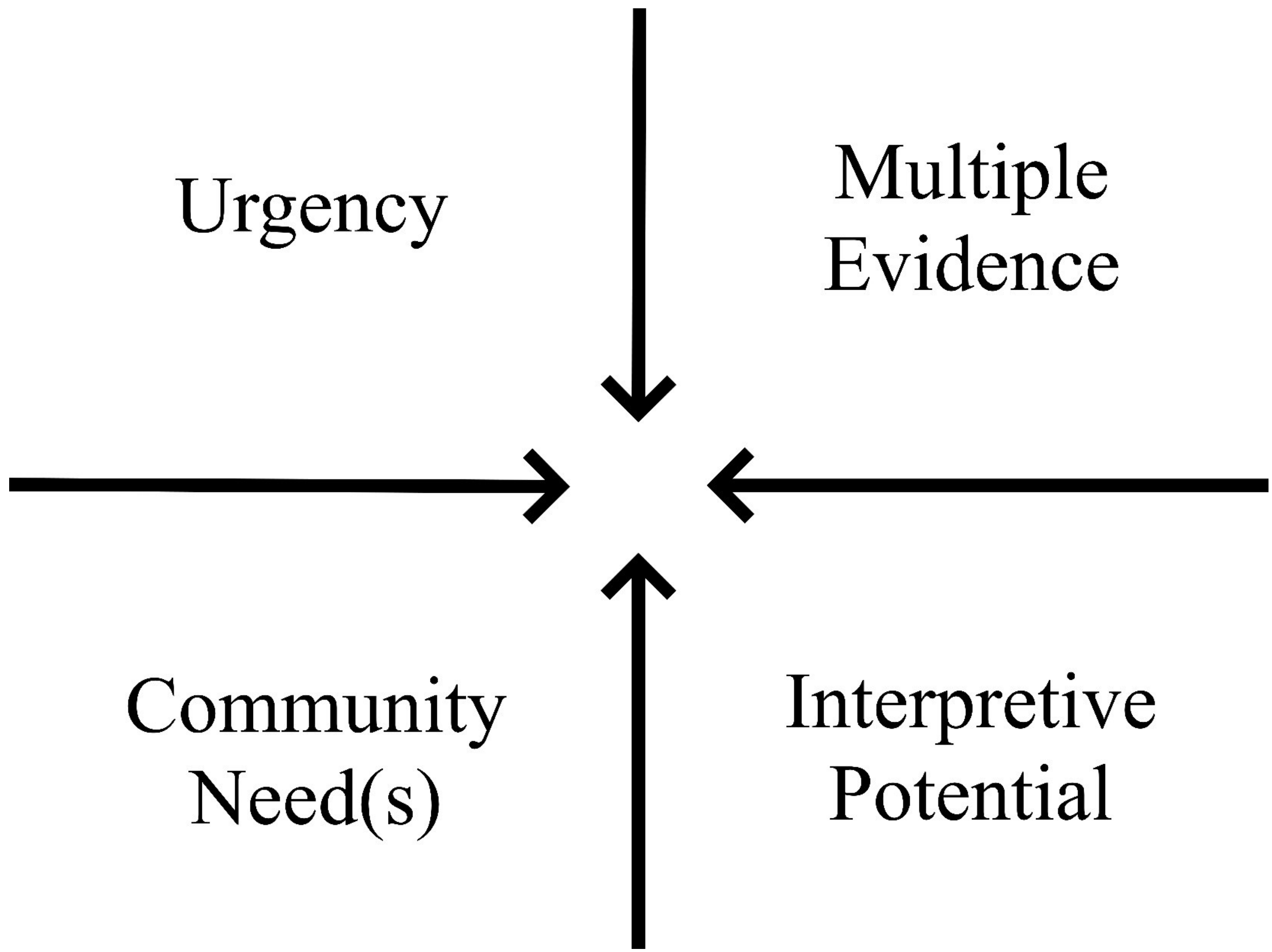


Figure 3.2 A community-based ARS research design model. Community-driven/collaborative projects are affected by forces, specifically urgency, community need, multiple evidence, and interpretative potential, during research design. Projects incorporating these ethics fall somewhere within this representative model. These are not exclusive or mathematical categories, but this is a potential way to order and prioritize forces. Positioning within this figure is important, as more focus is placed on urgency and community need, the project's ability to incorporate multiple lines of evidence and improve interpretative potential will decrease. When urgency is plotted against community need, multiple lines of evidence are needed to accomplish survey objectives. However, when urgency is not an issue interpretative potential increases as there is more ability and opportunity to address community specific needs and incorporate Indigenous voices.

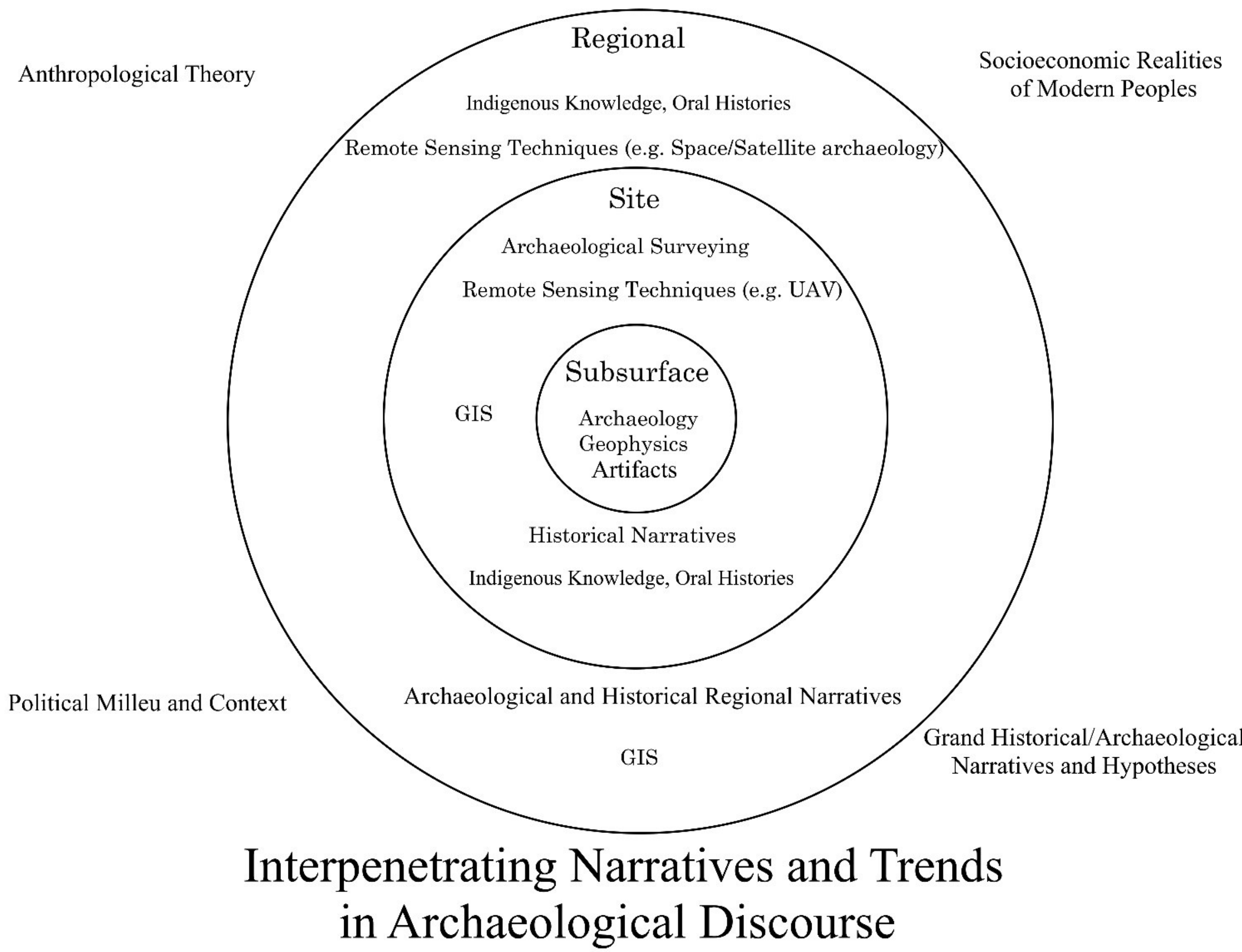


Figure 3.3 A diagram showing how different lines of evidence or narratives can contribute to different levels of discourse and synthesized narratives, interpretations, and questions. For example, geophysics and archaeology are likely the principle ways of understanding the subsurface. When imagining a site narrative, larger scale remote sensing (e.g., UAV techniques), archaeological surveying, and GIS can be combined with site histories and Indigenous knowledge to develop more meaningful discourse. Larger still, regional narratives are primarily known from Indigenous knowledge, large-scale remote sensing (e.g., satellite or space archaeology), and/or archaeological and historical regional narratives. The layer beyond these more concrete levels is how these constructed narratives fit within broader theories and aspects of past and modern life. All levels of this discourse are important and reciprocally act on one another. Not shown are artifact narratives and how they impact discourse, particularly with modern Indigenous communities.

developing well-rounded ARS research are archaeological/historical, GIS/geospatial, and oral histories/Indigenous knowledge.

First, there is truth to the archaeologist's commonly held belief in that 'the answer is down there, we just have to dig'. Archaeological evidence has been and continues to be widely incorporated into geophysical studies, despite few geophysical surveys having validated their findings through excavation (Hargrave 2006). However, as more archaeologists incorporate the use of remote sensing techniques on large archaeology projects, ground truthing geophysical findings is becoming more common. In this capacity, archaeological and geophysical interpretations reciprocally inform the other and continue to evolve over the course of the project as geophysical signals begin to be linked to particular archaeological features. As it becomes increasingly clear that large scale excavation is no longer feasible for ethical and economic reasons, ARS techniques must take a more central role to limit the destruction of sites (Gonzalez 2016). An interdisciplinary research program focused around precision excavation of geophysical targets allows for the immediate confirmation/refutation of hypotheses and can lead to further scientific analysis, such as radiocarbon dating, which adds a temporal component to geophysics data (as shown by Prentiss et al. 2008). Finally, historical evidence also has an obvious role in corroborating ARS interpretations.

Second, GIS and geospatial evidence have been increasingly called upon to address social questions (Anemone and Conroy 2018; Supernant 2017; Supernant and Cookson 2014). Again, the spatial nature of these technologies, and lack of theoretical distance from ARS, has led to numerous collaborative projects in the past. Often ARS data is processed within a GIS to be compared with other spatial data (Kvamme 2018). Spatial information generated from total station, RTK-GNSS, and other survey techniques are less frequently combined with geophysical data, despite authors recommendations for a high need of spatial control in geophysical survey (Goodman et al. 2006; Leckebusch and Rychener 2007; Percy and Peterson 2006). High spatial control becomes important when reconstructing cemeteries or locating unmarked burials for Indigenous communities, as often they would like to commemorate the grave sites. Furthermore, mine and my colleagues' (2020) research on an Underground Railroad cemetery demonstrated how topographic data, oral knowledge, and geophysical information uncovered evidence of the intentional destruction of a burial ground which led to more anthropological questions regarding motivation and politics of neglect.

Combining geophysical, archaeological, and geospatial information has long been an acceptable practice to draw interpretations. In comparison, oral histories and Indigenous knowledge have not been as widely accepted or incorporated within archaeology. In North America, Indigenous history remains the primary form of research for archaeologists. Local informants have been commonly employed by archaeologists to help locate sites; however, archaeologists have only recently begun to consult Indigenous communities regarding their needs and their narratives of their history (Atalay 2012; Colwell 2016; Nicholas and Markey 2015). As previously mentioned, archaeology is changing and authors have begun to reflexively use oral histories and Indigenous knowledge to corroborate and inform archaeological hypotheses and artifact interpretation (Echo-Hawk 2000; Yellowhorn 2002; York et al. 1993). The depth and meaning of oral histories and Indigenous knowledge also lends them to far more reflexive analysis and narrative construction than written documents (Linde 1993; Portelli 1991). On a practical note, Indigenous knowledge also encodes information about relationships and social rules on coherence and reportability that could influence archaeological projects with descendant communities (Atalay 2012). Therefore, I argue that oral histories and Indigenous knowledge should be incorporated into archaeological remote sensing studies, especially in areas with limited historical information and/or the community has asked for work to be conducted.

Synthesized Interpretations and Dissemination

Once data collection has finished, interpretations must be made with the consideration of all lines of evidence, and this may require the co-creation of interpretations with Indigenous knowledge holders. To accomplish this, Indigenous knowledge and Indigenous ideas must be considered as (at least) equal evidence alongside western thought (Tuhiwai-Smith 2012). In his PhD dissertation, Yellowhorn (2002) described an 'internalist archaeology' which treated oral histories as a 'middle-range theory' that linked archaeological remains to grander archaeological hypotheses for the benefit of Indigenous peoples. Similarly, Indigenous knowledge can act as a linking mechanism for remote sensing data to archaeology if the proper steps are taken to encourage Indigenous engagement. Gonzalez (2016) and Atalay (2012) also promoted the importance of onsite Indigenous interpretations. Allowing Elders and other knowledge keepers to walk the site or attempt to make sense of artifacts or data will enrich archaeological interpretations and prioritize Indigenous knowledge. Furthermore, with a more active Indigenous role in the interpretative process there is less chance that the archaeologist will create a narrative that could be used to the detriment of the local community (Atalay 2012).

Once an interpretation has been agreed upon by the stakeholder parties, it has become clear that the archaeologist must again be reflexive about the research's impact after its completion (Atalay 2012; Lightfoot 2008; Tuhiwai-Smith 2012; Yellowhorn 2002). This is a common (and important) theme within Indigenous archaeology, and decisions must be made with the Indigenous group regarding the publication of the data. The researcher should also create more community accessible ways of disseminating the information, such as an ESRI story map or a magazine/local bulletin article. If there is a chance that this information might somehow hurt the Indigenous community, it is best to not publish it but rather give the data back to the community. It is unfortunate that we must be wary of others misusing research data but being aware of the colonial/capitalistic systems' ability to hurt local communities is a necessity (Martindale 2014; Tuhiwai-Smith 2012).

Finally, once the research is disseminated, a researcher should continue to work with the partnered community to help facilitate more research and promote the community's interests (Atalay 2012). Simply, relationships are not over once the research is finished.

A new pragmatic methodology, as described above, is best suited to the application of ARS techniques to Indigenous contexts. By deconstructing the sovereignty of geophysical/remote sensing data and incorporating multiple diverse forms of evidence to generate new narratives at the service of communities, archaeology can be transformed into a more ethical practice posed at tackling issues relevant to modern Indigenous peoples. In the next three chapters, I present a number of examples from my work in western Canada. These case studies intentionally occupy different sections of Colwell's (2016) collaborative continuum (Indigenous-control, collaboration, and participation), as well as different areas of my ARS research design model (Figure 3.2). Each also engages with different Indigenous communities. In Chapter 4, I describe community-driven research where our team was enlisted to conduct unmarked grave surveys at the request of Dene and Cree communities. In the following chapter, I present work from a collaborative project in B.C. where objectives are co-decided by researchers and communities. In Chapter 6, I highlight work from southwestern Saskatchewan that would be classically defined as a ‘participation’ project, however, members of the research team identified as Métis and are linked to the site’s history. The purpose of these varying case studies is to highlight how an archaeological remote sensing approach can be applied within any ethical research structure, within any landscape, and with any community.

CHAPTER 4:

UNMARKED GRAVE INVESTIGATIONS AT THE SERVICE OF INDIGENOUS COMMUNITIES

In this chapter, I present the results from three community-driven unmarked grave investigations. The three case studies represent different community partnerships, different histories, and different impetuses for conducting geophysical investigation. First, I worked with the Chipewyan Prairie First Nation (CPFN) to conduct a GPR survey of the Cowper Lake Burial Ground. Much burial information about this early 1900s burial ground was known by the community members. The project's goal was to commemorate their family members by erecting new grave markers and constructing a protective fence. I highlight this survey as an excellent geophysical example of diffraction hyperbolae interpreted as unmarked graves. Next, working with the Papaschase First Nation (PFN), I conducted a geophysical exploration looking for the Kaskitewâw asiskîy Cemetery in south Edmonton, the location of which was unknown with limited information about the burials. This project was driven by the unique history of the Papaschase First Nation and the modern community's political goals. Finally, on the west side of Edmonton, I conducted a GPR survey in an attempt to mitigate the effects of pipeline development on one of Enoch Cree Nation's (ECN) ancestral burial grounds. The situation was urgent as pipeline development was planned to start as we began the survey. The resulting GPR survey located graves near the pipeline right-of-way, supported the Enoch Cree Nation's claims, and I recommended protective and mitigative efforts take place to protect the ancestors. This chapter is an amalgamation of reports that I prepared for each survey (Wadsworth and Dersch 2019; Supernant et al. 2019; Wadsworth et al. 2019) and each of the partner communities have given their enthusiastic consent for the data's inclusion in this thesis (Appendix A).

4.1 Methods applied to unmarked grave investigations

GPR has been the primary method of inquiry for unmarked grave investigations for decades and has proven to be highly successful at locating evidence of burials (see previous chapter) (Bevan 1991; Gaffney et al. 2015; Jones 2008; Wadsworth et al. 2020). Indigenous communities in Canada have recently become aware of the technique (Clark et al. 2018; Nichols 2015) and are interested in using it to non-destructively monitor their sacred places and burial grounds. I was asked by three Indigenous communities to conduct the GPR surveys presented in this thesis. The exact locations of the burial grounds in question are obscured for sensitivity (Figure 4.1).

Figure 4.1 Map of North-Central Alberta with approximate locations of the partner communities/unmarked grave surveys

While geophysicists must always tailor their survey strategies to each site, the methods employed in these case studies remained relatively consistent over the three surveys. Rectilinear grids, typically less than 30 x 30 m (when the terrain allowed), were created to maintain consistency in the GPR survey. A 400 MHz centre frequency antenna attached to a GSSI SIR-3000 controller with a survey wheel (which measured distance) was used to conduct each of the surveys. Survey transects were typically unidirectional and spaced in 25 cm intervals to maintain a high enough resolution to detect the same grave in multiple profiles. The only survey that deviated from this strategy was the Papaschase survey (5.3) which started out with this design, but then transects became bidirectional in order to complete larger grids under a pressing time constraint. Readings were logged at a rate of 50 scans/m, samples were set to 1024, and three gain points were set automatically and used consistently over the course of each survey. Exact GPR settings for the surveys are available in Appendix B.

A number of assumptions must be agreed upon to conduct an unmarked grave survey. The most important of these assumptions is the expected character and orientation of the graves, however, these are well understood by community members and can inform surveys through the incorporation of Indigenous knowledge. I asked community members how deep we should expect to find graves, what materials and structure the interments would likely consistent of, and which direction would they be oriented. Each of the communities expected the graves to be approximately around 3 ft rather than the typical 6 ft Christian burials. This appears to be a relatively consistent and well known trend across Indigenous communities in the Canadian Prairies (Tyler 1979). Coffins were only expected to be found in the more recent Christian burials that may occur in the CPFN or Enoch surveys. Otherwise, it was expected interments were shallow shroud burials with possible grave inclusions. Finally, for the CPFN and PFN surveys, community members knew that individuals were buried oriented toward a nearby body of water (either Cowper Lake or the Blackmud Creek, respectively). In the case of the Enoch survey, individuals were suspected to be oriented toward the East and the rising sun. Therefore, the GPR transects were placed in order to 'cross-cut' or perpendicularly bisect the graves.

It is well known that unmarked grave investigations should strive to incorporate multiple techniques when possible to increase confidence in the results (Gaffney et al. 2015); however, given the nature of these communities' needs as well as financial and time constraints, this was not realistic. Only the PFN Survey included other techniques, as it was conducted as part of the University of Alberta Field School. A magnetic gradiometry and RTK/GNSS survey were also conducted at the site. A GEM Systems GSM-19GW overhauser gradiometer was used to collect gradient and total field data as part of the magnetic gradiometry survey. The instrument was used with a survey backpack and data was collected in GPS mode. The sensors were set to a height of 20 cm and 75 cm above the ground, survey lines were spaced every 25 cm, and data was collected every 0.2 seconds. The magnetic survey at the Papaschase burial ground was conducted by Katherine Gadd (another graduate student at the University of Alberta). Dr. Kisha Supernant conducted the RTK/GNSS survey to map in the grid locations and other topographical features or ground obstructions with high-precision GPS coordinates.

Beyond field collection at the three burial sites, the data was processed at the University of Alberta. The GPR data was processed and 'sliced' using GPR Process an open-source program developed out of the University of Denver (Conyers and Lucius 2010). To analyze the GPR profiles, the complimentary program, GPR Viewer, was also used (Conyers and Lucius 2016). Basic processing techniques, such as time-zeroing and background removal, were conducted. The data was also inputted into Golden Software's Surfer 15 to construct contour/amplitude maps. I used a similar workflow to locate potential graves to the one developed in my undergraduate thesis (Conyers 2012; Wadsworth et al. 2020). Graves were first identified in the GPR profiles and characterized as either a 'possible' (if the reflection was high amplitude or paired with another reflection, but only occurred in 2-3 profiles), or 'probable' (if the reflection had those characteristics and was observed in three or more profiles) grave. If the locations of these identified grave-shaped GPR reflections corresponded with higher amplitudes in the time slices, these reflections were deemed as having the highest likelihood to be graves. To analyze the magnetic data, I used SIGKit, a MATLAB based data modeling and processing software developed at the University of Toronto (Kruse et al. 2017). Finally, Esri's ArcGIS Pro was used to process and visualize any RTK/GNSS or geospatial data obtained from the surveys. This procedure was followed in each of the case studies below.

4.2 Chipewyan Prairie First Nation (near Janvier, AB)

Introduction

In the summer of 2019, community members from the Chipewyan Prairie First Nation approached Dr. Ave Dersch (Moccasin Flower Consulting) about conducting various unmarked grave surveys on their reserve near Janvier, Alberta. She recruited me to help with the geophysical surveys. However, given the limited time available for fall fieldwork, only one cemetery was surveyed at the time (October 2019). The Cowper Lake Burial Ground was selected as a priority location by the community and thus surveyed first. This study was focused around a ground-penetrating radar survey that sought to 1) identify/geophysically characterize the burials and 2) delineate their extent in order for CPFN to construct a protective fence. I highlight this case study to serve as an introduction to the methodological process of using GPR to locate unmarked graves at the service of Indigenous communities, as well as promote an exciting and budding partnership between CPFN and the University of Alberta.

Chipewyan Prairie First Nation is a *Déné'suline* (or Chipewyan, a term derived from Cree) community located in northeastern Alberta, approximately 120 kilometres south of Fort McMurray. Since time immemorial to the present day, the members and ancestors of CPFN have derived their livelihood, culture and identity from hunting and gathering throughout their traditional lands that radiate outward from the Christina River watershed. As a signatory to Treaty 8, Chipewyan Prairie First Nation has three reserves set aside for the use and enjoyment of its membership. The main Reserve, I.R. 194 Janvier, located 97 km southwest of Fort McMurray, encompasses an area of 2486.7 hectares (Statistics Canada 2016). There are two other Reserves: I.R. 194A Cowper Lake (located on the north shore of Cowper Lake and covers 143 hectares) and I.R. 194B Winefred Lake (located on the North Bay of Winefred Lake and covers 450 hectares) (CPIRC 2014).

Background Context

The origins and family histories of current CPFN membership are complex and varied. Many of the originating families of the "band" or *Déné'suline* community that came to be known as CPFN, came from the Garson Lake and Lac La Loche area in Saskatchewan (Chipewyan Prairie Dené First Nation 2007). The originating clans of Janvier are: Bunion of Rabbits, Sagista, Chicken Neck, Old Man, and Porcupine Foot. At the time Treaty 8 was signed in Ft. McMurray in 1899, these families had been regularly meeting during the summer months along the Christina River (CPIRC 2014). They lived, trapped, hunted, fished and gathered at Big Jackfish Lake (Winefred

Lake)/Doltu'chogh, Christina Lake/Huldázentú, Christina River/Kai' Kos' Deseh, Cowper Lake/Doghostu', Bohn Lake/Chelatu', and at many other lakes and rivers throughout the area (Chipewyan Prairie Dené First Nation 2007). Chipewyan Prairie became a summer gathering place for several of these families in the late 1800s and early 1900s (CPIRC 2014). It is known by community members that the Cowper Lake Burial Ground is dated to this early 1900s period and contains relatives and ancestors.

Chipewyan Prairie First Nation's homeland is within the Central Mixedwood Natural Subregion of Alberta (Downing and Pettepiece 2006). It is characterized by upland forests and wetlands on level to gently undulating plains. Upland forests are a mosaic of aspen, mixed wood, white spruce and Jack pine. Common understory species include: low-bush cranberry; prickly rose; green alder; Canada buffaloberry; hairy wild rye; bunchberry; wild sarsaparilla; and dewberry. Wetlands are often extensive and are dominated by black spruce fens and bogs (Downing and Pettepiece 2006).

The study area also falls within the Athabasca Oil Sands region of Alberta, which is the largest Cretaceous oil sands deposit in the province (Conly et al. 2002). Much of the surface deposits in the area are a mix of these cretaceous sands and fluvial sediments from the Lower Athabasca river, Clearwater river, and their tributaries (including, the Christina river) (Conly et al. 2002). It is well-known that these exposed oil sands have resulted in a history of resource extraction in the area. The near surface geological/sedimentological stratigraphy has shown underlying geological formations (McMurray, Clearwater, and Grand Rapids formations), overlaid by glacial till, then a thick layer of alluvial and glacial sand/silt and finally organics (Donahue 1975). Due to the burials being in the near surface sand-silt strata, this area was deemed an appropriate target for a GPR survey.

The 2019 Cowper Lake Burial Ground GPR survey

The 2019 unmarked grave survey was accomplished over two days in October of 2019. The survey was on reserve land and did not require a provincial archaeology permit. The area was very flat and had limited obstructions besides small sapling trees that were either pushed aside or cut down by community members (Figure 4.2). The entire area that the community requested was surveyed as part of two grids, 18 x 18 m (A) and 7 x 8 m (B), respectively (Figure 4.2). As there was prior knowledge of burial practices by community members, two-way travel time was recorded to 60 ns in order to capture up to 2.5 m of depth. This was later converted to depth using a hyperbola fitting analysis in GPR Viewer (Conyers and Lucius 2016), and the dielectric constant was determined to be about 11 (which is appropriate for mixed dry sand/silt soils) (Conyers 2013).

The 2019 GPR survey at Cowper Lake proved to be very successful at locating the graves. The sandy soil matrix produced exceptionally clear GPR results, including reflections indicating intact and clear grave shafts (Figure 4.3). Most of the graves were found to be approximately 80-90 cm deep or 3 ft, corroborating Indigenous knowledge of burial practices.

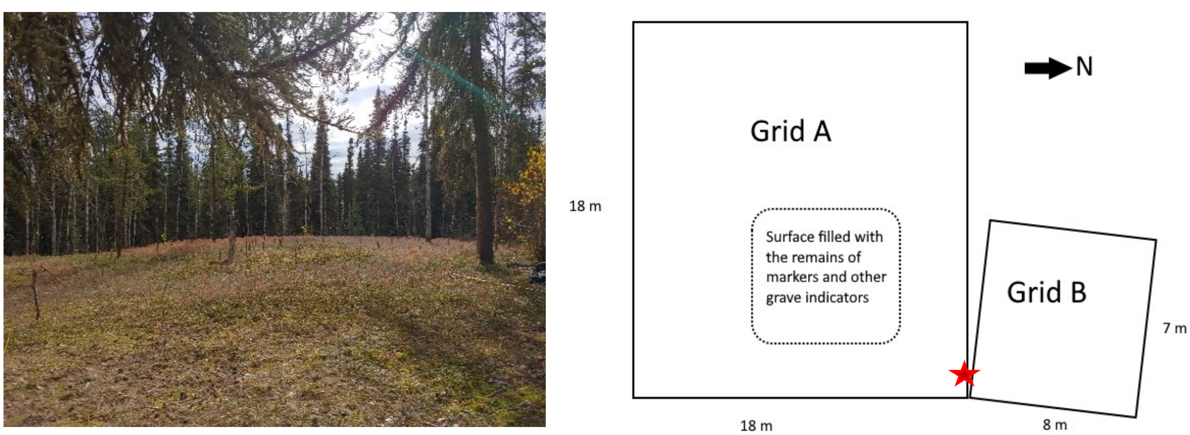


Figure 4.2 Cowper Lake Survey Site Map. Left) Picture of the survey area with clear ground cover, some small saplings and grave markers still standing. Right) Schematic diagram of the GPR survey grids at the Cowper Lake Burial Ground. Red triangle indicates where the picture was taken overlooking Grid A.

There were some clear grave-shaped reflections that only occurred in a few profiles. Upon consultation with community members, they wished to interpret these as the possible graves of deceased children. In total, fifteen probable grave-shaped reflections were identified in the GPR profiles, twelve matching higher amplitudes in the time slices and many matching slight surface depressions (Figure 4.4). Six additional possible grave shaped reflections were also identified, these might be graves; however, they did not span more than a few profiles, and were oriented in a different way than the other graves, casting doubt.

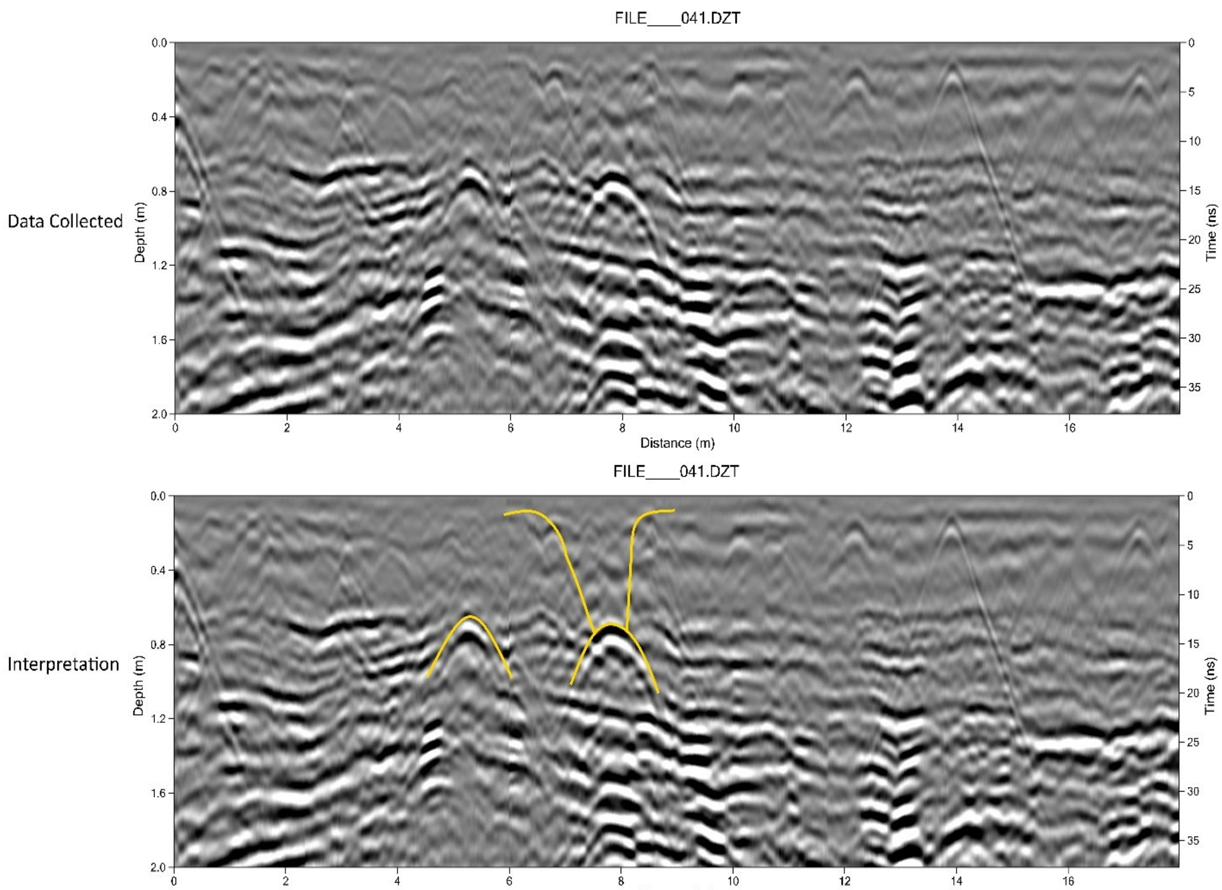


Figure 4.3 Example data collected from the CPFN Cowper Lake Burial Ground. The radargram showing two clear grave shaped GPR reflections. This is exceptional data as the sandy matrix allowed for one of the grave shafts to be clearly identified as very much intact, while the other is less intact.

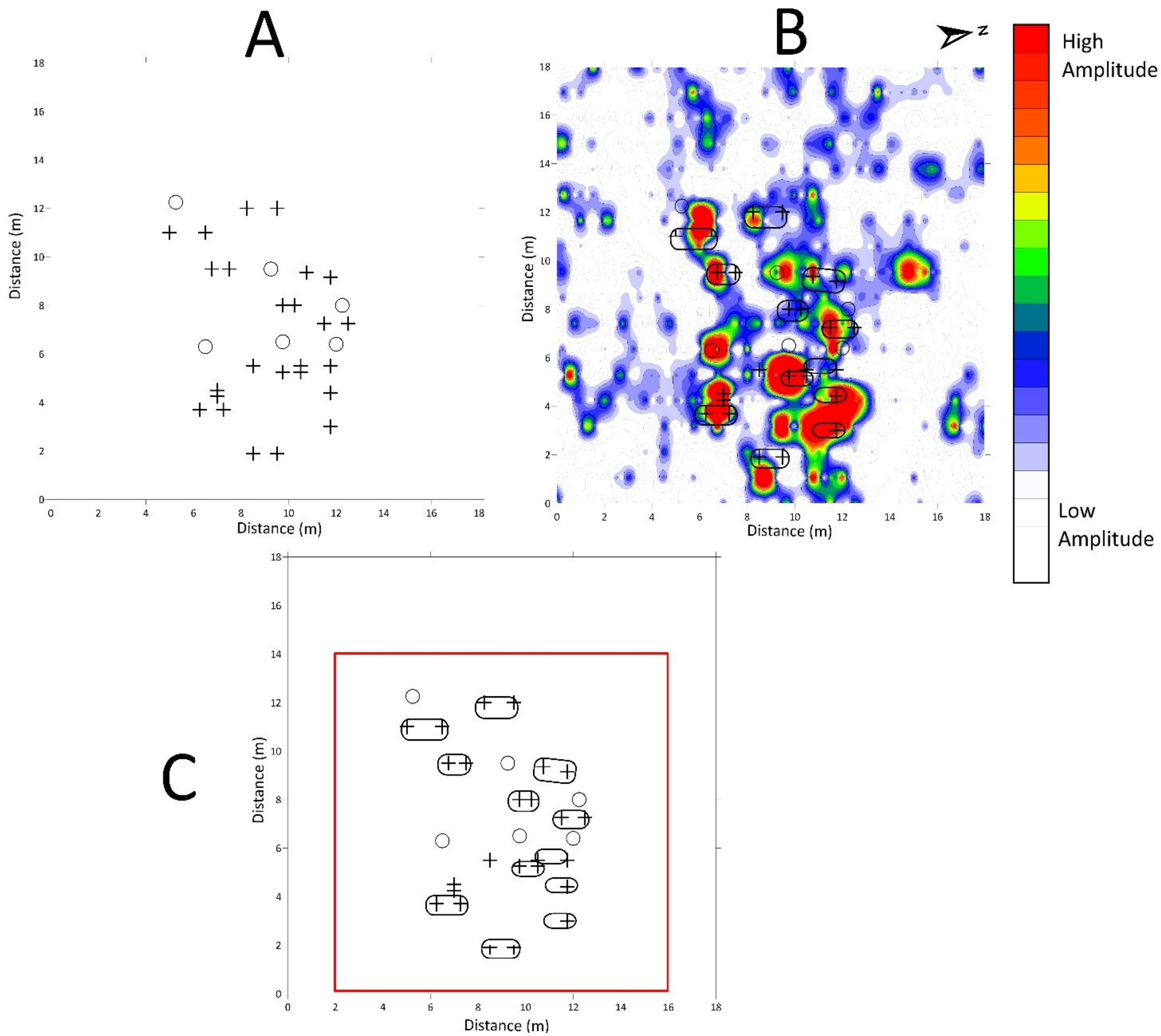


Figure 4.4 Results from the Cowper lake Burial Ground GPR survey. A) post map of 'head' and 'feet' of graves identified in GPR profiles. Circles denote possible grave-shaped reflections, and black crosses denote probably grave-shaped reflections. B) GPR Profile interpretations overlaid on amplitude map of 80-90 cm deep. This GPR colour scale is used for each GPR figure in this thesis. C) Identified graves with interpreted shapes and recommended minimum fence boundary (14 x 14 m).

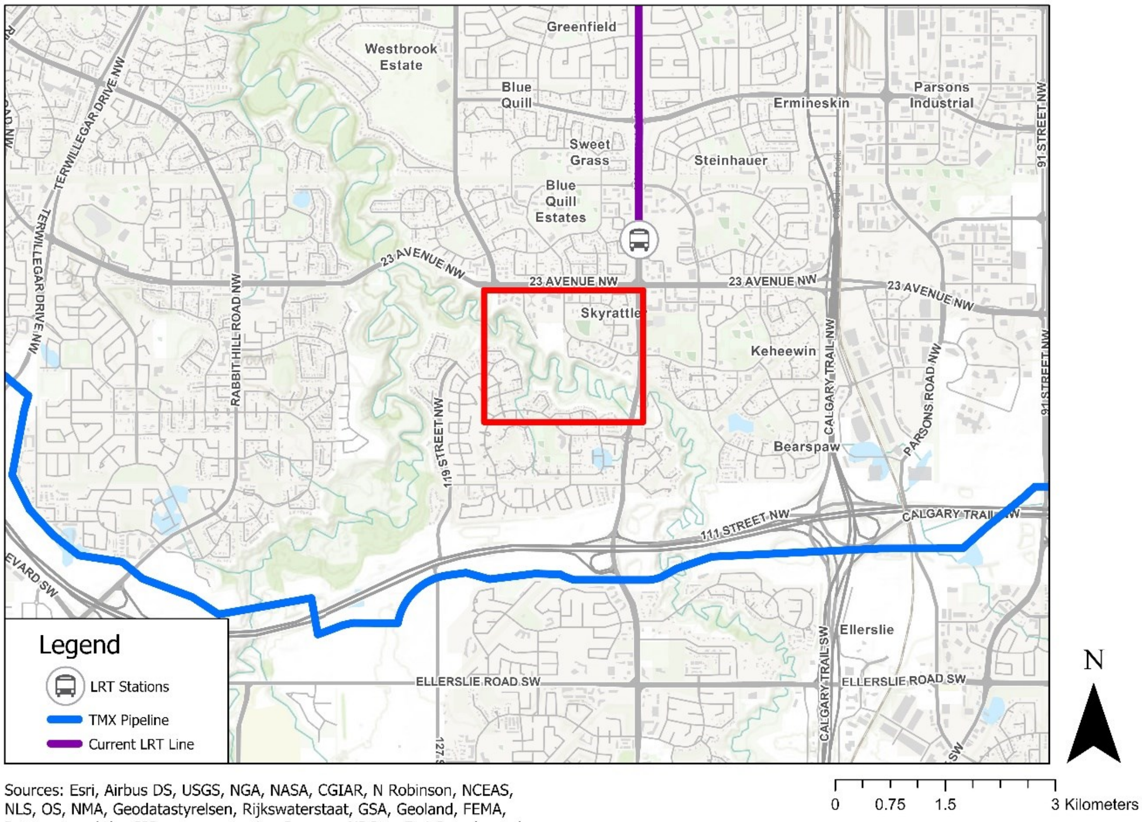
The boundaries of the Cowper Lake Burial Ground were also delineated. The graves were largely concentrated in one part of the survey area and were oriented in rough rows. No graves were found to extend beyond or near the south and west boundaries of Grid A. To the east of Grid A, there was a heavily treed area and no graves were found with the GPR. There was a suspected area that may contain graves to the north of Grid A, a small grid (7 x 8 m) was conducted to tests this hypothesis. No graves were identified in this 'Grid B', thus I concluded that the GPR survey had delimited the boundaries of the burial ground. I recommended to the community that if protective measures are taken, a minimum of 14 x 14 m area should be fenced and centered on the grave shaped reflections.

Conclusions from Cowper Lake

I have highlighted the CPFN work as a classic example of how GPR detects grave-related diffraction hyperbolae in sandy contexts (for more examples see Conyers, 2012). The GPR survey was able to successfully complete objectives set out by the Chipewyan Prairie First Nation. The graves and the boundaries of the cemetery were identified, and a 14 x 14 m protective fence constructed around the burial ground was recommended. Ultimately, my interpreted number of graves closely matched the number of graves expected to be found in the cemetery by Elders. Since the boundaries of the cemetery were delineated, the recommended dimensions of a fence determined, and there was no immediate threat endangering the graves, no additional archaeological/geophysical work was recommended. At the time of writing, the community was encouraged by the results and positive outcome of the process and are looking forward to working with our team in the future on other archaeological remote sensing projects.

4.3 Papaschase First Nation (Edmonton, AB)

The second case study of this thesis highlights how archaeological remote sensing can become entangled with the political aspirations of modern communities. In 2017, Chief Calvin Bruneau of the Papaschase First Nation (PFN) approached University of Alberta archaeologist, Dr. Kisha Supernant, about conducting an unmarked grave survey in a large field formerly owned by Taylor Seminary and College (TSC) in south-central Edmonton, Alberta. The Papaschase First Nation are not a federally-recognized Indigenous community due to the colonial history of Edmonton. Chief Bruneau has been researching a potential Papaschase burial ground since the mid-1990s. He found oral histories suggesting that the burial ground had been in use prior to the disputed surrender of the Papaschase reserve land in 1888 and conducted elder interviews which told him ceremonies were still being conducted on the property as late as the 1970s (Calvin Bruneau, personal communication). This area is now under threat by development. The TSC field containing the potential burial ground was recently sold to a Vancouver developer to build on the land. Other possible sources of disturbance in the area include the new Light Rail Transit (LRT) expansion to the south and the twinning of the Trans-Mountain Pipeline, the original route of which is not far from this location (Figure 4.5). Due to potential impacts to the area and a lack of clarity about the precise location of the burial ground, remote sensing surveys (ground-penetrating radar, magnetic gradiometry, RTK-GNSS) were conducted in June/July 2019, in the hopes to identify and protect the burial ground (research permit no. 19-085). As evident in the next section, this case study required a much more extensive historical review (in comparison to the other surveys presented in this chapter) as the exact location of the cemetery was unknown.



Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: NRCan, Esri Canada, and Canadian Community Maps contributors., Esri Canada,City of Edmonton Open Data, and Trans-mountain Pipeline.

Figure 4.5 A map of southwest Edmonton, Alberta with area of interest. The general area of interest for the Papaschase survey is highlighted in red, and possible nearby disturbances are identified. LRT line expansion is planned to be due south of the current station. Map Author: William Wadsworth, created in ArcGIS Pro.

Background Context

The study area (Figure 4.6) is less than a mile upstream of the confluence of Whitemud and Blackmud Creeks and is considered an archaeologically significant area because the Blackmud Creek ravine was one of the outlet channels of proglacial Lake Edmonton (Bryan and Gibson 1980). Projectile points up to 9,000 years old have been collected from fields between the Whitemud Creek and North Saskatchewan River, demonstrating evidence that people were living in this land soon after deglaciation. By the mid-1800's, the western Cree had shifted from pre-contact hunter-gatherers to holding a major role as the traders/middlemen in the fur trade

(Friesen 2003). These economic changes were accompanied by a sharp decline of their population due to disease epidemics (i.e., smallpox and influenza) and famine (decline of the Bison) across the Prairies (Daschuk 2013; Friesen 2003). It is because of these demographic effects that Chief Papaschase and his people moved to the area directly surrounding Fort Edmonton in order to increase their access to the Hudson's Bay Company (Papaschase First Nation, 2018). On August 23, 1876, Chief Papaschase and his brother, Tahkoots, became co-signatories of Treaty Six at Fort Edmonton. The signing of this federal document recognized the Papaschase Cree as a First Nation, and they were supposed to receive reserve lands, annual payments, tools, and medicine, as well as hunting, trapping, and fishing rights in exchange for their territory.

In 1880, Dominion Land Surveyors were sent to stake out an area for the Papaschase Reserve (Papaschase Historical Society 1984). By 1884, after numerous objections from Edmonton settlers about the Band being so close, the reserve land was resurveyed under instructions from Mr. T.P. Wadsworth, the Indian Inspector, to not provide more than 40 acres to the Papaschase Band far to the south of the settlement (Papaschase Historical Society 1984). In the following years, and after continued systemic discrimination, Papaschase members had to take Métis scrip or leave the settlement in order to survive (Tyler 1979; Papaschase First Nation, 2018). On November 19, 1888, a surrender for the Papaschase reserve was obtained from only a few voting members living on Enoch Cree Nation's reserve (Papaschase Historical Society 1984). The current position of the Papaschase First Nation is that this surrender was illegal (Papaschase First Nation, 2018). Afterwards, its members fled, the lands of the Papaschase First Nation were sold off at auction and some of the remaining community members joined other nearby reserves.

The survey site addressed in this chapter was situated on the western part of the Papaschase Reserve land. In 1905, wooden crosses were seen by “Audie Toan” (Austin Toane) on the Blackmud Creek Ravine edge, near the modern-day Taylor Seminary and College (Melnyk 1983). In 1912, Julius Albert made an Application for Entry for a homestead for West ½ of section 31, Township 51 Range 24 W4M (Dominion Lands Office 1911). Mr. Albert was a Russian citizen who had emigrated from Poland in 1906 with family. He applied for homestead Patent for this land on July 24, 1915 and received it August 31, 1916. From these records and air photos (Figure 4.6), we can assume that the area of interest was tilled from at least 1912 or 1913 into the mid-1950s. During the mid-1960s, the TSC was built on the survey site. As part of its construction, a large septic pond was built underneath the present-day soccer field. By the mid-1970s, the area was annexed by the City of Edmonton from Strathcona County and air photos show the construction of the Sweetgrass and Blue Quill neighbourhoods. It is around this time that the TSC switched to municipal water and sewer services and the septic pond was filled in. In

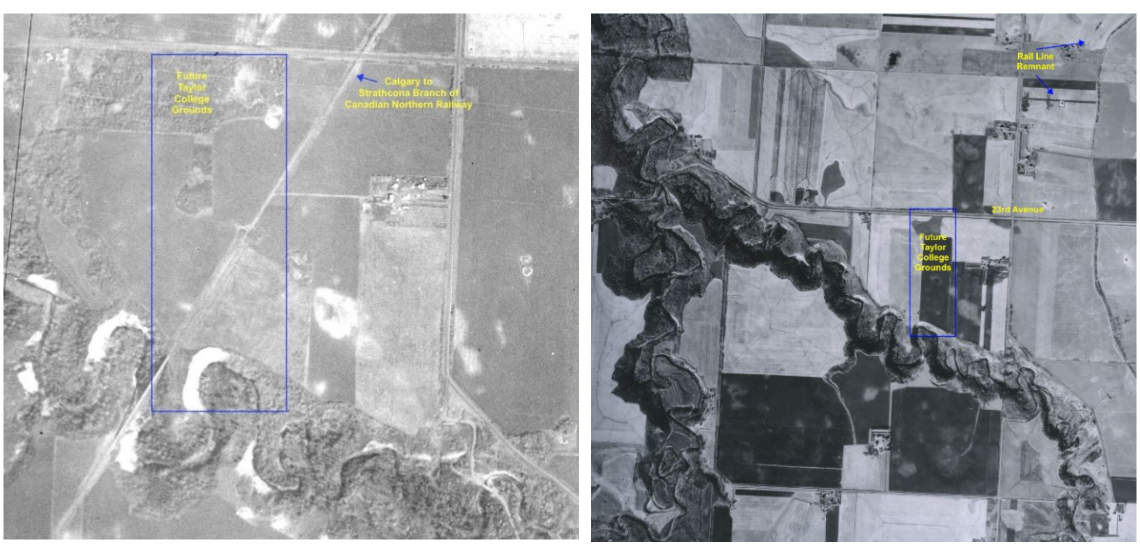


Figure 4.6 Aerial photographs from the Taylor Seminary and College. Left) 1920’s air photo (Alberta Air Photo Office 1920), Right) 1956 air photo. Taken from Supernant et al. (2019) report.

Figure 4.7 More recent aerial photographs from the TSC. Left) 1976 air photo with TSC, septic pond, neighbourhoods and annexation areas. Right)2002 Aerial photograph. Taken from Supernant et al. (2019) report.

2002, the outline of the septic pond was still visible in aerial photographs (Figure 4.7). The land was probably considered contaminated and left for nature to reclaim it; hence the soccer fields.

Given the high degree of disturbance, it is important to consider the effect it would have on any burials occurring at the site. Modern farming practices have been shown to alter artifact and feature distribution, by effectively mixing the top soil and underlying horizon (Navazo and Díez 2008). Assuming the burials would have been buried according to Cree tradition (approximately 3-5 ft), modern farming practices may have disturbed the grave shafts making them harder to detect with GPR. Additionally, the construction of the septic pond would likely have disturbed the graves in its construction and/or in its operation should they have been located here. The pond works by allowing solid materials to settle and decompose while water seeps into the gravel below the pond to be filtered into the groundwater table (Komex Consultants Ltd. 1985). This does not bode well for any burials that escaped direct disturbance by its construction as the bacteria-rich water in the pond would soak into the ground and decompose organic materials.

Considering Previous Research

This is not the first time archaeological and geophysical surveys have been undertaken in this part of Edmonton. In 1979, archaeological investigations were conducted directly south across the river from the site in question, in advance of a new subdivision. Archaeological sites FiPj-56 to 61 were identified and characterized by pre-contact lithics (Bryan and Gibson 1980). All sites were determined too disturbed by modern farming practice to warrant further investigation. As the subdivision surrounding the TSC was built prior to the 1974 Alberta Historical Resources Act, this area has not been archaeologically investigated. A ground-penetrating radar survey was conducted by Altamira Consulting Ltd in 1998 to locate a possible mass burial (Figure 4.8) (Altamira Consulting Ltd 1998). No written documentation of a mass burial event exists beyond letters between Violet Andres and Doreen Wabasca in 1996 that described thirty bodies being removed from the Papaschase reserve burial grounds to a mass burial around the Blackmud Creek ravine. There is no mention in the report to why the investigators thought that this location around the Blackmud Creek contained the mass burial. Regardless, the Altamira GPR survey was unsuccessful at locating a mass burial and provides no information regarding individual unmarked graves as transects were spaced over 5 m (in order to locate a pit), far exceeding current standards for using GPR to identify graves (Conyers 2012; Kalman et al. 2004; Gaffney et al. 2015).

Figure 4.8 Map of Altamira GPR survey area. *Taken from the Altamira Consulting Ltd (1998) report.*

The 2019 Remote Sensing Survey

The survey site is in the Parkland ecoregion of Alberta (Altamira Consulting Ltd 1998). The geology of the parkland region is underlain by terrestrial upper-cretaceous deposits and was subjected to the ancient advances and recessions of glaciers ending in the Pleistocene epoch (11,500 years ago) (Kalman et al. 2004). In most regions, however, glacial till only thinly covers the bedrock (< 2 m). The near surface sedimentology of the region typically consists of agriculturally productive black chernozem soils (Downing and Pettepiece 2006), making the area suitable for geophysical survey. The dielectric constant was later determined to be about 10 (which is appropriate for mixed dry sand/silt soils) (Conyers 2013).

The 2019 unmarked grave survey was accomplished over eight days in June and July. Ground-penetrating radar, magnetic gradiometry, and RTK/GNSS techniques were used to characterize the site and locate potential burials. Ground-penetrating radar was the focus of this survey, and an area of approximately 2.5 acres was surveyed (Figure 4.9). The magnetic gradiometry survey was also conducted on the city property areas outside the TSC field. A significant portion of this research was conducted with community members (who visited the site and participated in the survey) and undergraduate students who were a part of the University of Alberta Archaeology Field School. Originally, the new owners of the TSC field refused the research team access and five of the eight days were conducted outside the field on nearby City

Figure 4.9 Remote Sensing coverage by the 2019 Papaschase First Nation Survey. Map created by Kisha Supernant using RTK-GNSS data. Taken from Supernant et al. (2019) report.

of Edmonton property. Once access was granted, a small research team returned to conduct only ground-penetrating radar on the south-west portion of the TSC field.

As this was a community-driven project, Papaschase elders provided information about where we should survey and at what depth we should expect to find burials. The Elders believed burials would be oriented towards and in areas close to the Blackmud Creek. They also expected for us to find mostly traditional burials around 3-5 ft down, and these were thought to possibly contain grave inclusions, corroborating Tyler (1979).

Ultimately, the ground-penetrating radar failed to locate as many graves as predicted at the site. It was able to provide, however, interesting results that have created more questions about the site's history. When profiles are compared side-by-side, surveys conducted on the city property share few similarities with those conducted on the TSC field (Figure 4.10). The city property GPR profiles showed roughly what was expected to be found at a Parkland region site; two approximately 30 cm thick organic soil layers before what is suspected to be glacial till around 80-100 cm deep. Within the top layer, interpreted as the disturbed or recent layer, there are roots and surface reflections, as well as other smaller amplitude reflections from rocks. In the underlying layer, more shallow grave reflections and stratigraphic changes were identified in the GPR data towards the ravine edge. Below this layer, the signal largely attenuates due to the glacial till and little information was gleaned. Compared to the TSC field, the city property seems extremely heterogenous. The field's stratigraphy seems to be basically one layer with very little reflections until switching to glacial till around 1.2 m deep.

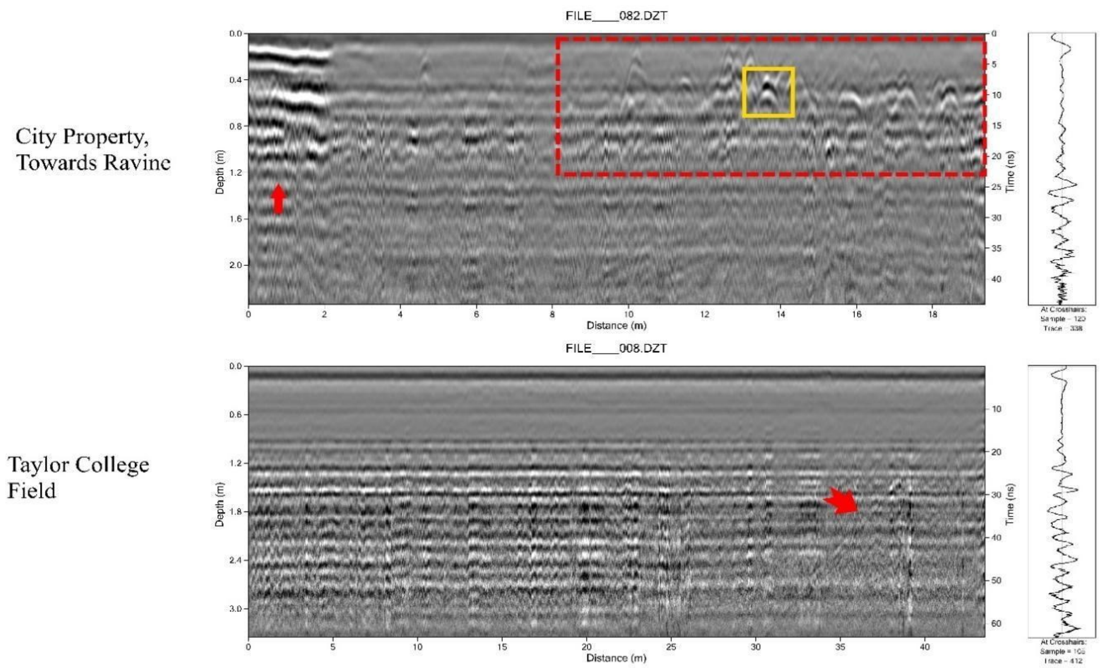


Figure 4.10 GPR profiles from inside and outside the TSC field. Outside the TSC field, a possible shallow grave is visible (yellow box), within a larger area of higher reflection activity and some surface reflections (red dotted box). Area of high amplitude is reflection from crossing over the gravel path and the pit associated with it. The red arrow in the Taylor field cross-section denotes the horizontal ringing affect/ air reflections produced by the metal fence.

Near the southern edge of the grids, air waves were generated from the nearby chain link fence which produced horizontal ‘ringing’ reflections (Conyers 2012:86). Otherwise, there were very few reflections inside the field, a result that was somewhat unexpected and may represent extensive disturbance. Outside the TSC field there was approximately 18 possible grave-shaped reflections identified across all areas. Only four probable grave-shapes were identified, and these were clustered near the ravine edge and in the southwestern area of the site.

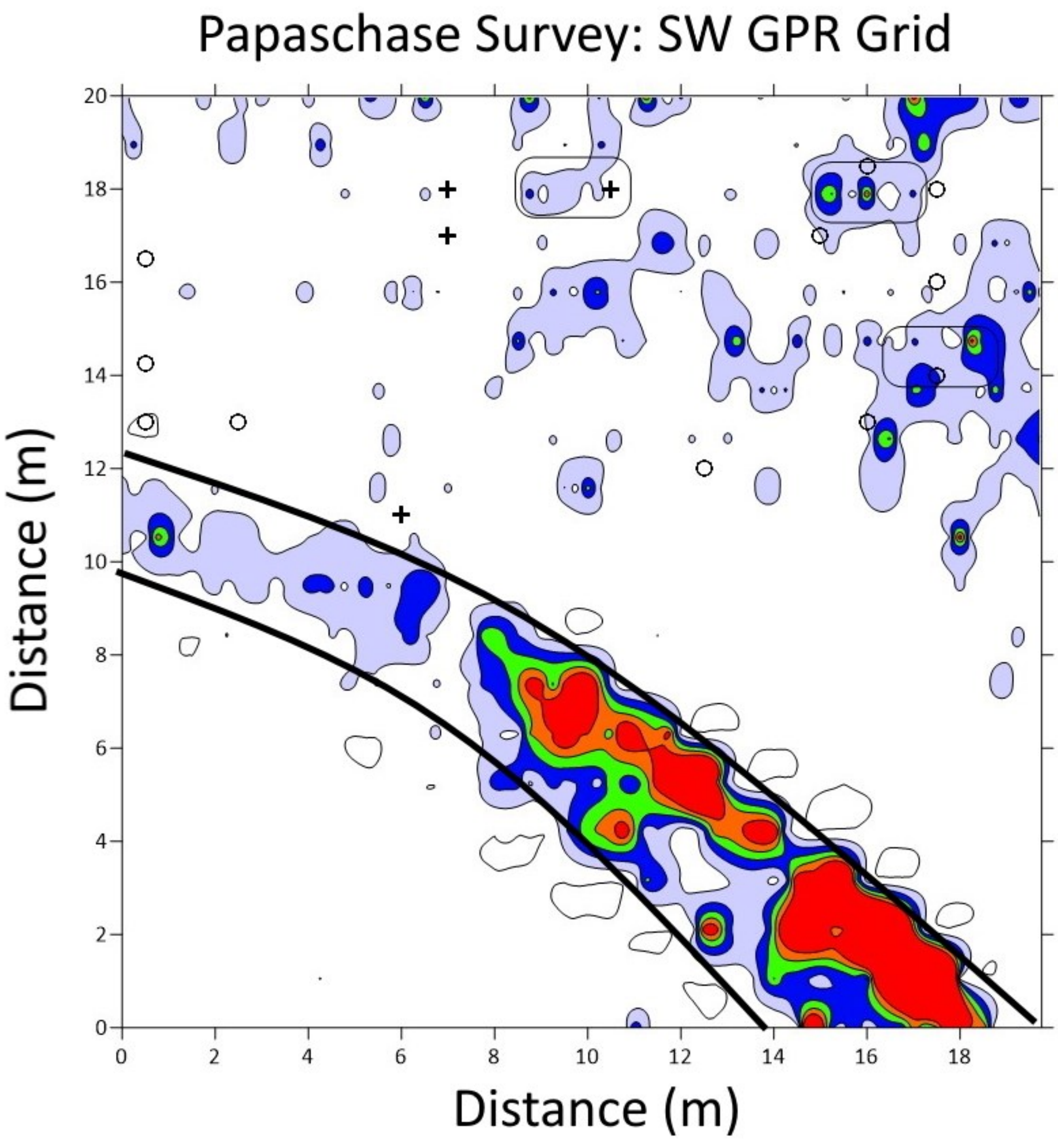


Figure 4.11 GPR amplitude map of the southwest portion of the Papaschase survey area. Black circles denoted possible graves and black crosses denoted probable graves prior to placing the locations on an amplitude map. When the reflections were shown with corresponding 60-70 cm amplitudes, 3 'likely' graves were identified (drawn black rectangles). The higher amplitude linear feature crossing across the map (annotated with black lines) is the gravel path.

When compared to the amplitude map, three groups of identified anomalies corresponded with higher amplitudes and roughly rectangular shapes, and thus can be thought of as the most probable graves (Figure 4.11). One of these reflections corresponded with an anomaly in the magnetic gradient data and was determined as a 'likely' grave reflection.

Much of the magnetic gradiometry data was deemed uninformative due to the high presence of metal from the city surroundings. The chain-link fence, streetlights, telecommunication boxes, and passing/parked cars played havoc on our magnetic sensors and created a large amount of error. Some useable data was collected from the magnetic results, including from the southwest area which was also identified as containing burials in the GPR data (Figures 4.12 and 4.13). In this grid, little information could be gleaned from the total field data which primarily showed a large negatively magnetic anomaly that corresponded with the streetlamp, metal barricade, and fence. Further from these objects, and closer to the ravine edge, more gradient anomalies were found.

Three magnetic dipoles profiles were analyzed, using a computer code by Singh (2002), to predict their approximate size, depth, and magnetic character (Figures 4.12). The modelling software used primarily relied on matching visual characteristics, rather than quantitative criteria, and should only be thought of as an estimate. Gradient anomaly 1 corresponded with a GPR reflection identified as a probable grave. The magnetic object's signature was 'off north' indicating that the deposit was different from the surrounding soil. The object was determined to be about 10 x 10cm, 50 cm deep, was magnetically susceptible and had a strong remnant magnetization which suggested a small (possibly metal) artifact, potentially included with the grave. Profiles 2 and 3 were not likely associated with graves. Both objects seem to be about 5 x 15 cm large, approximately 50 cm deep, but have a far weaker magnetization and appear less magnetically susceptible.

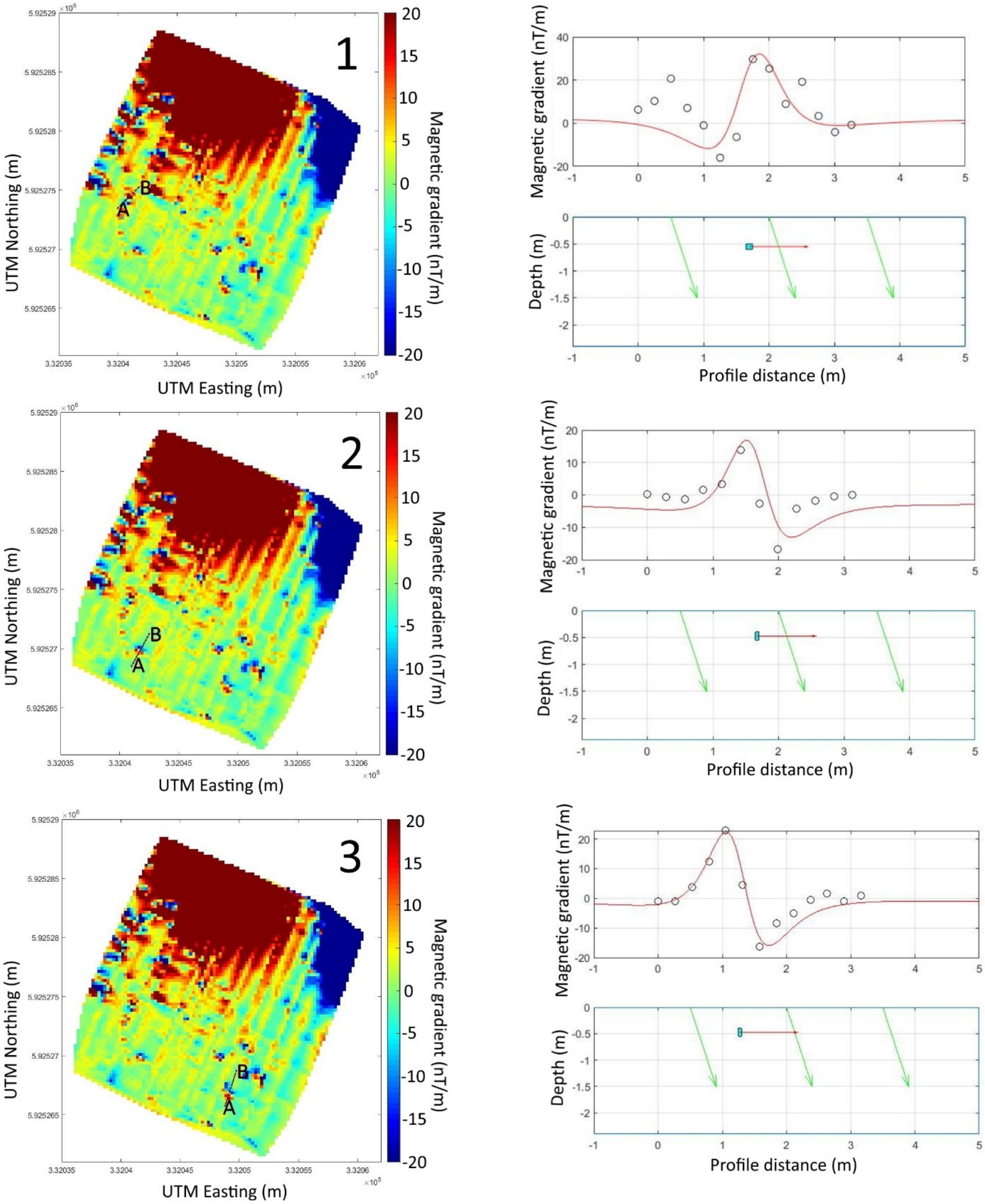


Figure 4.12 Magnetic gradient (nT/m) profile analysis from the southwest grid of the Papaschase First Nation survey (displayed in UTM coordinates-Zone 12). Three dipole anomalies from this grid (plates 1-3) were sampled using a MATLAB script (left), and a two-dimensional object with magnetic characteristics was estimated for each anomaly based on visual characteristic matching (right). Green arrows represent the overall Earth's ambient magnetic field given inclination, declination, and intensity. While the green object is the estimated two-dimensional object with a directional remnant magnetism (represented by red vector line).

These could be magnetic rocks (such as gabbros and granites, which are common in Alberta) that differ from the underlying sandstone geology. Sedimentary rocks typically do not produce a strong magnetic field, but gabbros and granites can produce such an anomaly (Dunlop and Özdemir 1997). Lastly, an area of the site where a probable grave was identified in the GPR data but had no corresponding magnetic anomaly was sampled (Figure 4.13). The varying positive and negative values (between -2 and 5 nT/m) were clearly produced by the bidirectional collection of the data and not representative of significant changes in the subsurface. Currently, the software used to model this magnetic data has not been modified to calibrate GPS magnetic data with a zero mean traversing correction. In the future, better de-striping techniques and processing techniques will hopefully be used.

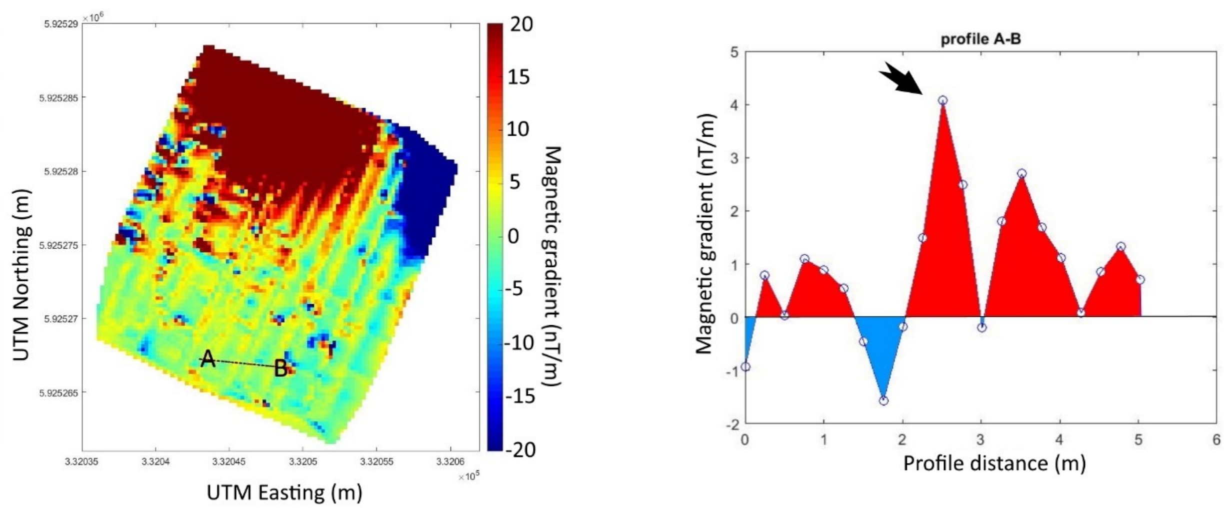


Figure 4.13 Magnetic gradient (nT/m) profile analysis of an area without a magnetic anomaly from the Papaschase First Nation survey. The area had a possible GPR grave reflection but did not have a magnetic anomaly (left). The magnetic profile results for this GPR anomaly was inconclusive as the profile was found to only be representative of the uncorrected traversing lines (right).

Conclusions from the Papaschase First Nation Survey

Ultimately, the remote sensing survey at the Kaskitewâw asiskîy Cemetery produced few GPR reflections that were indicative of potential graves; however, GPR helped characterize the site and inform community history. While it would be convenient to dismiss the survey based on the unknown location of the cemetery, the clear disparity between the GPR profiles from within and outside of the TSC field raises questions. There are several historical reasons that might explain the lack of graves in the TSC field, including substantial farming, subdivision development, and refitting of the property to become a seminary. This means there is a strong possibly that the area was cleared of graves, or large portions of the cemetery, if present on this property, have already been disturbed during the site's stages of reuse. Furthermore, remote sensing data from outside the field contained reflections indicative of graves and corroborated where the Elders and community members suggested the burials were located. Graves were probably closer to the ravine and many are likely hidden from site by tree cover or have been subject to natural erosional processes. Either way, it is suggested that the cemetery was located in the suspected area but due to site processes has either been removed or is reduced to being within the forested sections. We recommended in the 2019 report that if development were to continue in the area, a more systematic archaeological survey, including shovel testing, must be conducted, as well as, a systematic survey and continual monitoring of the forested ravine and its erosional edge. Working with the Papaschase First Nation, I have demonstrated with this case study that unmarked grave investigations do not always uncover large cemeteries full of graves; they can, however, difference identify disturbed versus undisturbed contexts and contribute evidence to support Indigenous claims.

4.4 Enoch Cree Nation (Edmonton, AB)

Introduction

The final case study in this chapter demonstrates how ARS research has the potential to quickly survey archaeological sites and protect them from imminent destruction. In the summer of 2019, Cody Sharphead, consultation coordinator for the Enoch Cree Nation, approached Dr. Kisha Supernant (University of Alberta) about conducting an unmarked grave survey on an Enoch Cree Nation burial ground, presently located on City of Edmonton property. The cemetery is directly adjacent to the path of the proposed twinning of the multi-billion-dollar Trans-Mountain pipeline project and the objective of the geophysical survey was to identify whether the burials continued beyond the existing fence and into the pipeline's right-of-way. While previous GPR research completed as part of the project's regulatory process had cleared the area for pipeline development (i.e., Harrison 2016), our 2019 GPR survey found evidence to contradict this claim. The following sections describe the situation and outcomes of the 2019 project (research permit no. 19-168).

Background Context

Enoch Cree Nation (I.R. 135) is a Cree community located in central Alberta, outside the western limit of Edmonton. They are some of the original people of the Beaver River area of Alberta and have been here since 1670 (River Cree Development Corporation 2020). Under their original leader, Chief Lapotac, the Lapotac Band was recognized in 1842 and traded with Fort Edmonton and the Hudson's Bay Company. After the Chief's death, his son Tommy Lapotac became chief until he died in 1883 and was succeeded by his brother, Enoch. In 1876, Enoch Lapotac signed Treaty 6 on behalf of his band. Chief Enoch Lapotac also accepted the formal survey of the Enoch Reserve, which was created in 1889. When Enoch Lapotac passed away, he was buried in the cemetery under investigation, hence the name "The Chief's Burial Ground." The present-day reserve is 51.55 km^2, and has 1,690 people living in 576 dwellings (Statistics Canada 2018).

Little information exists about the individuals buried in the cemetery beyond the knowledge that this area was where Chief Enoch Lapotac was interred. A granite monument exists dedicated to the individuals buried in the cemetery since the 1800s (Figure 4.14). Oral histories have also suggested that the cemetery was in use long before European contact. It is suspected that that many different burial practices exist among the graves at The Chief's Burial Ground, as the interments would have varied according to traditional or Christian beliefs. Additionally, some of the burials at the cemetery are suspected to be related to tragic events, such as disease epidemics. The cemetery fence was erected by the City of Edmonton more recently, and was intended on being an approximation of the boundary and not the actual limit (Harrison 2016). Interestingly, there is a slight mound in the center of the fenced area that is reminiscent of plains burial mounds (i.e., the Senota Complex) (Neuman 1975).

Figure 4.14 The only standing monument at The Chief's Burial Ground. Photo taken by William Wadsworth, 2019.

Like the previous case study, Enoch Cree First Nation's homeland is within the Central Parkland region of Alberta. While most of the surface deposits in the area are a mix of chernozem soils, much of the region is underlain by glacial till (Downing and Pettepiece 2006). Due to the burials being in the near surface soil deposits, this area is an appropriate target for a GPR survey. As will be seen in the results, the glacial till evidently attenuated the GPR signal beyond the soil-till interface.

Considering Previous Research

This is not the first-time ground-penetrating radar has been used to identify burials around The Chief's Burial Ground. In 2016, James Harrison of Maverick Inspection Ltd. conducted a GPR survey on the ATCO right-of-way 50 m away from the cemetery, ahead of the future pipeline (Figure 4.15). This study used a Sensors and Software Inc. Noggin250 GPR system which operates at a frequency of 250 MHz (Harrison 2016). The area was surveyed in both east-west and north-south directions. North-south transects were collected approximately 1 m apart, while east-west transects collection distances varied across a range between 0.5 m (close

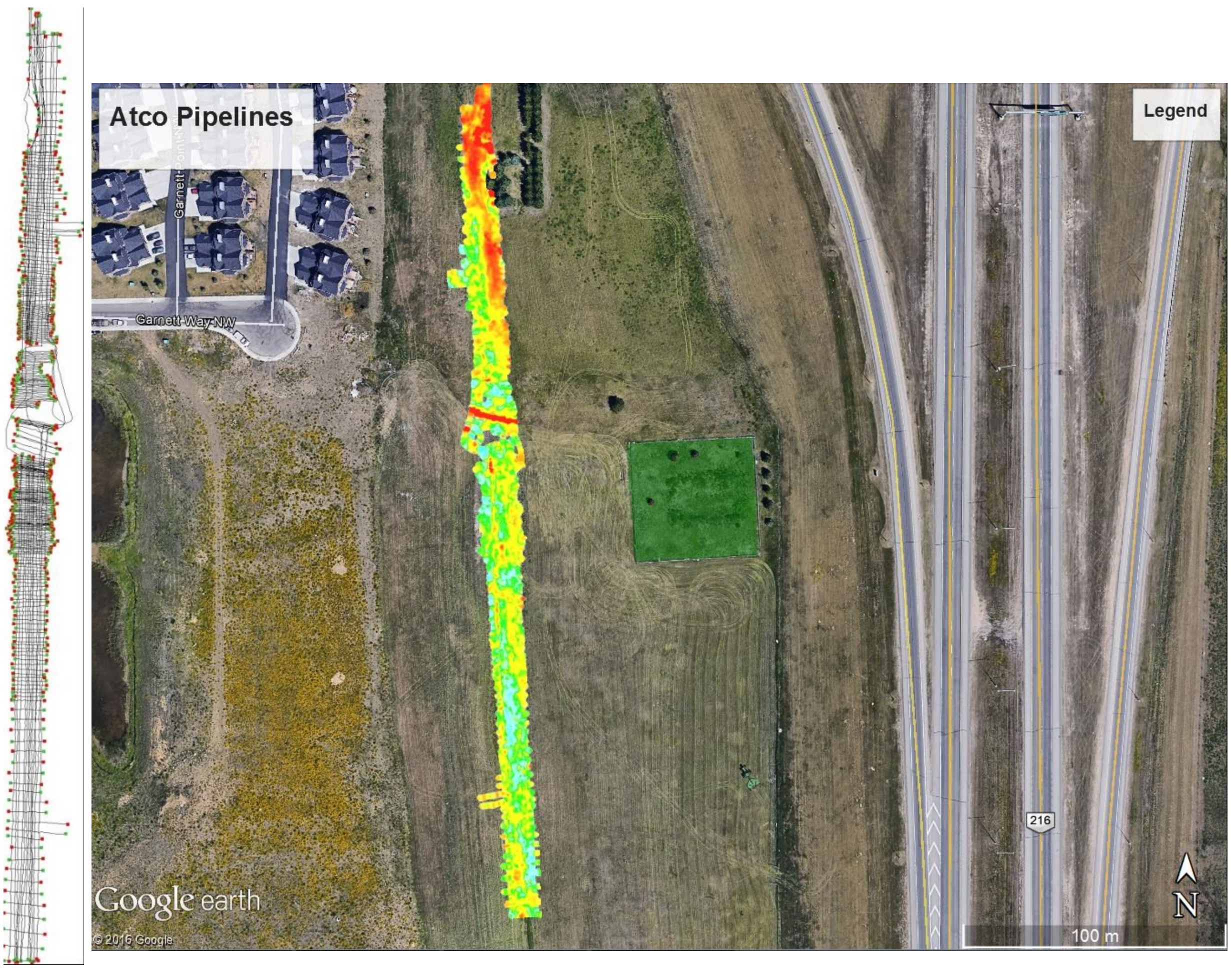


Figure 4.15 GPR results from Harrison's (2016) survey of the ATCO right-of-way (taken from his report). The survey transects are shown to the left, and their timeslice/amplitude data is plotted on a google earth image. Their survey only included the already-disturbed path of the ATCO right-of-way. The square green area is The Chief's Burial Ground.

to the cemetery) and 8 m (near the edge of the survey area). The survey recorded their GPR profiles using an integrated RTK-GNSS which records the GPS coordinates of the system (with an error range of approximately +/- 2cm).

There are a number of considerations that call into question the findings of Harrison's (2016) initial unmarked grave study. First, their study employed the use of a 250 MHz center frequency antenna, the efficacy of which has been debated with regards to its ability in locating unmarked graves. Many authors agree that mid-range frequency antennas (350 MHz to 500 MHz) are best in this application, and many believe lower range antenna (i.e., Harrison's 250 MHz) results to be too coarse to locate graves (Conyers 2012; Gaffney et al. 2015; Goodman and Piro 2013; Wadsworth et al. 2020). Similarly, the size, variation and direction in radar transects by Harrison's (2016) study also casts doubt. The current scientific literature (Conyers 2012, 2013; Gaffney et al. 2015; Jones 2008; Wadsworth et al. 2020) states that the most accurate way to record unmarked graves using ground penetrating radar is to create an arbitrary rectilinear grid where transects are spaced only 25-50 cm apart, consistently separated, and collected in a single direction. Simply, the previous study was too separated and inconsistently spaced to identify graves, even if they had found any grave-shaped reflections. Finally, the biggest issue with their study is the lack of consideration for antenna tilt and elevation. The ATCO right-of-way is a deep channel with steeply sloped sides, which their GPR survey had to traverse, and would have created variation in antenna tilt which would have heavily distorted results and produced inaccurate data (Figure 4.16) (Goodman et al. 2006). There are few acceptable points in the previous GPR survey, but their inclusion of high resolution RTK-GNSS data, survey of both N-S and E-W directions, and knowledge to examine the GPR profiles is commendable. The 2019 survey of The Chief's Burial Ground employed methods much more attuned to the current scientific literature and produced a higher resolution map of the area.

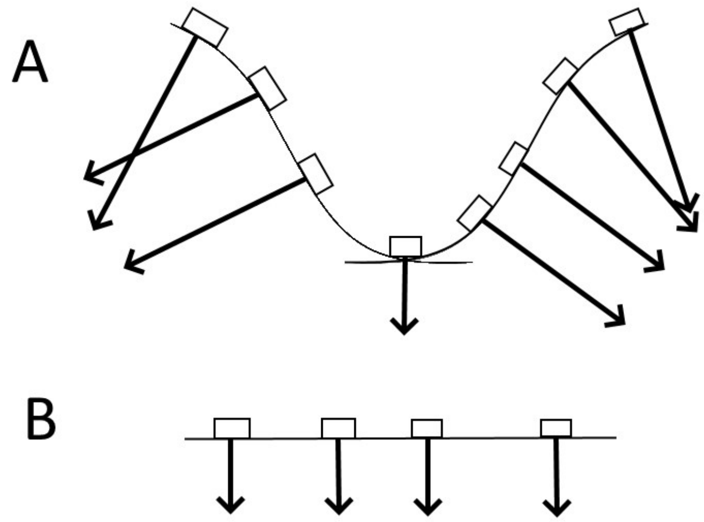


Figure 4.16 Schematic diagram depicting the antenna tilt distortion effect. A) This is a generalized E-W profile view of the ATCO right-of-way showing that the radar waves are sending in different directions and in some cases crossing each other. There is little consistency. B) This a generalized profile of The Chief's Burial Ground, which is relatively flat with little topography (besides two slight mounds). These radar waves are consistent as they propagate through the ground. Created by William Wadsworth, inspired by figures in Goodman et al (2006).

The 2019 GPR survey of The Chief's Burial Ground

The 2019 unmarked grave survey was accomplished over four days in September and October and followed similar settings to those outlined at the beginning of the chapter. Eight grids varying in size were surveyed (Figure 4.17). All survey transects were unidirectional and spaced at 25 cm intervals. Most grids were conducted in the E-W directions, after the initial grid within the cemetery returned with positive results; however, some grids were conducted in the N-S direction. Three gain points were set automatically and used consistently over the course of the three days in September, and new gain points were set in October. Using hyperbola fitting analysis, the dielectric constant was determined to be about 12 in September and 15 at the end of October when the ground was more frozen (which seemed appropriate for slightly saturated mixed sand/silt soils) (Conyers 2013).

The 2019 GPR survey proved to be successful at locating many graves. Grid A within the cemetery was first conducted in order to try and characterize the appearance of the graves in the GPR and if they replicated the typical patterns set out in the scientific literature (e.g., Conyers

Figure 4.17 Diagram of the GPR survey grids at The Chief's Burial Ground. The grey dotted line indicates the approximate line of stakes found in October 2019 which appears to be the edge of the ATCO right-of-way. Produced in ArcGIS Pro using ESRI basemap imagery.

2012). The graves at the burial ground indeed followed these classic patterns and were overall easily identifiable in the radar profiles (Figure 4.18). Most of the grave-shaped reflections were determined to be about 0.5-0.7 m into the soil matrix. Within the cemetery, large pits with many GPR reflections were cautiously interpreted as mass graves (Figure 4.19). Conyers (2012:146-147), described a mass grave as having pit edges and either being filled with different reflective layers or having many point-source hyperbolic reflections within them. The latter being what we believe we found during this survey as these pits were completely different from the rest of the survey's profiles and concentrated around the mound portion of the site (the only portion with significant topography).

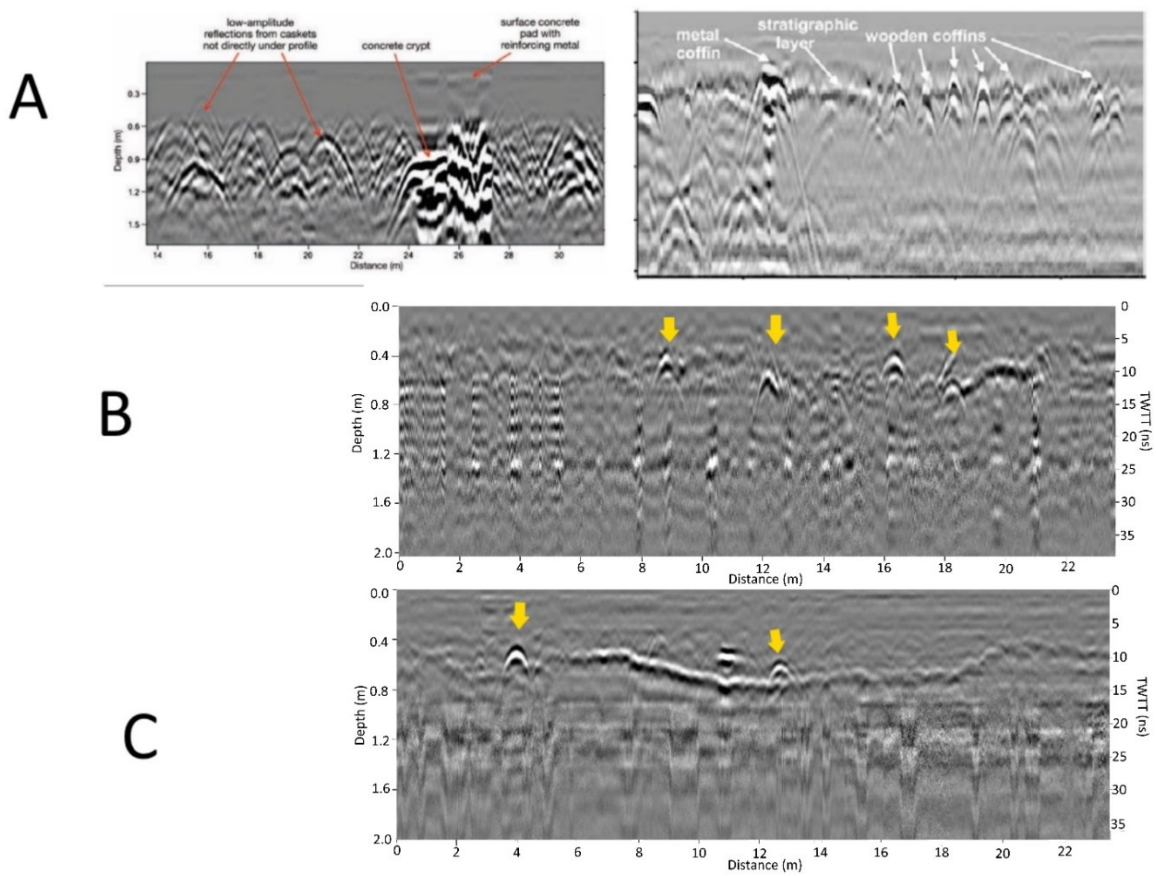


Figure 4.18 Radargram examples from The Chief's Burial Ground compared to published grave shaped GPR hyperbolae. A) Interpreted figures from Conyers' (2012) book on interpreting ground-penetrating radar images, showing what different types of graves look like in radar. B) A radargram from inside The Chief's Burial Ground showing a line of four graves. C) Two graves found outside the cemetery in Grid H, the westernmost grid of the survey.

In total, ninety-six probable grave-shaped reflections were identified in the GPR profiles, some matching higher amplitudes in the time slices (Figure 4.20). Ninety-nine additional possible grave shaped reflections were also identified. Forty-nine of the ninety-six probable graves were found outside the current chain-link fence. There are a few reasons for why more graves were found outside the current cemetery: 1) the placement of the fence was arbitrary and

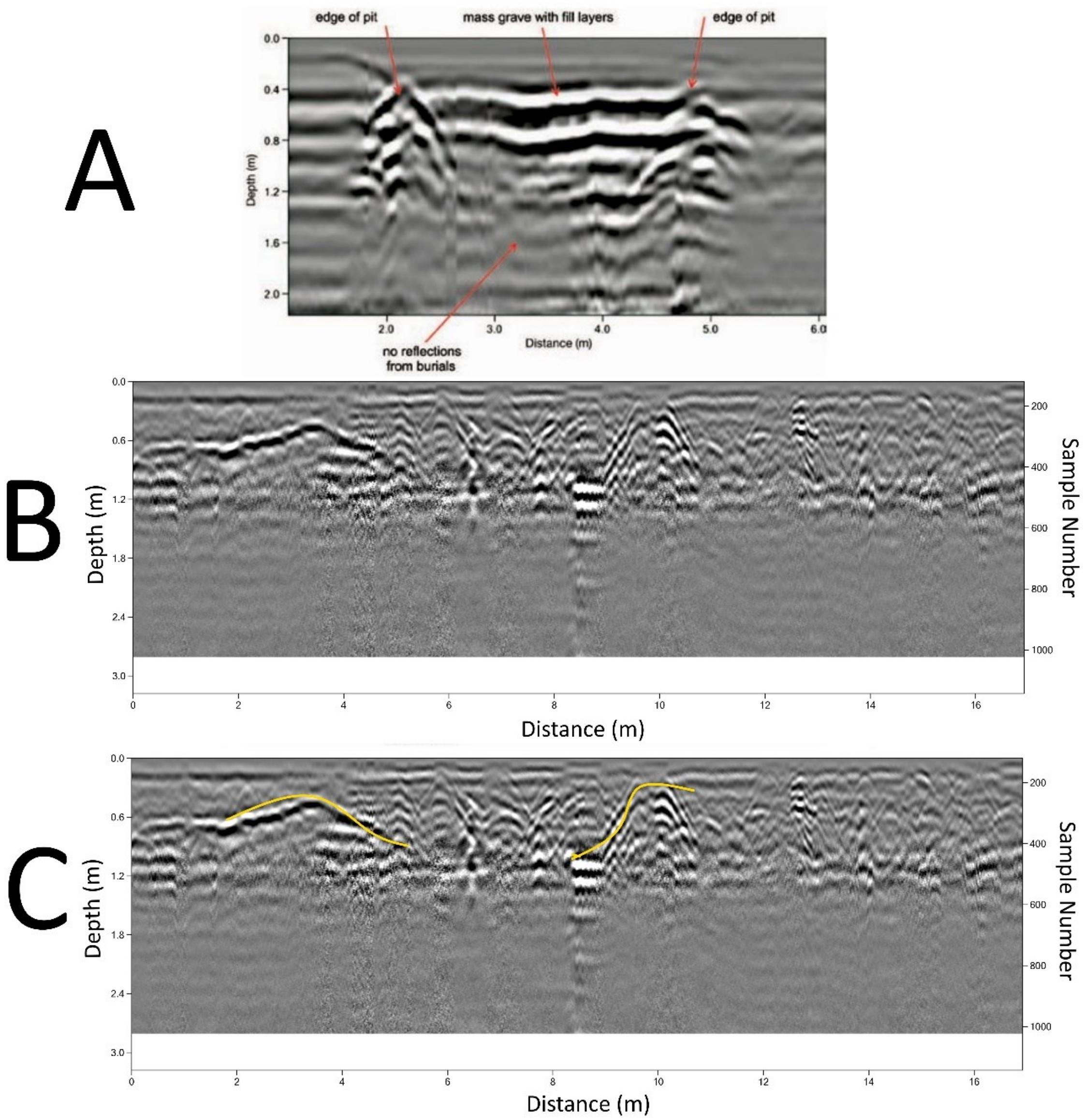


Figure 4.19 Suspected mass grave/burial mound feature compared to published literature. A) Conyers' (2012) depiction of a mass grave with ringing horizontal bands within pit edges. B) Radargram from The Chief's Burial Ground survey. C) Interpreted pit/mound edges filled with hyperbolic reflections suspected to be associated with many interments.

concentrated around the mound feature, 2) not all of the areas inside the cemetery were surveyed as this was not a priority for the study, and 3) there are likely far more individuals interred in the current cemetery, however, it was hard to delineate specific graves around the suspected mass graves. In Grid H, the closest grid to the ATCO right-of-way, many grave-shaped reflections

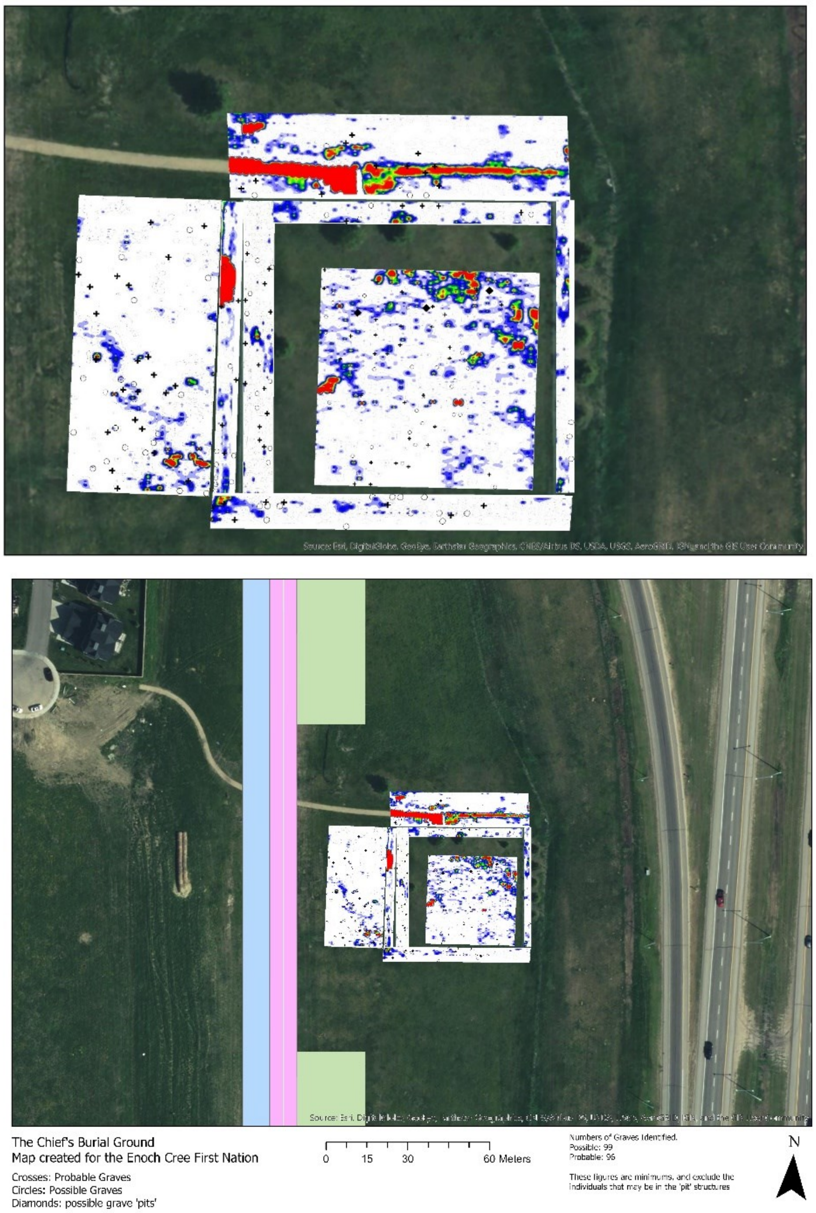


Figure 4.20 Results from the 2019 GPR survey of The Chief's Burial Ground in relation to the incoming TMX pipeline development. Top) Results from the 2019 GPR survey with black crosses indicating probable and circles indicating possible grave reflections. Bottom) Overview map showing where the burial ground and our survey grids are in relation to the TMX pipeline project, pink is the actual pipeline, green is the temporary workspace, and blue is extra temporary workspace.

were found, and many were within 15m of the proposed pipeline work, the closest being only 8m away (Figures 4.20 and 4.21).

The GPR survey also attempted to locate the boundaries of the cemetery. The north boundary of the site was located as there was a 4 m area where no possible or probable grave-shaped reflections were recorded. The western boundary was the area at highest risk of disturbance by the Trans-Mountain pipeline construction. Unfortunately, the western boundary of the cemetery was not located as some grave reflections continued up to the boundary of the Trans-mountain right-of-way/ATCO right-of-way. This sad fact means that the construction of the original pipeline likely disturbed graves, and that any future mitigation efforts should focus

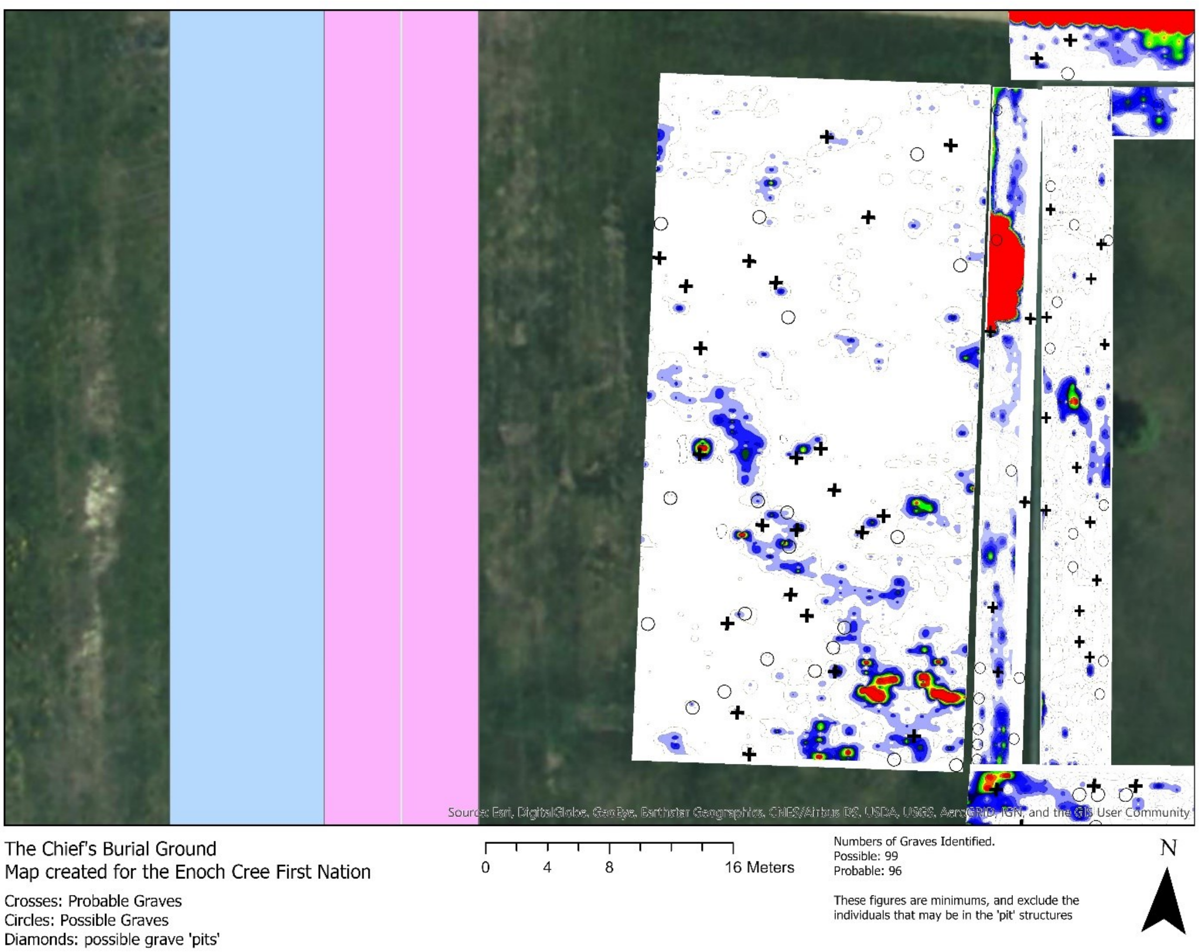


Figure 4.21 A close up view of the nearest grid to TMX. The closest interpreted grave is 8 m away. Nine probable graves were found 15 m away

on this edge. This includes extending the fence as far as possible (Figure 4.22). The southern boundary of the graves was not found, but this side is at less risk from the Trans-Mountain pipeline. Similarly, the eastern boundary was not located as it abutted the area already cleared during the construction of the Anthony Henday highway. Figure 4.22 depicts the recommended fence expansion according to the GPR results, recognizing that the extent of the burials to the south has not yet been finalized.

Figure 4.22 Recommended fence expansion for The Chief's Burial Ground (red dotted line).

Conclusions from The Chief's Burial Ground

The GPR survey was able to successfully complete objectives set out by the Enoch Cree Nation and raised concerns about the current trajectory of the Trans-Mountain pipeline, as well as the previous surveys that were conducted to 'clear' the area. Over 190 reflections were identified as being possibly related to graves. Outside the current cemetery markers, 49 probable graves were identified, many endangered by TMX development. It was recommended that the Enoch Cree Nation and the City of Edmonton collaborate to determine the best way to protect the burial ground and the history it represents. Specifically, the need for immediate mitigation of pipeline impacts on the graves and expansion of the fenced area were strongly encouraged.

The case study with the Enoch Cree Nation is a prime example of how archaeological remote sensing research can be used to pursue Indigenous goals and protect heritage in the face of rapid economic development. As expressed in Chapter 3, the urgency of this project took priority over the incorporation of multiple lines of evidence in order to achieve the Nation's goals. Despite this, some interpretation was possible (such as, the existence of notable interments and mass burials) and the community's response to our results were positive. At the time of writing, the Enoch Cree Nation is pursuing the protection of this burial ground and the history it represents.

Table 4.1 Summary table of the burial ground surveys that appeared in this chapter

Community	Impetus	Burials	General Environment	Techniques	Outcomes
Chipewyan Prairie First Nation	Interested in protecting burial grounds in advance of disturbance.	Known burial grounds with understanding of orientation, size, and practice.	Boreal Forest, Sandy Soils.	GPR with 400 MHz antenna, but interested in future techniques	Located the graves and determined their extent at one cemetery. Future work is planned at other burial grounds in CPFN's traditional territory.
Papaschase First Nation	Interested in locating a lost burial ground in Edmonton	Unknown burial ground. Limited information about burials.	Urban, sand-loam soils underlain by glacial till.	GPR with 400 MHz antenna, Magnetic Gradiometry, and high precision GPS mapping.	Promising initial results. Burial ground location suspected but yet to be confirmed. Future work is planned with the Papaschase First Nation to better locate and map the cemetery.
Enoch Cree Nation	Interested in protecting an important burial ground from economic development	Known burial ground. Some information about burials, including orientation and practice.	Urban, sand-loam soils underlain by glacial till.	GPR with 400 MHz antenna.	Many graves and features were located using GPR. The community was very pleased with the work we conducted and have been in conversation with Trans-Mountain about avoiding the cemetery. There is the potential of future work at other sites.

4.5 Conclusions, Considerations, and Future Directions

The case studies I have presented in this chapter have contributed to the growing body of unmarked grave research in North America. Working with one Dene and two Cree communities provided me opportunities to test these techniques within a community-driven research paradigm. Unmarked graves that varied by cultures, burial traditions, and orientations were located as a result of these surveys. I also suspected that there might have been mass graves located as part of the Enoch Cree Nation survey. Furthermore, three different survey contexts were evaluated (in the order they appeared in the chapter); 1) a known burial ground with some grave markers intact and understanding of burial practice, individual interment, and orientation, 2) an unknown location with little known about the interments beyond buried in the traditional style, and 3) a known burial ground but with limited knowledge of the burial distribution, orientation, practice and extent. Ground-penetrating radar proved successful as the main tool in these investigations and located graves to the communities' satisfaction. In the case of the Papaschase First Nation survey, when limited grave reflections were found, the GPR still provided useful information that highlighted the history of site disturbance and corroborated historical evidence. Although limited, magnetic gradiometry also provided interesting evidence that corroborated potential interpretations, and RTK-GNSS provided a far more accurate geospatial control.

In the context of ARS research as described in Chapter 3, these case studies fall short of providing multi-instrument surveys of burial grounds, which somewhat limits their interpretative potential. That being said, I designed each of the surveys around what the community needed and the urgency of each project. CPFN had a timeline to construct a fence around the Cowper Lake Burial Ground and knew they wanted a GPR survey. The Papaschase Survey had to be conducted urgently due to impending on-site development by a Vancouver construction company and potential disturbance from nearby LRT construction and the twinning of the TMX pipeline. Similarly, the most urgent case study was the Enoch Cree Nation survey, which was conducted in advance of the TMX pipeline expansion. While conducting the ECN survey, workers from the project approached us as they were expecting to break ground imminently. Despite the urgency and community need (rightly) outweighing the incorporation of other techniques or collection of disparate information, community members and elders were still invited to the site to provide input, share stories, and focus the surveys. Given pressing time constraints, I was unable to formally incorporate these stories into this thesis' ARS surveys. In the future, more research needs to be conducted in this area as Elders and community members often accurately predicted where graves were, how they were oriented and, in rare cases, who was interred there.

While there are limitations to the use of a single technique, it has also provided a useful comparative dataset to draw on, and experiment with survey standardization. While geophysical techniques cannot be implemented the same way in different environments, at the beginning of this chapter the main principals and settings for the surveys were described. The methods and GPR results were designed after those appearing in published literature (Conyers 2012; Gaffney et al. 2015; Ruffell and McKinley 2008), and give hope to the ongoing standardization of the technique. While previous authors have undergone much work to develop reliable methods for unmarked grave investigations, I have hoped to show that applying these techniques also has a real effect on modern people, specifically, Indigenous communities.

ARS researchers must recognize the political ramifications, and impacts to Indigenous rights and sovereignty, that arise from doing this work. For instance, working with the Papaschase First Nation, archaeologists are providing evidence of a colonial history that resulted in their disenfranchisement. By working with the Nation, we (as researchers) are indirectly supporting their claims to be re-instated as a federally-recognized First Nation. Similarly, by conducting the GPR survey with the Enoch Cree Nation, we are supporting Enoch's rights and sovereignty by opposing the destruction of their burial ground and pushing Trans-Mountain to move their pipeline's right-of-way. By recognizing that community-driven ARS research is political, more meaningful survey designs and interpretations can be formed.

While the reliable implementation of one technique at the service of Indigenous communities is noteworthy, in the future it would be best to incorporate additional techniques when possible to increase geophysical reliability (Gaffney et al. 2015; Schmidt et al. 2015). The most important addition to future surveys must be the acquisition of high-precision GPS data, demonstrated by the Papaschase survey, to increase geospatial control. While not discussed in this chapter, the ability to pinpoint where a geophysical target is in the event that it is tested through excavation is crucial. Alternatively, in the case of unmarked grave surveys, survey designs must have a high degree of spatial control if potential graves are planned to be commemorated with physical markers. While only briefly discussed in the Papaschase survey, the incorporation of magnetic gradiometry in unmarked grave studies has shown to be an asset in locating associated grave materials (Gaffney et al. 2015) or providing useful site information helping to solidify interpretations (Bevan 1991; Wadsworth et al. 2020). Similarly, resistivity and other geophysical techniques have shown to provide more datasets to draw upon when locating unmarked graves or archaeological features. Finally, given the increased access and use of UAV technology, LiDAR and multispectral imaging should also be considered possible lines of inquiry in future unmarked grave investigations.

In accordance with multi-component ARS research, the next chapter describes such an approach applied to archaeological sites. Working with Tsimshian communities in Prince Rupert Harbour, BC, the next case study works within a collaborative research framework.

CHAPTER 5:

AS APPLIED TO ARCHAEOLOGICAL RESEARCH – PRINCE RUPERT HARBOUR, BC

In this chapter, I present the results of remote sensing surveys conducted on Tsimshian houses in Prince Rupert Harbour, BC. These surveys were part of the ongoing Prince Rupert Harbour (PRH) archaeology project that examines the intersection between archaeological data, landscape, and oral history in the region. Working collaboratively with the nearby Tsimshian communities of Lax Kw'alaams and Metlakatla, three sites were surveyed in 2019 (GbTo-23, GbTo-34, and GbTo-4) to explore the efficacy of remote sensing techniques in future applications. Archaeologically, house floors, shell middens, hearths, and posts/post molds have been commonly identified during excavations at sites in PRH (Martindale 2006b). I describe my initial efforts to resolve architectural patterns in the geophysical data given this unique archaeological and environmental context and discuss the potential of remote sensing methods in future collaborations with Indigenous communities in and around Prince Rupert Harbour.

5.1 Community Context

Located on British Columbia's northern coast, the Coast Tsimshian have inhabited Prince Rupert Harbour for millennia, built monumental winter villages, and developed detailed oral histories (*adaxw*) (Martindale, Marsden, et al. 2017; Supernant and Cookson 2014). They had a highly specialized marine economy focused on shellfish, salmon, oolichan (or eulachon) and herring. This specialization created dense shell matrices in and around village sites, leaving house depressions on the surface and intact architectural features within. These winter villages at PRH are often described as 'shell-laden' and having denser shell matrices than elsewhere on the

Northwest Coast (NWC) (Coupland et al. 2010; Martindale 2006b). Previous archaeological studies have demonstrated the immense importance these sites had on Tsimshian life (Martindale, Marsden, et al. 2017; Patton 2011; Supernant and Cookson 2014). The adaxw also captures some of the macroscopic changes to the villages' structure and organization throughout the Coast Tsimshian's history. It is worth noting that events in oral histories are seen archaeologically and have aided the interpretation of occupation sequences in the harbour (Edinborough, Por, et al. 2017). Due to this unique history, Prince Rupert Harbour holds hundreds of sites with huge and complex archaeological deposits.

The modern Coast Tsimshian comprise nine Allied Tribes and many communities. The largest and closest to Prince Rupert are Lax Kw'alaams and Metlakatla. The development of the contemporary communities began during the coastal fur trade that saw increased European presence and decline in Tsimshian population (Cookson 2013). In 1831, many Tsimshian houses moved to HBC Fort Simpson, later to be known as Port Simpson/ Lax Kw'alaams, which is situated at the mouth of the Nass River (approximately 30 km north of modern Prince Rupert). Under the direction of William Duncan, a Anglican minister, many houses splintered off to form a "utopian" Christian community at Metlakatla in 1862 (MacDonald and Inglis 1981; Patton 2011). The most prominent Tsimshian entity in this story is Ligeex, a name carried by powerful hereditary house leaders, who were converted by Duncan but continued to straddle old and new traditions, as well as, split their time between Metlakatla and Port Simpson (Lax Kw'alaams Band 2019; Martindale 2003). Ligeex rose to prominence during the fur trade when the site of Lax Kw'alaams/Port Simpson was originally chosen to be on his family group's land (Lax Kw'alaams Band 2019). Chief Ligeex held exclusive rights to trade with HBC Fort Simpson, and therefore, controlled the other Tsimshian groups who wished to trade their furs (Martindale

2003). By the 1830s, Ligeex controlled the entire interior Tsimshian area, transformed the Tsimshian social structure into a paramount chiefdom, and had become a prominent fixture in the adaxw (Martindale 2003). Since 1871, however, when British Columbia joined the Dominion of Canada, both Lax Kw'alaams and Metlakatla have been increasingly subjected to European/Canadian law and influence (Lax Kw'alaams Band 2019).

5.2 The Prince Rupert Harbour Archaeology Project

Given the remarkable preservation of PRH sites, investigating Tsimshian houses and settlements has always been a focus for archaeology in the region. While the first archaeological projects began as early as 1909 (Ames and Martindale 2014), the first extensive project in PRH began in 1966 by George F. MacDonald at the Museum of Man (now known as the Canadian Museum of History in Gatineau, QC) (MacDonald and Inglis 1981). This project focused on establishing settlement patterns, regional chronologies, and investigating social complexity through architectural features. In the 1980s, Gary Coupland, then a graduate student at the University of British Columbia, began working in the eastern portion of the Prince Rupert region with a household archaeology focus. Between 1988 to 1997, Coupland moved his investigations to the PRH and produced much information regarding PRH site architecture, primarily from his investigations at McNichol Creek (Ames and Martindale 2014; Coupland 2006). At the same time, David Archer was regionally surveying PRH in an attempt to understand rank between village sites (Archer 2001). Archer's project found many new village sites across the region and mapped many house depressions. It is from these years of excavation and survey, that Tsimshian household features are well understood archaeologically and have been inventoried and described in-detail (Martindale 1999).

In 2011, Andrew Martindale (University of British Columbia) and Kenneth Ames (Portland State University) began the current iteration of the PRH project in the hopes of continuing a site-specific focus but departing from high intensity excavations in favour of a new low-impact and multi-evidence-based methodology (Ames and Martindale 2014). This new project more greatly incorporated and considered cultural information and Indigenous knowledge from the Coast Tsimshian (Martindale and Marsden 2003; Martindale 2006a), and therefore, research questions have shifted from issues of social complexity to methods-driven settlement and landscape studies (i.e., C14 dating, sea levels and architecture) (Letham et al. 2018; Edinborough, Porčić, et al. 2017; Martindale, Marsden, et al. 2017). Greater involvement and collaboration with the local Indigenous communities (Lax Kw'alaams and Metlakatla) also prompted a reconsideration of traditional methods and development of more technology-focused low-impact research strategies. A key component of this has been using geomatics and C14 dating to map and date village sites to understand how people have moved through and settled the physical landscape (Edinborough, Porčić, et al. 2017; Gustas and Supernant 2017, 2019; Supernant and Cookson 2014).

While the Prince Rupert Harbour region has been consistently mapped for over five decades, few geophysical studies have been conducted (i.e., Cross 1996). As the PRH project continues, my colleagues hope to develop a new methodological approach to apply archaeological remote sensing techniques to expedite the survey and mapping of village sites. As part of a new (2018) SSHRC-funded research project in PRH, led by Andrew Martindale (UBC), Kisha Supernant (UAlberta), and Bryn Letham (SFU), I was asked to conduct various geophysical experiments on three village sites to test the efficacy of GPR and magnetometry in locating Tsimshian house remains. A GSSI SIR 3000 GPR system with a 400 MHz center frequency antenna and a GEM Systems GSM-19 Overhauser magnetic gradiometer were used to conduct the surveys. Prior to survey, I reviewed existing geophysical literature on archaeological sites in British Columbia (e.g., Prentiss et al. 2008; McLay et al. 2009; Dolan et al. 2017). In addition to the geophysical surveys, UAV-LiDAR was also flown over the Kitandach site (GbTo-34), the results of which are not presented here but will be the subject of future discussions.

Three sites were included as part of the 2019 geophysical investigations, GbTo-23 (Garden Island), GbTo-34 (Kitandach) and GbTo-4 (Ligeex's) (Figure 5.1). These sites are situated on reserve land and did not require provincial permits as permission was granted by the communities. Garden Island is the smallest island at the eastern outlet of Venn Passage (Ames 2005). It is situated in the largest tidal flat in the harbour and is easily accessible on all sides by boat. The site is represented by one house row with four house depressions, canoe skids on its southwest bank, and historic grave markers. The site's median radiocarbon dates place site-use between 341 to 6657 cal. BP (n=27) (Martindale et al. 2016). The site has been disturbed by coastal erosion and the impact of a modern cemetery (Ames 2005). There has been significant interest in monitoring the rate of erosion on the island, which appears to be quickly disappearing. In 2014, an erosion profile was recorded by the PRH project and in 2019 we returned to recover GPR data and photogrammetry from the same exposure.

Kitandach (GbTo-34), a large village site, has been previously subjected to much archaeological investigation and represents one of few consistently occupied sites during the Middle period (1000-3500 BP) (Cookson 2013; Edinborough, Porčić, et al. 2017; Letham et al. 2017). The site has three house rows and 17 house depressions, and has radiocarbon dates spanning the last 5000 years of history, with a median date range of 313 to 5721 cal. BP

(Edinborough et al. 2016; Letham et al. 2017). The site has also been impacted by historic gardening; a practice introduced by European contact in the area. Starting in 1971, Richard Inglis excavated a partially destroyed house feature (Inglis 1972a, 1972b; MacDonald and Inglis 1981). Although his reports on the site hold limited utility for the present study, they contain a list of artifacts found in a house depression and a pH analysis of the soil (which was found to be relatively neutral). Given Kitandach's prominence and importance to the archaeological record of the harbour, the current PRH project had already collected high resolution topographic data, systematic percussion cores, and radiocarbon dates from GbTo-34 (Letham et al. 2017). Given the high degree of spatial control at the site, and the ability to compare geophysical data to existing archaeological information, House 16 at Kitandach (which has not been archaeologically investigated) was chosen to test the geophysical methods.

GbTo-4 is also an important village site for the Coast Tsimshian community. First, it is the main late period coastal village of the Gispaklo'ots Tsimshian Tribe and the largest house depression at the site is associated with its prominent chief, Ligeex. Second, the site is near the sacred petroglyph, the Man Who Fell from Heaven. Archaeologically, it is an interesting site because it contains two village areas separated by an engineered shell causeway (Martindale, Letham, et al. 2017). It is known that NWC house size and location is related to the power and rank of the family group (Coupland 2006). At GbTo-4, two large houses are separated from the others by the shell causeway and are seated at a higher elevation overlooking Venn Passage. The largest house depression was associated with the 'Old' Ligeex, and it was occupied until the communities left Metlakatla in the 1830s to Lax Kw'alaams (Martindale 2003). After the site's abandonment, GbTo-4 was also substantially impacted by historic gardening and, as such, many of the house depressions are partially obscured. In total, there are two house rows and 12 house depressions found at GbTo-4, spanning 240-3180 cal. BP (Letham et al. 2016; Supernant and Cookson 2014). Despite these median dates, GbTo-4 is historically known to have been occupied later into the historic period (up to the 1830s). Finally, the site has been previously mapped by the PRH project and has undergone some percussion core testing.

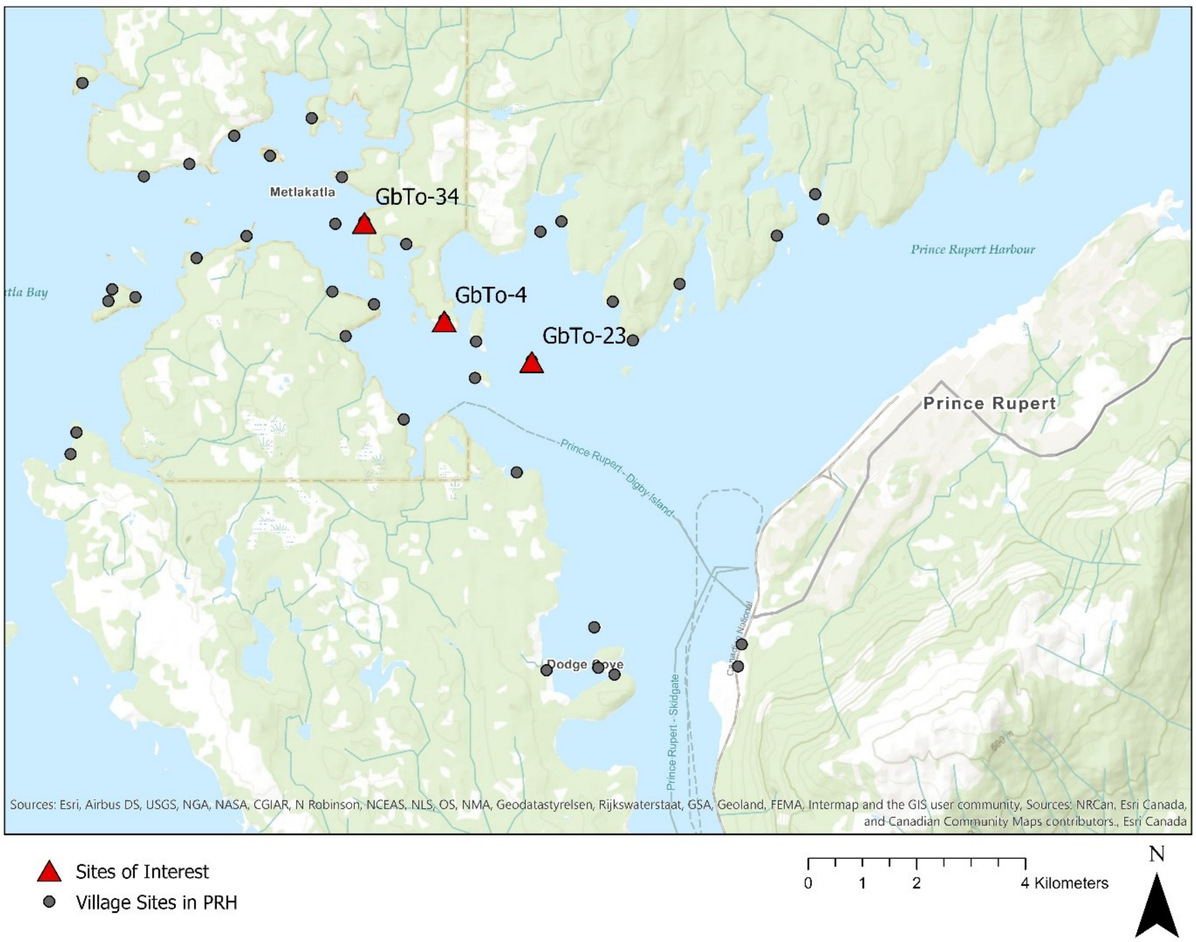


Figure 5.1 A regional map of Prince Rupert Harbour with archaeological sites. Red triangles represent the sites that were surveyed as part of this study. The map was created in ArcGIS Pro.

5.3 Establishing a GPR Baseline for PRH

A crucial part of any GPR survey is determining the character of the ground and how it affects radar velocity and the dielectric constant. While in other regions, work has been done to survey shell middens (Miller et al. 2018, Napora et al. 2019), values for the dielectric constant of shell-dense soil matrices are rarely reported (Table 5.1). Moreover, the dielectric constant of particular shell layers change, and it is necessary to undergo testing to determine a suitable estimation for each site (Miller et al. 2018). The investigation of one site in PRH, however, has the potential to determine an approximate dielectric range for the harbour's environment and aid the interpretation of geophysical surveys at the other village sites. In 2019, the PRH archaeology project had been asked by the communities to monitor the erosion of Garden Island (GbTo-23). By using measurements from photogrammetric models and carefully surveyed GPR profiles, we were hoping that direct depth comparisons can be made from the radargrams to the active erosional profiles at GbTo-23 (Figure 5.2). This would effectively establish accurate dielectric constants without causing unnecessary damage from excavation or even percussion coring. Unfortunately, issues with this summers' photogrammetry model of the erosional face forced me to use the hand-drawn stratigraphic profiles done in 2014. While not ideal, as the profile has undoubtedly changed within 5 years, this process provided an estimate dielectric constant of 20 (using the equations listed in Chapter 2).

Table 5.1. Typical relative dielectric permittivities of common materials found during archaeological projects	
Air	1
Water (sea/fresh)	~81
Ice and Snow	3-4
Dry Sand	3-6
Saturated Sand	20-30
Coastal Sand	10
Dry Silt	3-30
Saturated Silt	10-40
Clay (wet)	5-40
Average Organic Rich Soil	12
Marsh or Forested Land	12
Organic Rich Agricultural Land	15
Pastoral Land	13
Asphalt	3-5
Concrete	6-30
Sources: Modified from Conyers (2013) and Reynolds (1998).	

Figure 5.2 Pictures of the erosional profile on Garden Island. Left) 2014 photo of the (cleared) erosional face in question being measured Right) Wadsworth surveying the same (uncleared) erosional profile in 2019.

To test my estimated dielectric constant of 20, I also derived estimates from GbTo-34 and GbTo-4 using hyperbolae estimation analysis (also used in Chapter 4 and 6 of this thesis). These estimates proved to be approximately 20 to 23 depending on the site. To further compare these values, GPR data from the Gulf Islands in southern British Columbia was provided to me by Dr. Colin Grier. His project investigates Coast Salish architecture, which have different styles than Tsimshian architecture and are in a much drier environment (Grier et al. 2017). That being said, the Coast Salish also have shell-soil matrices, primarily as a result of large terraforming projects (similar to PRH), that also provide useful comparisons to justify our estimates. The dielectric constants from the Gulf Islands have been found to be around 9 (Colin Grier, personal communication), which justifies the Prince Rupert values as the environment is more saturated with water and shell. Therefore, I was able to justify the application of an approximate dielectric constant of 20 derived from stratigraphic drawings and photographs of an erosional profile on

Garden Island. We are hopeful that in future summers the direct comparison technique of these erosional faces can be further refined.

Analyzing the stratigraphic profile and the GPR data from Garden Island also led to basic conclusions about how radar reacts in this environment. While the annotations on Figure 5.3 are hypothesized stratigraphic breaks since the profile has changed, erosional changes have likely been on a scale of centimeters rather than meters, and therefore the maps and descriptions are still comparable to the GPR data. First, the higher dielectric constant is primarily from the

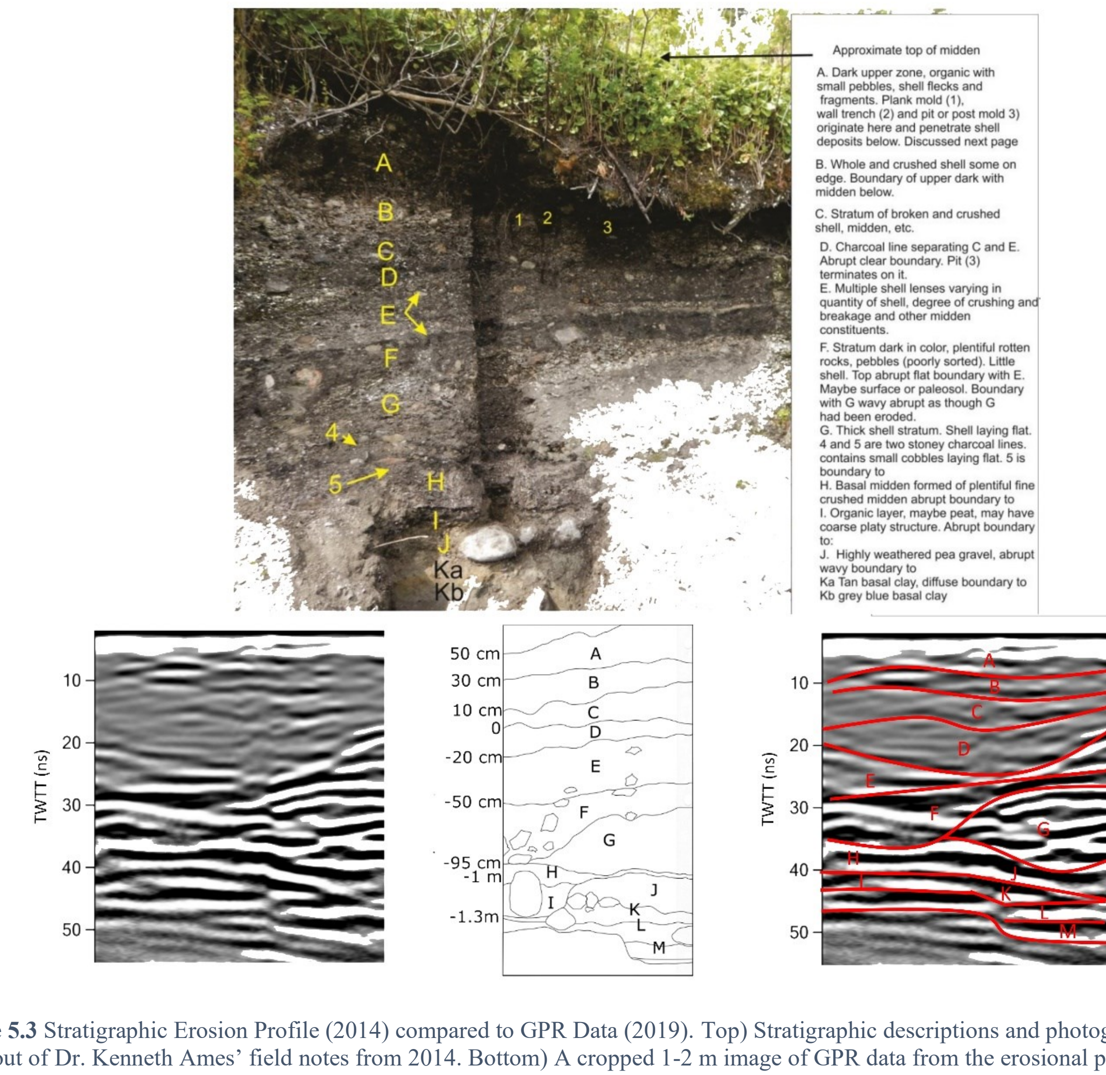


Figure 5.3 Stratigraphic Erosion Profile (2014) compared to GPR Data (2019). Top) Stratigraphic descriptions and photograph taken out of Dr. Kenneth Ames' field notes from 2014. Bottom) A cropped 1-2 m image of GPR data from the erosional profile (left). Using the real stratigraphic measurements mapped in 2014 (middle), I was able to interpret similar patterns in the GPR data from 2019 (right). The dielectric constant that was produced matched estimates from other sites, suggesting this method was viable as a future non-destructive test prior to GPR survey.

higher water content, slowing the radar waves' velocity which results in fewer (due to worse energy penetration/reflection) and laterally defined diffraction hyperbolae (Conyers 2016b). Second, the variation between different shell layers drastically changes the GPR signal. For example, Layer B, a stratum of whole and crushed shell, is more reflective than Layer C, which is represented by a shallow layer of broken and crushed shells bordering a midden. In the Gulf Islands, when the shells are more finely crushed, the radar reacts similar to its dry sand matrix (Colin Grier, personal communication). More reflective still is Layer G, a thick shell stratum with whole shells laying flat. These overlapping shells in Layer G produced a consistently strong reflective signature in the GPR data. By Layer K, the composition of the layer is primarily basal clays, which corresponds with increasing attenuation of the GPR signal with depth. While these results from GbTo-23 are still preliminary, it has helped to create a basic understanding of the expected return from GPR in Prince Rupert. Specifically, we should expect less typical diffraction hyperbolae from features and multiple overlapping (and admittedly confusing) shell layers with different levels of reflectance. In the following paragraphs, I apply this knowledge to the investigation of house depressions at GbTo-34 and GbTo-4.

5.4 Sensing Houses: GPR and Magnetic Gradiometry

At Kitandach, 25 cm transect spacing and unidirectional GPR profiles were chosen in order to capture the architecture of House 16. A grid of 10 x 14 m was laid over the house depression. At GbTo-4, a 50 cm transect spacing was chosen to compare the two different line spacings' ability to detect the subsurface features. A 15 x 19 m grid was laid over the largest house depression at the site. At both sites, the magnetic gradiometer's sensors were set to a height of 15 cm and 70 cm above the ground. Both GPR and magnetic gradiometry surveys were conducted in x and y directions over both grids to ensure replicability and the future potential of combining the datasets to produce finer results.

Given the substantial topographic variation of the house depressions (see Figure 4.15 for a previous discussion on antenna tilt), the ground-penetrating radar data had to be corrected for elevation (Goodman et al. 2006). Prior to analysis within GPRViewer (Conyers and Lucius 2016), I inputted total station and RTK measurements (taken in 2012, 2014 and 2019) into ArcGIS Pro and generated a surface using the kriging tool (Figure 5.4). I then created straight lines across the surface and sampled the values to create a table of XZ values. Lines were manually spaced over the areas with the largest changes. Using these tables, I created .xyz files for each GPR profile to be opened in GPRViewer and analyzed. Similarly, magnetometry data can be influenced by topographic variation as the distance of the sensors to the ground changes (Cross 1996). While I recognize this to be an issue, I was unable to correct for this beyond high density sampling and a consistent pacing.

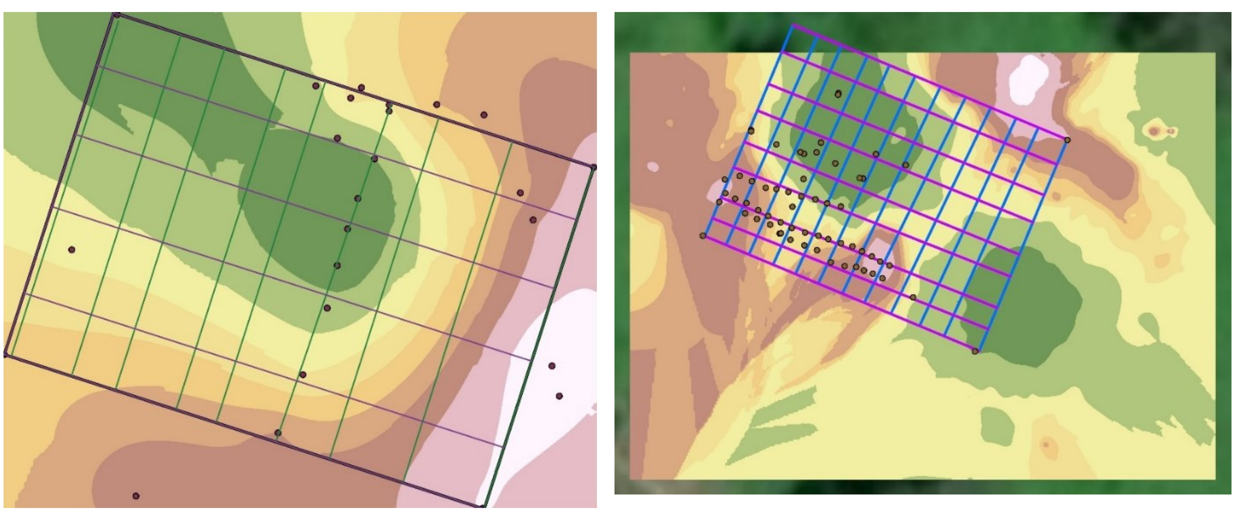


Figure 5.4 Sampling elevation profiles on surface elevation maps (ArcGIS Pro). Surface elevation maps of GbTo-34 House 16 (Left) and GbTo-4 Ligeex's House (right) created in ArcGIS Pro. These surfaces were constructed using topographic points taken by Kisha Supernant in 2012,2014 and 2019. I then used ArcGIS Pro to sample elevation profiles in both directions (shown as coloured lines), which were converted in excel to .xyz files to be read in GPRviewer. Every GPR transect that was conducted also has an accompanying elevation correction file and could be more accurately interpreted.

Interpretations of house features were initially formed by examining the GPR radargrams in GPRViewer (Conyers and Lucius 2016). These were then compared to the magnetic profiles sampled in SIGKIT (Kruse et al. 2017). This mode of comparative profile analysis has been shown to increase the interpretative potential of geophysical surveys (Conyers 2018). Features identified in either the radar or magnetic data were recorded as XYZ data, and plotted on amplitude/plan view maps in Surfer 15 (Golden Software LLC 2018). These maps were then used to interpret house architectural features, size, and orientation. These interpretations were 'tested' with a developing percussion core research strategy. Cores crosscut the house depressions and were conducted every 1-2 m. The data from these cores are currently being analyzed at UBC by Dr. Andrew Martindale and Evangeline M.H. Bell. While the definition of an 'occupation layer' in a percussion core is still developing, the main indicator so far has been signs of hearths (i.e., dark sand/soil layers above or interspersed between layers of highly fragmented and compressed shell) (Evangeline Bell, personal communication). These layers also contain charcoal and sometimes plant materials. Bell then constructed the core cross sections that appear in Appendix C using Strater 15 (Golden Software LLC 2019).

GbTo-34 (Kitandach): House 16

The ground-penetrating radar and magnetic gradiometry survey of House 16 was able to locate aspects of Middle Period Tsimshian architecture. Of most importance to the Prince Rupert Harbour archaeology project was the identification of hearths so that houses could be percussion core tested and radiocarbon dated to establish occupational chronologies. A central hearth was described by Martindale (1999) as a large basin-shaped depression that had three concentric layers of undisturbed fire-reddened soil, overlain by an ash/charcoal/sandy matrix, which was covered by a layer of sand with lesser amounts of charcoal. These features, being ceremonial and in the center of houses, were often cleaned and their form maintained. A GPR simulation was run in SIGKIT (Kruse et al. 2017) to determine what a central hearth feature may appear as in a radargram (Figure 5.5). The simulated model is consistent with published literature on hearth feature reflections (Conyers 2012), and a similar reflection pattern was found near the centre-back of House 16 and spanned over 1-1.5 m in both X and Y profiles (Figures 5.6 and 5.7). These reflections are particularly interesting when compared to the magnetic profiles as they correspond with low negative signatures (-20 to -30 nT/m). While much research has found hearths to be associated with positive signatures (Conyers 2018; Dolan et al. 2017), magnetic signatures are dependant on how hearths are constructed. Knowing that a central hearth would likely be comprised of various burnt soils and sands (Martindale 1999), and not positively magnetic rocks, it seems reasonable that the hearths' magnetic signature is strongly negative. Furthermore, there is geophysical evidence from the interior of British Columbia that found the lowest negative values within pithouses were strongly associated with hearths and archaeological

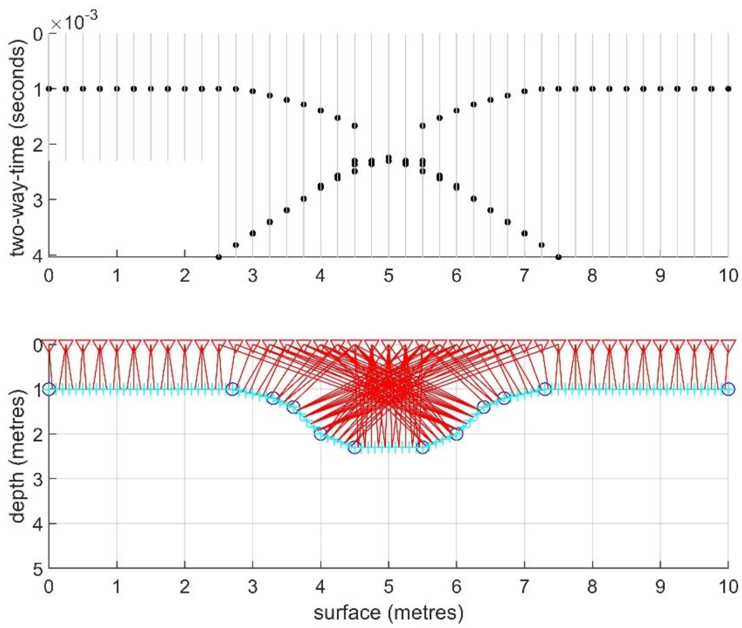


Figure 5.5 Hypothetical GPR model of a hearth shaped feature. Top) The predicted reflection in a GPR profile. Bottom) The blue line is the hypothesized shape, and the red are the simulated radar waves. Created in SIGKIT.

deposits of charcoal, fire-cracked rock and burnt bone (Prentiss et al. 2008). The negative values from House 16 were tested with a percussion core during the 2019 field season and preliminary analysis has showed promise in their identification. One core from House 16 near the identified geophysical hearth contained layers of burned sand and pieces of charcoal at a comparable depth and was interpreted as broadly corroborating the presence of a hearth (Appendix C).

Two potential features were also identified in House 16's GPR profile data. While looking for hearth features, I found vertical, rectilinear reflective areas that spanned multiple profiles (Figure 5.7). These anomalous features had similar shapes, reflective characteristics, and appeared near the center of the house. There are few possible interpretations for these features. Most likely are that these features represent posts or post molds as they correspond with a positive anomaly amid the negative values from the house. This feature might not necessarily

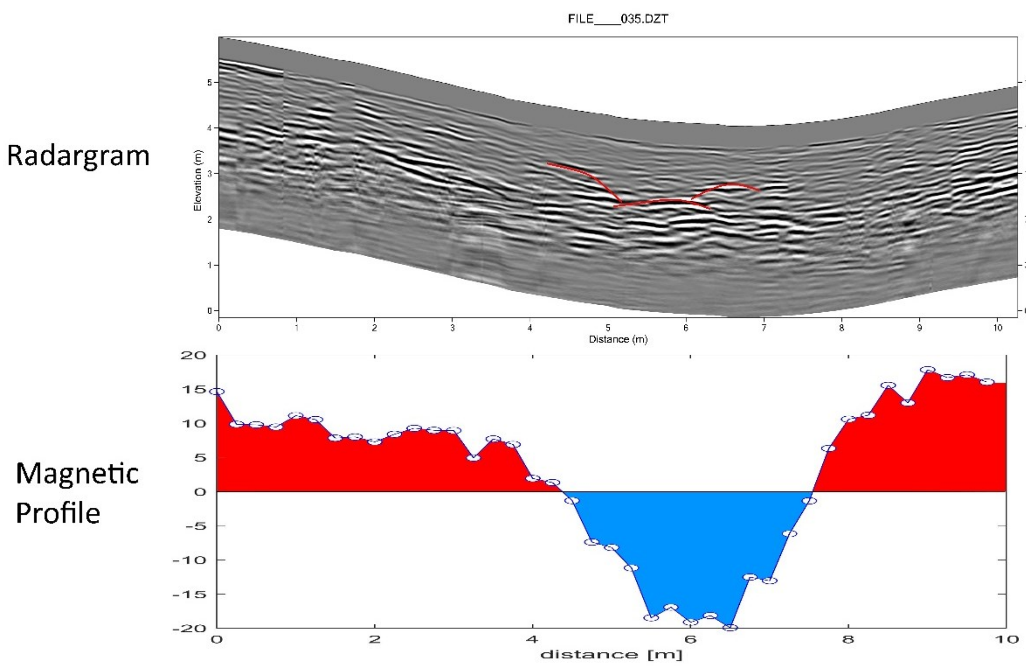


Figure 5.6 X-direction profile analysis of House 16. Elevation corrected GPR radargram with interpreted hearth and magnetic profile (nT/m). The interpreted hearth shape found in the radargram corresponded with magnetically negative values (-15 to -20 nT/m), while the shell middens outside the confines of the house corresponded with positive magnetic values (+10 to +20 nT/m).

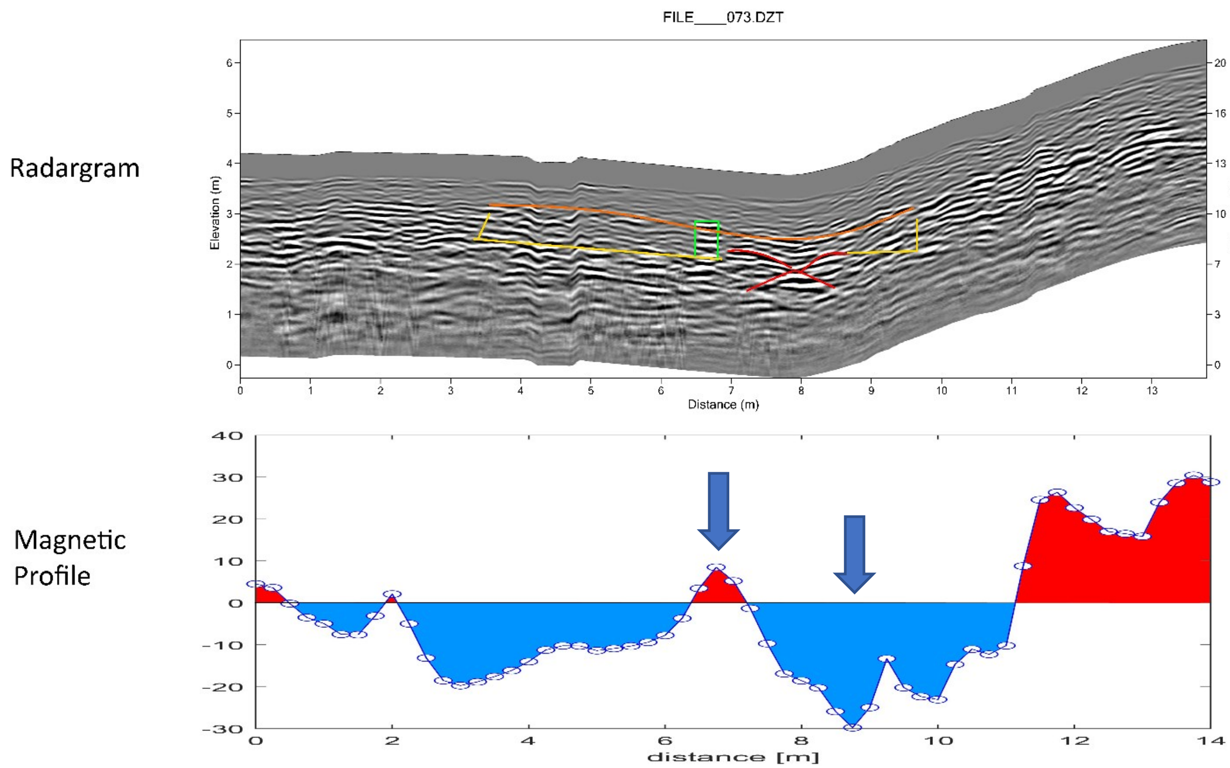


Figure 5.7 Y-direction profile analysis of House 16. Elevation corrected radargram and magnetic profile (nT/m). The green lines represent the central post reflection, the red lines are the hearth and the yellow lines denote the possible house floor and possible front back boundaries of the house. Orange line denotes a possible occupation surface below infilled sediments (also suggested in coring results/ Appendix C). Two arrows in the magnetic profile represent the suspected central post of the house (positive anomaly) near the magnetic low/ hearth anomaly. Some of the more exaggerated/variable spikes in the magnetic data may be the result of my zero mean traversing script not removing all the trending effects (see also for Figure 5.9). The points along the magnetic profile do not represent real measurements but equally spaced interpolation.

represent an intact post, but perhaps represents the ephemeral remains/different matrix (Martindale 1999) produced from one of the largest posts in the house. It is also strange how these 'posts' begin higher in the stratigraphic sequence and may relate to a later occupation and perhaps a different building. If these were posts, there should also be additional 'posts' along the house walls. These were not found; however, it was hard to distinguish between wall features and shell matrix. Alternatively, these vertical reflections might represent clay-lined pits, typically used for tanning hides. Again, this would be unlikely as this feature would normally have been outside the house or duplicated in other areas (Martindale 1999). Another option for these features may be small cooking hearths. Differing from the large ceremonial/central hearths, these small family cooking hearths were narrow pits built to have increased oxidation (Martindale

1999). While this would not explain the high positive magnetic values, the potential for small cooking hearths from a higher occupation layer cannot be ruled out prior to further investigation. At present, given these cases, it is probable that these interior features are posts or post molds. One core near this anomaly has been tested and revealed large amounts of gravel. This may have been a part of the post mold and used for drainage. Alternatively, Martindale (1999:233) found gravel lenses inside central hearths, and this core may reflect this. The coring analysis is too preliminary and the strategy too coarse at the present to suggest a potential interpretation, beyond it being broadly corroborative.

Like Garden Island, shell midden layers appeared as overlapping reflectors outside the house depression. Where the reflective shell layers met with the infilled sediments from the house in profile, it often created a clear separation. These features were interpreted as 'house wall zones' and their positions were recorded. The orientation and general size of House 16 were hypothesized from the house wall zones (Figure 5.8). Interestingly, these features were more easily identified away from the water. It is suspected that the areas towards the water had been subject to more erosion and terrain slumping which obscured identification. Outside the 'walls' of the house, shell middens were expected to be found. GPR and magnetic gradiometry data showed this was indeed the case with overlapping reflector layers in the GPR profile and a high positive magnetic signature terminating just before the interpreted house. A magnetic profile was sampled from one of the middens (Figure 5.9). The feature showed positive negative values as high as 15-20 nT/m. These high values make sense because matrices with high organic material are known to produce strong positive signals (Oswin 2009). I am hopeful that in future iterations of this project these shell middens may be quickly mapped using magnetic gradiometry so that their size and depth can be modelled. Finally, the shell midden was very present in the coring results (Appendix C), and the cores from inside versus outside the house look starkly different with respect to shell content.

The last objective was to locate the house floor of House 16. There was a clear difference between the infilled sediments that overlay reflective features inside the house and the shell-matrix outside the house. Few hyperbolic reflections were found within the infilled sediments. I found it difficult to identify a specific layer as the house floor, therefore overlapping reflective layers were determined to be house floor zones. In House 16, two potential floor zones were identified. The first ‘occupation layer’ was around 50 cm, potentially associated with the post mold feature, and is represented by a broken reflective layer. A clear occupation layer is found beneath this around 1-1.2 m deep and is associated with the hearth feature. Both of these layers are seen around the same depths in Core 28, and to a lesser extent the other two cores (Appendix C). The identification of occupation layers and ‘house floors’, however, is further complicated by the variance found at different sites across PRH (Coupland et al. 2009). Despite this limitation, there are clear areas in the House 16 data that I would identify with occupations.

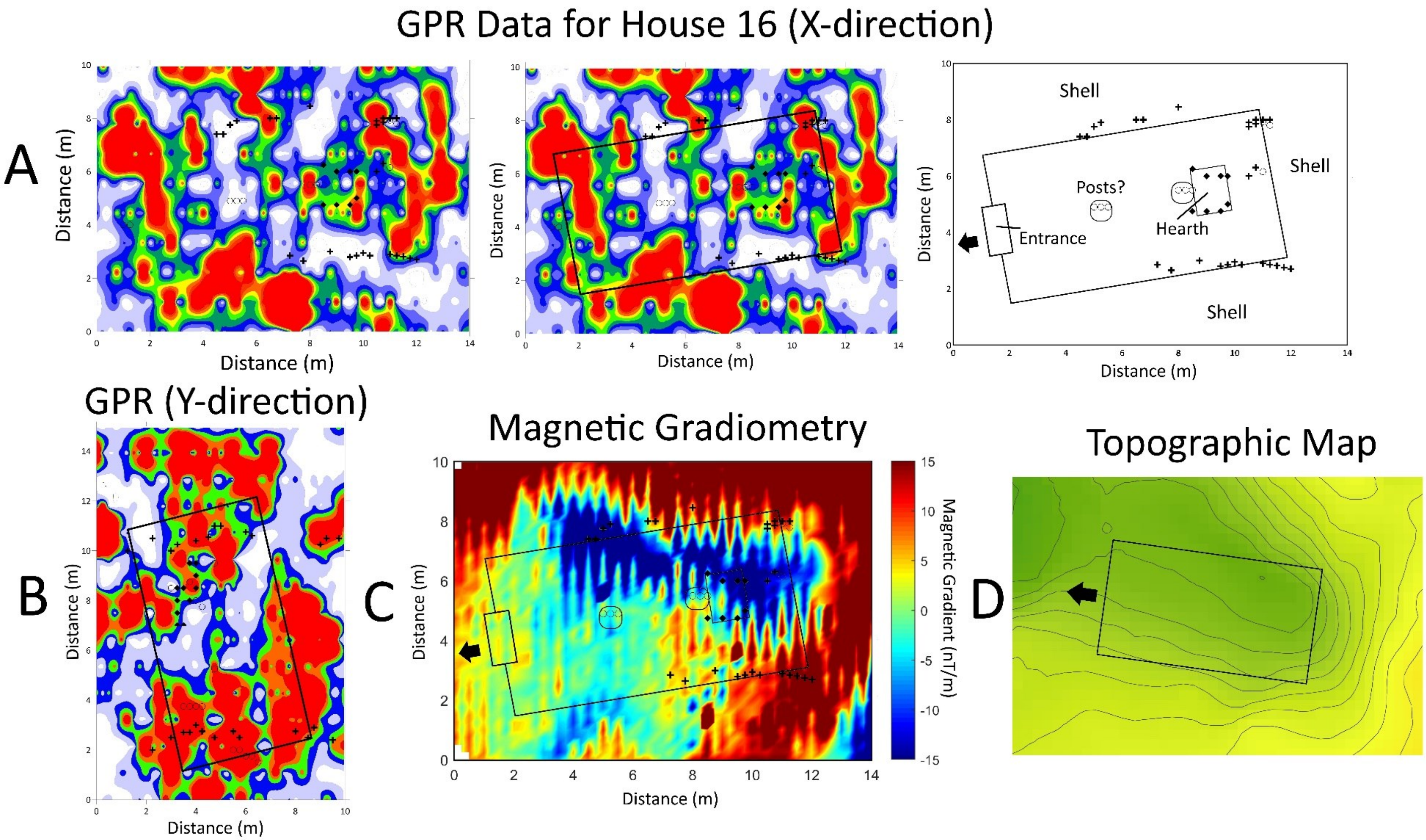


Figure 5.8 Overall interpretation of (the deeper) House 16 from GPR and magnetic gradiometry. A) GPR results from House 16, including a 5ns thick amplitude map from 25-30ns TWTT overlaid with post map of possible feature reflections of shell midden edges /wall areas (✚), post/post molds (O), and hearth boundaries (♦), the interpreted house boundaries on the amplitude map, and a schematic interpretation of House 16 from the data. Amplitudes are displayed on a range spanning low (white/ light blue) to high (red). B) GPR data was also collected in the Y-direction helping to prove the reliability of Interpretation A. C) House interpretation overlaid on the magnetic gradiometry m ap. The magnetically positive ring around the house is the shell midden, and negative values within the house roughly correlated with the interpreted hearth feature. D) The House 16 interpreted boundaries overlaid on the 2012 total station topographic map (contour intervals: 25cm).

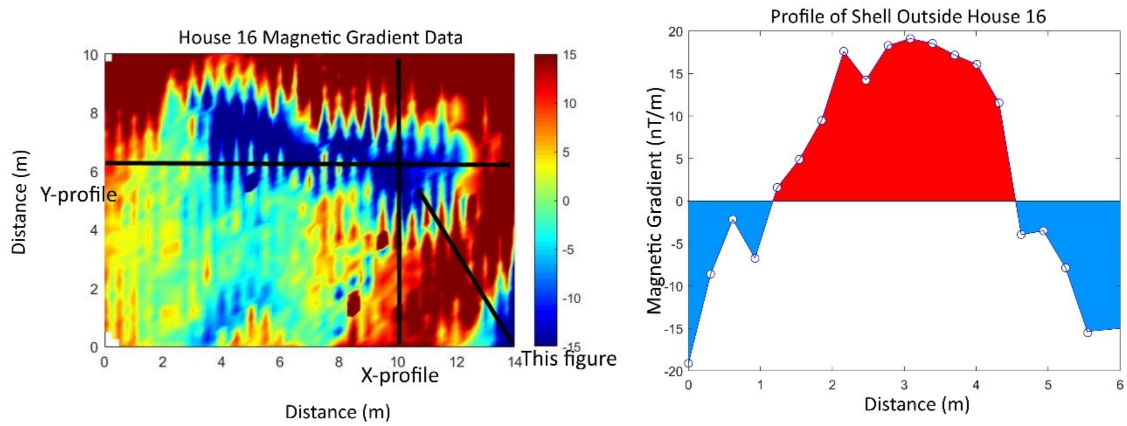


Figure 5.9 Magnetic gradient profile analysis from House 16 (scale in nT/m). Left) The overall magnetic gradiometry map from House 16 showing locations of sampled profiles (Figures 5.6, 5.7 and this figure). Right) The magnetic profile of a shell berm/midden. Note, not all trending effects were able to be removed.

GbTo-4: Chief Ligeex's House

The survey at GbTo-4 proved to have more interpretative challenges than GbTo-34's House 16. This was primarily due to its experimental nature and coarser survey methods. While both X and Y directions were surveyed using magnetic gradiometry, the Y-direction was captured using GPS mode. The number of trees prevented accurate GPS location and thus the data was removed from the case study. The X-direction magnetic gradiometer was conducted in a local grid format and provided useful magnetic results for interpretation. Similarly, GPR captured in the Y-direction provided fewer representative profiles than the X-direction. I still do not understand why the Y-direction provided less useful results, but perhaps it had to do with the data being collected on a different day and how the radar reflected off the subsurface objects. Furthermore, due to the 50 cm spacing, if a reflection was seen in either the X or Y directional profiles it was hard to identify it in other profiles. Therefore, smaller features identified at House 16 were not found as easily at GbTo-4, such as posts/ post molds.

Between the magnetic gradiometry and the GPR, a hearth was located at the GbTo-4 house (Figure 5.10). This hearth had the same characteristic GPR reflection pattern that was found at House 16 and in the simplified model. It corresponded with a negative value of -20 to -25 nT/m in the magnetic profile from the same location as the radargram. The hearth was found approximately in the center of the house depression and may represent a large central hearth (~2 x 2 m). Next to this hearth feature, GPR reflections possibly representing a post/post mold feature were found. Like at GbTo-34, this feature corresponded with a positive spike in the magnetic signature. This was the only interior feature, besides the hearth, identified within the interpreted house boundaries. Two percussion cores were analyzed as preliminary results from

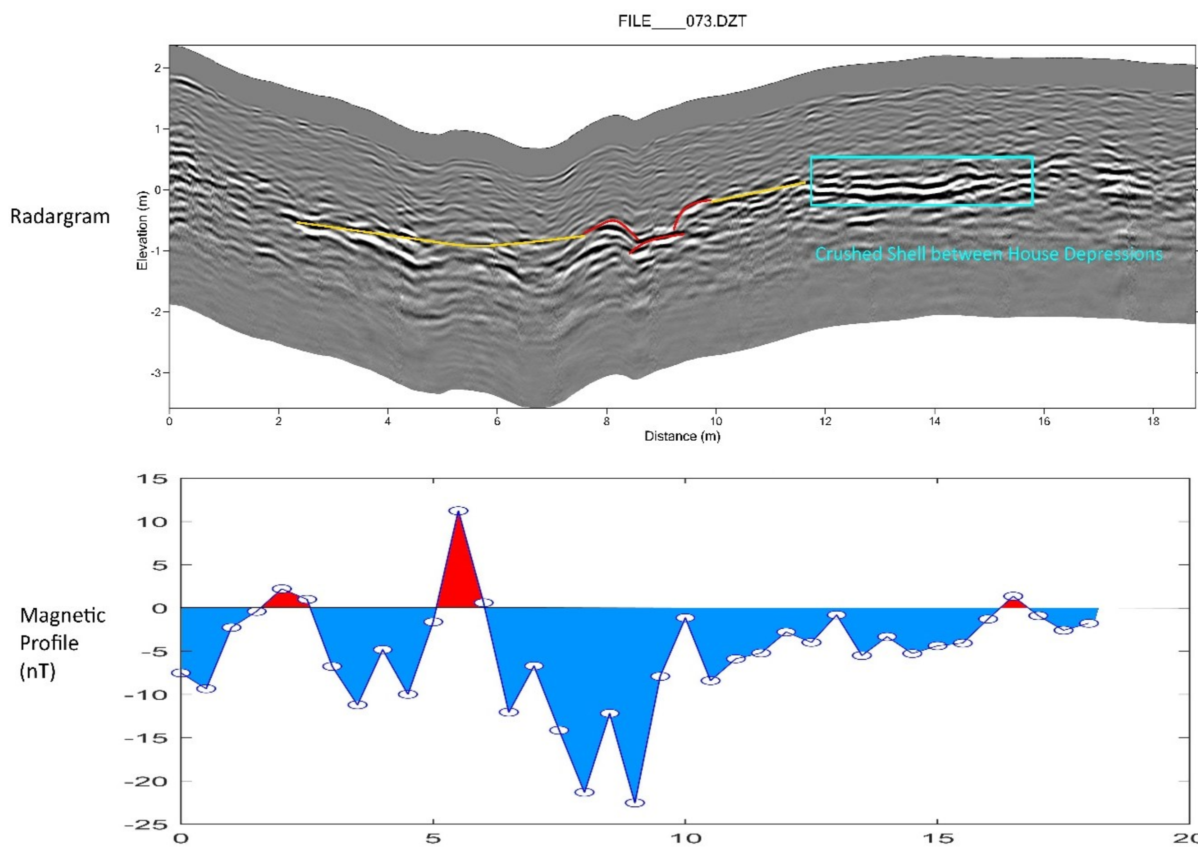


Figure 5.10 GPR and MAG profiles of the GbTo-4 interpreted Hearth anomaly. The hearth feature corresponds with low negative values, and the positive anomaly corresponds with possibly a central post seen in other radargrams. A possible house floor was also identified. Between the two surficial house depressions, an area expected to be shell midden was found to be compressed. It is expected that these shells were crushed and compressed as individuals walked between the houses. Locations of these profiles displayed as a red line on the topographic map of Figure 5.11.

GbTo-4, one testing the hearth anomaly and the other near the center of the house. The hearth core ‘rocked out’ and was unable to penetrate to its full depth, and subsequently had to be cored again (the results from which are still being analyzed) (Appendix C). The core near the center of the house located a ‘hearth’ or occupation surface at the same depth as the geophysical hearth further toward the center of the house. Perhaps, the central hearth was larger than what was found in the geophysical results, however, the results from the percussion cores are still nascent.

Similar to House 16, house wall zones were identified in an attempt to differentiate the house from the surrounding shell deposits. It was clear that at GbTo-4 the shell deposits were larger and more prominent in the data than at House 16, making it more difficult to identify wall remains. These deep shell deposits were also seen in a percussion core outside the interpreted house (Appendix C). The shell deposits surrounded the house in a U-shape, suggesting the entrance to the house faced toward the ocean (Figure 5.11). The east shell berm appeared as a flattened highly reflective layer in the GPR profiles. As this area was between two house depressions, it was interpreted that the shell berm had been compacted as people walked between the houses. Interestingly, these shell berms’ magnetic signature was weakly positive, with the corners and back of the house showing higher values. When compared to the whole grid it is clear that the magnetic data for the area in general was more negative than House 16. This may have to with the relative closeness of the bedrock basement at this particular site (Clague 1983). Prince Rupert sits on a Mesozoic formation of metamorphic schists and shales, which have been known to be magnetically susceptible (Dunlop and Özdemir 1997), and their nearness at the GbTo-4 site might be influencing the magnetic data.

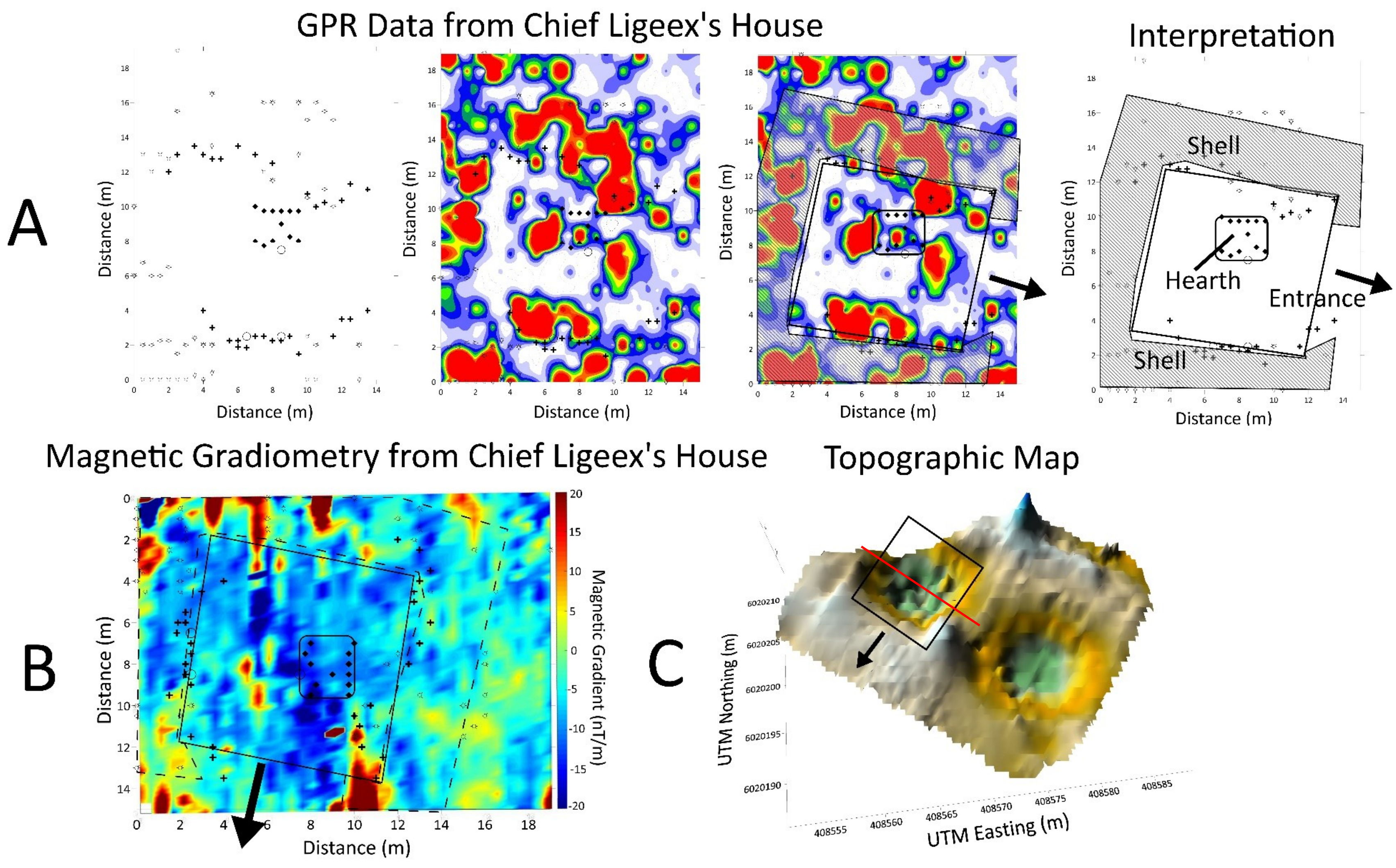


Figure 5.11 GbTo-4 results from Chief Ligeex's House. A) GPR data from Chief-Ligeex's House, including a post map with identified features, timeslice data (30-35ns TWTT), overlaid interpretation and amplitude map, and interpretation map. B) GPR Interpretation map overlaid on magnetic gradient map. Some features are well correlated, such as negative values near the hearth. The whole area appears weakly negative likely due to the geology. Not all trending effects were able to be removed. C) Elevation map of the area of interest at GbTo-4. Black box indicates the house depression for Chief Ligeex's house with another house depression lying adjacent. The red line indicates where the profiles were sample for Figure 5.10. Map created from 2012 total station data (UTM Zone 9).

Finally, occupational surfaces were also found. While less successful at locating a specific house floor, the GPR proved useful in identifying the house floor 'area' around 1-1.2 m deep where the reflection pattern changed, and hearth features were found. This same pattern was also found in a core and can be understood as broadly corroborative. While still only moderately successful, I hope to better interpret this data once more of the percussion core samples have been analyzed.

5.5 Future Potential of ARS research in Prince Rupert Harbour

Theoretically speaking, most Northwest Coast sites, being heavily vegetated, highly saturated, topographically variable, and overlaying shallow glacial soils typically do not provide a favourable environment for remote sensing techniques (McLay et al. 2009). Specifically, GPR's application in high moisture environments, some similar to the temperate rainforest around Prince Rupert, has produced variable results in the past (Conyers 2013). Furthermore, Northwest Coast cultures' predominant use of woods and organic materials as part of architecture has also led to some question over GPR's utility in locating these remains (McLay et al. 2009). Although these are merely considerations, and no researcher would deny remote sensing's utility prior to surveying the area under question, this 2019 preliminary study sings a more optimistic tune.

Our results have concluded that Prince Rupert Harbour does not preclude geophysical study. GPR and magnetic gradiometry surveys have proved effective, when applied in high resolution survey strategies, at sensing Tsimshian architectural features from a variety of temporal periods. Using an erosional profile at GbTo-23, I was able to understand how radargrams correlate to exposed shell-matrix and establish an approximate dielectric constant range for use at PRH sites. Furthermore, I was able to determine that the radar interacted with the different shell matrices in different ways, which influenced the interpretations of the houses. Better depth control from GbTo-34 and GbTo-4 will become available as the percussion cores continue to be analyzed ahead of the next field season.

At GbTo-34 and GbTo-4, a geophysical template for a Tsimshian house was developed. Hearth shaped depressions were found in the GPR profiles which correlated with low negative values in the magnetic gradient data. Likely post or post mold features were identified at GbTo-34 and were represented by highly reflective vertical shapes in the radargram. These corresponded with positive anomalies in the magnetic data, possibly due to their organic composition. House walls were more difficult to detect in the geophysical data. At GbTo-34, house wall zones were identified as the separation between the outside shell layers and inside infilled sediments apparent in most GPR profiles. In the magnetic data, shell middens found outside the house were determined to be strong positive magnetic anomalies, however, I was unable to make as clear of a distinction between inside/outside the house with the technique. Combining both sets of data, boundaries of the house were interpreted and described as house wall zones. Similarly, house floors were more difficult to identify in the GPR profiles, yet occupation zones were identified from overlapping reflective layers. These areas also roughly correlated with negative magnetic values. Interestingly, this geophysical template is not dissimilar to Cross' (1996) initial findings from McNichol Creek (GcTo-6) in PRH which also identified hearths as being magnetically negative lows in the center of largely negative (but this depended on size and construction) house floors. Additionally, he also found the middens to be made of complex near surface stratigraphy and largely positive. While his GPR results were nascent, as this was prior to the 'digital revolution', his magnetic results were corroborated with conductivity methods that showed similar patterns.

These geophysical results are corroborated by the results of household archaeology conducted in and around PRH (Coupland et al. 2009; Coupland 2006; Martindale 2006b). Coupland and colleagues (2009) described north coast architecture as being consistently focused around a central hearth (Figure 5.12). At the McNichol Creek site, the large negative magnetic anomaly at House O (Cross 1996) was later excavated and found to be a large 2 x 2.5 m central hearth (Coupland et al. 2009). House O also had a partial clay floor which was interpreted as high-status (Coupland et al. 2009), which appeared as variable magnetic signature (Cross 1996). This archaeological information supports the geophysical interpretation of large central hearths at House 16 and the GbTo-4. Similarly, Martindale (2006b) found the presence of central posts and post molds in contact-era Tsimshian houses. As such, the potential post features at GbTo-34 may represent a later occupation on top of the Middle-period house, however, this will become

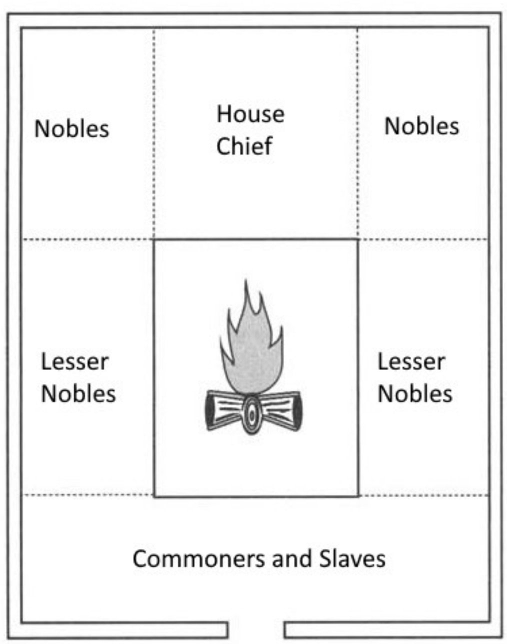


Figure 5.12 A schematic diagram of a North Coast house (taken from Coupland et al. 2009). Ranked sleeping areas are oriented around a central hearth.

clear through more archaeological investigation Finally, it has been well documented that shell berms/middens typically surround houses, excluding the entrance way (Martindale 2006b). While the geophysical data may contain additional evidence of artifacts, the presence of sleeping benches and specific distributions of artifacts within the house (characteristics that have been investigated archaeologically) were not interpreted in the data due to limited archaeological information. Regardless, comparing the archaeological evidence previously obtained from PRH sites has demonstrated the reliability of the techniques as a tool for future projects.

As the 2019 Prince Rupert field season was primarily focused around developing methods to locate architectural features using remote sensing techniques, I have a number of recommendations for future projects following our results. First, GPR proved to be effective at identifying different features in Tsimshian houses. The 400 MHz antenna also proved to be a great compromise between sensitivity, in order to sense possible post mold features, and depth. This was obtained from finely spaced transects (25 cm) collected in both X and Y directions and a higher sampling (1024 samples per scan). It is recommended that features be identified first in elevation-corrected profiles rather than relying on timeslice/amplitude maps, as these proved less informative for forming initial interpretations. Second, magnetic gradiometry was able to identify hearths and rough house dimensions. Datasets were effectively duplicated with X and Y directions; thus, it is recommended future iterations of this project only survey the house depressions in one direction. Again, a high-resolution survey strategy (every 25 cm) is recommended for the houses. Future research should continue to experiment with different magnetic gradiometry strategies in PRH, as few dipole anomalies were produced leaving me unable to estimate depth from the magnetic data. The percussion cores also provided an interesting dataset that broadly corroborated the geophysical results. In the future it is recommended that more effort is used to refine this strategy in order to capture the most information from the house features.

There were also significant limitations for ARS research in Prince Rupert Harbour that should be considered when planning future projects. First, many (if not all) of the sites in the harbour are primarily accessible by boat. Large waterproof containers were used to haul the equipment in and out of boats each day, limiting data collection. Furthermore, although utmost care was taken, some of the cables were showing signs of corrosion from the saltwater. Second, significant clearing was required to survey each house depression, further slowing progress. While the magnetic gradiometer was fine, the GPR struggled at times in the high biomass and variable topography environment. To maintain ground coupling, especially over the slopes of the house depressions, a team member would sometimes have to push down on the antenna to make sure it was not knocked by the stumps and cropped vegetation. Third, GPS features do not work in PRH given its heavy forest. Therefore, everything had to be conducted in local grids and then recorded with total station.

While archaeological research at Prince Rupert Harbour has extensively included Indigenous knowledge(i.e., Edinborough, Porčić, et al. 2017), this chapter has been light on its incorporation because it was primarily focused on the development of remote sensing strategies to survey cultural deposits. The ability to non-invasively and quickly locate the features of Tsimshian houses will allow for more focused archaeological investigation and the combination of multiple components in the future. Each house took about one day to survey, and an additional day to percussion core specific targets. While we await the full results of this sampling strategy, I am optimistic it can be applied to other sites in the harbour, drastically reducing the time it takes to obtain radiocarbon dates from specific houses. With more dates from specific houses and better spatial control through geophysical mapping, we can begin to reconstruct intra-site chronologies (as per Prentiss et al. 2008) and, subsequently, link Indigenous knowledge and the history of Tsimshian house groups to specific villages. In the future, I recommend we keep returning to the research strategies to modify them and update the interpretations with the inclusion of multi-evidence-based narratives, drawing from the archaeology and the rich Tsimshian oral history of the harbour. In doing so, and working with the Tsimshian communities, the PRH archaeology project can come closer to developing grander narratives of the harbour and its surrounding landscape.

While the PRH project is not community-driven, it is a collaborative research project, and explicitly incorporates the goals of the Coast Tsimshian communities of Lax Kw'alaams and Metlakatla. The results of the geophysical survey illustrate that it is possible to advance archaeological goals while furthering the current objectives of local communities, who desire non-invasive alternatives to traditional archaeological techniques. The success of the project on all fronts is attested by the communities requesting that the project continue, and their desire to use GPR to monitor the erosion of Garden Island and document the historic cemetery.

CHAPTER 6:

AS APPLIED TO ARCHAEOLOGICAL RESEARCH - THE CHIMNEY COULEE SITE (DjOe-6)

While the previous chapters have emphasized various degrees of community-driven and collaborative research projects, I present a very different community context and the most multi-component project in this final case study. This chapter explores the remote sensing results from the 2018-2019 Chimney Coulee project in southwestern Saskatchewan (Type A research permit no. 19-070). Chimney Coulee was a Métis overwintering village during the 1870s-1880s. Using multiple geophysical and remote sensing techniques, I attempted to locate different archaeological features than presented in the previous chapters. By combining remote sensing, archaeological, historical, and photographic evidence, I generated a new narrative that was the best example of an archaeological remote sensing framework (as outlined in Chapter 3) and refined the survey methods. Furthermore, beyond holding important archaeological discoveries in regard to the Métis past, the Chimney Coulee site serves as an example for how archaeological remote sensing projects could benefit the Métis Nation in present day political rights discussions. I will conclude this chapter with a brief discussion of the techniques' future potential in these contexts.

6.1 Current Context and the EMITA Project

In the 17th/18th centuries, the Métis emerged as an Indigenous people in Canada alongside the Canadian Fur Trade (Supernant 2018b). Originally, the sons and daughters of European men and Indigenous women, the Métis underwent an ethnogenesis and developed unique sociopolitical and subsistence structures that allowed them to thrive on the plains in the Western Canadian and American borderlands (Burley 1989; Devine 2012). After the merger between the Hudson's Bay (HBC) and North-West fur trading companies in 1821, the Métis, who had played a crucial role as traders and interpreters, were forced to redefine themselves (Burley et al. 1992; Payne 2004). They began to hunt bison in kin groups (Macdougall and St-Onge 2013) and adopted a highly mobile lifestyle where they would form temporary prairie villages to overwinter (often referred to as *hivernant* sites) (Burley 1989). During the 1870s and 1880s, the Métis fought for recognition and their leader, Louis Riel, was executed (Peterson 2012). Both events have become widely known in early Canadian history. However, the resistance and Riel's fame have overshadowed much of Métis history in the public conscious. Métis history is not tied within the confines of the Red River Settlement, but also plays a largely underrecognized role in the histories of Alberta and Saskatchewan (Supernant 2018). Beginning in the 1880s and ending very recently, the Métis have been swindled out of their land and title by various colonial initiatives, such as the Halfbreed Scrip (Daschuk 2013; Niemi-bohun 2009). Furthermore, many of the contemporary injustices inflicted upon the other Indigenous peoples of Canada (such as the Indian Residential Schools) also included (or were preluded by) the Métis (Carney 1995).

The residual impacts of this colonial history are still being felt by the Métis Nation as they struggle to regain their rights and recognition (i.e., *Daniels v. Canada* 2016) (Teillet 2019). A contemporary issue is that their traditional land base, historically shared with other Indigenous Nations, is already occupied by treaty lands established between the Canadian government and First Nations (Usher et al. 1992). Another issue is the challenging nature of establishing a legal permanency of Metis communities in different parts of the Northwest (Madden 2019). For example, the Métis history in north-central Alberta is a well-known and established fact, whereas, the Métis presence in Calgary and southern Alberta continues to be contested (see *R. v. Hirsekorn* (2011) decision).

These factors led Dr. Kisha Supernant to begin the Exploring Metis Identity through Archaeology (EMITA) project in 2012. The project seeks to use archaeological tools to explore where, when, and how the Métis Nation created cultural landscape across the Canadian Prairies and add to the growing body of work seeking to establish their presence. Since that time, her team has established relationships with provincial Métis bodies (e.g., Métis Nation of Alberta) and archaeologically investigated Métis wintering sites (Coons 2017; Supernant 2018b; Tebby In Prep).

6.2 Previous Archaeological Work and Site Background

Few studies have focused on the Métis archaeological footprint and ethnogenesis (Beaudoin et al. 2010; Burley and Horsfall 1989; Coons 2017; Kooyman 1981). A few hivernant sites in Alberta and Saskatchewan have previously been archaeologically investigated (e.g., Buffalo Lake, AB and Petite Ville, SK) (Burley, Horsfall, and Brandon 1988; Coons 2017; Doll et al. 1988; Weinbender 2003). These settlements were primarily comprised of seasonal cabins and contained a wide range of activities indicated by intermingled artifact patterns (Burley 1989). The artifacts found at these sites primarily represented HBC ceramics and metal artifacts, materials typical of historic sites of the era. In addition to these artifacts, Métis wintering sites have also been shown to have a larger number of large animal faunal remains (i.e., bison), clothing, firearms/ammunition, and beads (Supernant 2018b). Interestingly, a distinct lack of architectural materials (e.g., glass, nails) have been found, speaking to the temporary nature of the Métis cabins (Burley et al. 1992).

Straddling the Alberta-Saskatchewan border, the Cypress Hills represent an environmentally, historically, and spiritually significant region for Indigenous peoples in Canada, being the site of thousands of years of Indigenous history and the Cypress Hills massacre in 1873 (Hildebrandt and Hubner 1994). The Chimney Coulee site (DjOe-6) was one of the Métis overwintering villages in the Cypress Hills region (Figure 6.1). The site has an excellent viewshed, allowing individuals to see other Métis sites across the prairie (Tebby 2017), and it straddles the continental divide allowing water access to both Hudson's Bay (via Swift

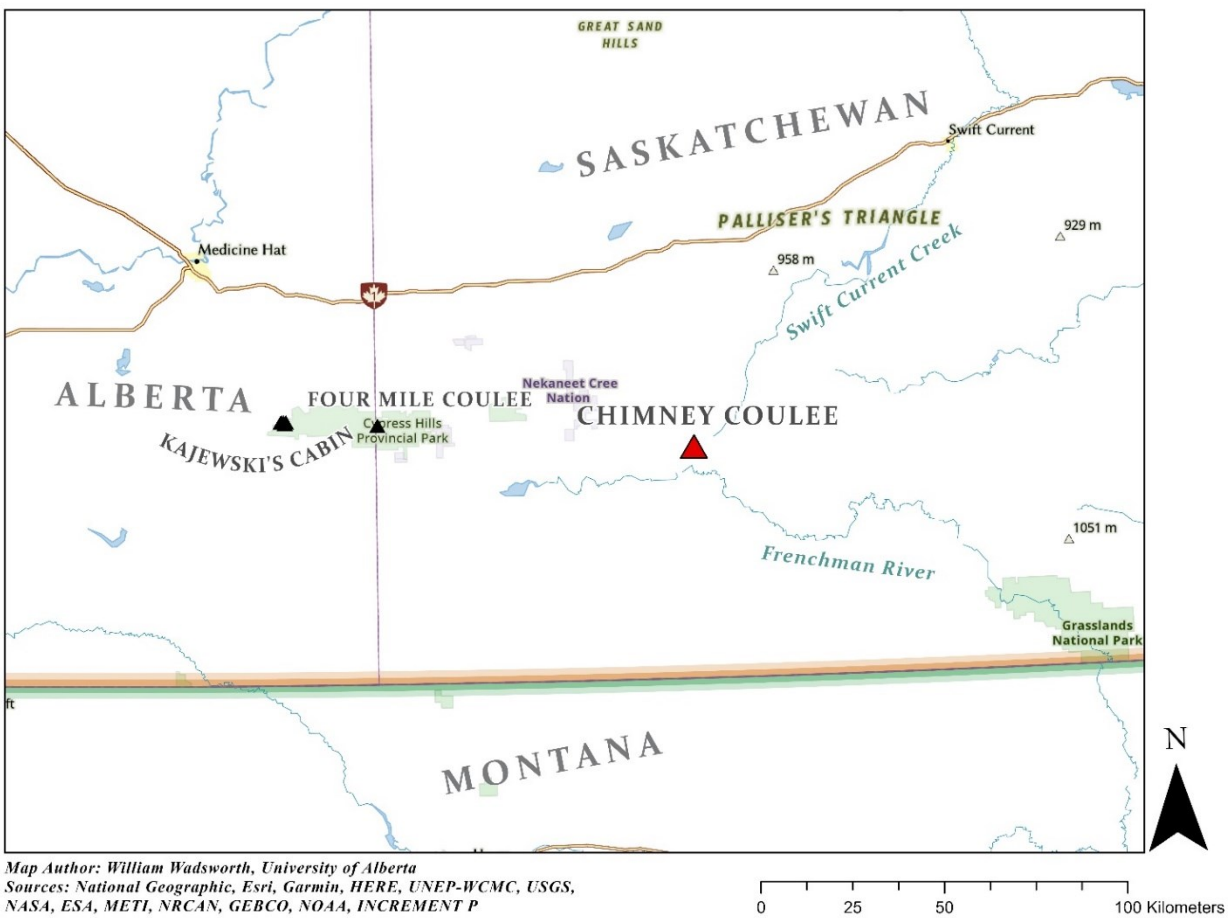


Figure 6.1 Map of Cypress Hills region of Canada, highlighting Métis wintering sites (black triangles). Chimney Coulee (near Eastend, Saskatchewan) (red triangle) is situated just north of the Montana border.

Current Creek) and the American South (via the Frenchman and Missouri Rivers) (Brandon 1995). A very small stream runs through the coulee giving life to the plethora of vegetation types at the site, including white spruce, goosefoot, hawthorn, wild strawberry, wild cherry, raspberry, knotweed, aspen, cottonwood, and poplar (Lyons 2019). As Burley and colleagues (1989) noted, the viewshed, access to the site, and collection of resources made Chimney Coulee an excellent place for a village.

While there are indications of a precontact occupation at Chimney Coulee (Brandon 1996), archaeology has focused on its historic occupations. In the 1870s, the site was occupied by the Métis, North-West Mounted Police, Hudson's Bay Company traders and American whisky/fur traders, and dissipated shortly after (Burley, Horsfall and Brandon 1992; Brandon 1995). By the 1860s, Métis hunters were regularly camping in the Cypress Hills searching for the quickly disappearing bison (Brandon 1996). In 1871-1872, Isaac Cowie, a fur trader from the Hudson's Bay Company, set up a post at Chimney Coulee and constructed a large three-room longhouse. According to Corky Jones (1953 cited in Burley, Horsfall and Brandon 1992: 70), sixty Métis families re-settled the area in the mid-1870s, and the population of the site would grow over a few years to approximately 400 people (Tebby In Prep). During this period at Chimney Coulee, the Métis constructed many cabins and a chapel (which Father Jules Decorby reportedly stayed at during the winter of 1876-1877) (Brandon 1996). It is unknown, however, the degree of permanence of this settlement. In 1877, the North-West Mounted Police constructed the "East End" post at Chimney Coulee (Brandon 1996), which was occupied seasonally, then permanently until June 1880 when it was closed; however, the NWMP continued to casually occupy the closed post during the 1880s (Tebby In Prep). By the 1890s, the remaining occupants of the Chimney Coulee site dissipated, and the buildings were salvaged.

John Brandon (1996) excavated a great deal of the site in the early to mid 1990s, as part of a public archaeology dig. He primarily focused on locating Isaac Cowie's longhouse and excavating the NWMP post. Much of the site, its material culture, and HBC/NWMP occupations are known to us from these extensive excavations (Brandon 1995, 1996, 2001). Prior to 2013, the Métis occupation at Chimney Coulee, beyond the survey in 1986 (Burley et al. 1992), had yet to be investigated in depth.

Once the bison population began to fail, the Métis were forced to redefine themselves (again) and began to occupy many diverse ecological niches and established farmsteads instead of hivernant villages. The cabins at Chimney Coulee were likely deconstructed and salvaged to build farmsteads or other structures, leaving little trace of their occupation (their chimneys were reportedly left to naturally erode, giving rise to the name Chimney Coulee). Although Métis families likely persisted in the area after the dissolution of the village, this history was largely overlooked until 1902, when the area began to be re-settled and would grow into the colonial town of Eastend (Tebby In Prep).

Since that time, the site has been disturbed. Being a local 'hangout' spot for decades, old beer bottles and modern trash can be found across the site. The main disturbance, however, is the local secondary road that was upgraded in the 1980s and destroyed 15% of the site (Burley, Horsfall, and Brandon 1992). In 2019, a site visit showed that the road was again expanding and disturbing the site. Today, Chimney Coulee is a designated Saskatchewan Historic site and, after years of post-depositional processes, disturbance, and neglect, there is no longer definitive surface evidence of the Métis occupation. This historical trajectory is not unique to the Chimney Coulee site and has led to the historical erasure of the Métis identity in some areas of the

Northwest. Today, the nearest Métis community to the Chimney Coulee site is 191 km away in Medicine Hat, Alberta.

The Chimney Coulee investigations by Supernant and her team occurred between 2013-2019. Originally, the goal of the project was to topographically map the archaeological site, locate the cabins using traditional archaeology/ shovel test methods, and excavate one of the promising cabins. One of the cabins was partially excavated by her graduate student, Eric Tebby, for his MA thesis in understanding Métis lifeways at the site (Tebby In Prep). When I joined the project in 2018, I experimented with GPR and magnetic gradiometry's potential in more quickly locating these ephemeral structures at the site. Upon the success of this experimental season, expanded remote sensing surveys were planned for 2019 that were framed around two goals; 1) expanding our multi-component surveys methods in hopes of making sense of different occupations' signatures, and 2) aiding the Métis' overarching political goals in the area by developing a methodology to quickly and accurately locate archaeological evidence of the Métis. Areas of the site were resurveyed, and magnetic susceptibility, conductivity, and UAV multi-spectral imaging were added to the suite of tools applied to the site. The following paragraphs describe the results of these investigations.

Although there was a degree of voluntary participation by the Métis community from Medicine Hat, given their distance to the investigations, the Chimney Coulee project could be best characterized as a 'participation' project (Colwell 2016). However, Colwell's (2016) collaborative continuum is likely not the best way to characterize the Chimney Coulee project. In fact, the idea of working with local Indigenous communities largely stems from NAGPRA and other western legislation that do not capture the Métis Nation's (and other Indigenous groups') different governance structures which were partly founded on freedom and mobility across the

American/Canadian prairie borderland (Macdougall and St-Onge 2013; Supernant 2017). In the case of Chimney Coulee, working with the nearest community would be more representative of settler-colonial impacts rather than association with the archaeological site. While the goals of the Chimney Coulee project were developed independent of a local Indigenous community, a number of archaeologists that worked at the site self-identified as Métis, including the project lead. These archaeologists shared a perspective that their research interests in Chimney Coulee had benefits for their community. In a way, the project was not driven by a local community but by specific community members who brought the results back to the Métis Nation, whose goals were incorporated into this project's research design.

6.3 Archaeological and Geophysical Results

Cabin A

In 2017, Tebby's excavation of three 1 x 1 m units uncovered archaeological evidence to suggest the presence of a Métis hivernant cabin (Tebby In Prep). He found many historic artifacts including historic drawn glass seed beads. The spatial distribution of artifacts differed on either side of a 'wood trench' identified in 2013 and confirmed in 2017. He suspected that this wood trench was the remains of a cabin wall. In 2018, a GPR survey was conducted on the site in an attempt to follow the trench, determine its orientation, and map the cabin (Figure 6.2). A 900 MHz antenna was selected to obtain the highest resolution data, since the wood trench was deemed too shallow (15-25 cm) and ephemeral for the 400 MHz antenna. A 10 x 5 m grid was surveyed prior to the excavation of four 1 x 1 m units. Due to the fact this was the first time we were using the new 900 MHz antenna, we discovered that the distance-measuring survey wheel had to be altered to fit the smaller antenna. As such, the 2018 data was collected in time mode,

Figure 6.2 Cabin A location prior to geophysical survey and excavation. Pictured Eric Tebby (left) and William Wadsworth (right). 2018.

and GPR transects were spaced every 25 cm and conducted in alternating directions. Despite the survey being conducted with less than ideal settings, it provided the researchers with enough preliminary data to warrant another more comprehensive survey of the cabin, and extending the techniques to the rest of the site (Wadsworth and Supernant 2019).

In 2019, the archaeological team returned to the site prepared to complete a more refined survey prior to the focused excavation of specific targets. A new GPR and magnetic gradiometry survey was conducted over a 10 x 10 m grid over Cabin A (Figure 6.3). The GPR was collected in 25 cm unidirectional transects with a 900 MHz antenna with a survey wheel. The magnetic gradiometer was conducted on the same transects, with sensors set to a height of 15 cm and 70 cm above the ground. The wood trench was relocated in the GPR as small hyperbolic reflections, occurring at 15-25 cm, within the GPR profiles and plotted in Surfer on top of a corresponding 3 ns thick amplitude map (Figure 6.3 and 6.4). Interestingly, on first glace the amplitude data did not corroborate our wall interpretation. When the profiles were re-examined, we found that these areas of higher amplitudes matched areas of strong non-hyperbolic reflections found 'outside' the wall reflections (Figure 6.4). This was interpreted to be the clay or mud used in Metis cabin wall construction (Carpenter 1977). When these overwintering cabins were left during the summer, it is suspected that the heating and cooling caused the mud and clay to melt off the wall on to the ground. In the magnetic data, a high positive signal towards the tree edge was suspected to be the chimney of the cabin. There was also a slightly more negative area towards the inside of the cabin and the presence of dipole anomalies, possibly associated with artifacts besides the fireplace. Hearths have been located on the plains before, and these are often associated with both positive and negative signatures (Jones and Munson 2005). Jones and Munson (2005) found that the positive anomalies found in campsite hearths related to the remnant magnetic rocks and associated materials, while the weaker negative signals related to the associated soils that are more affected by time and bioturbation. I reasoned that this description of a hearth is what we were seeing in the Cabin A data, as the presence of root disturbance might weaken the negatively magnetic soils while the positively magnetic chimney stones would have an unaffected strong signature. Higher amplitudes and point reflections were also found around the chimney area in the GPR data, supporting this interpretation.

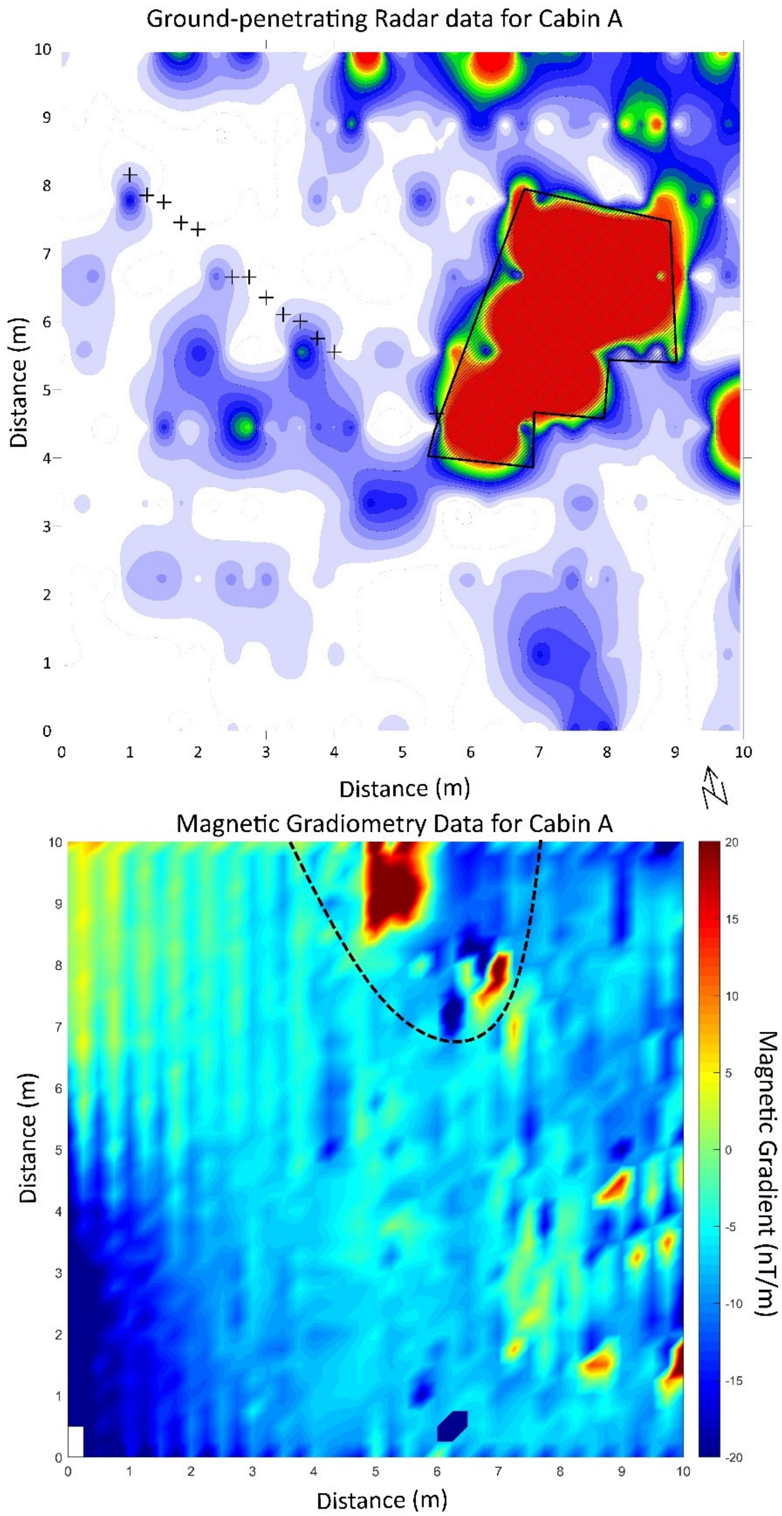


Figure 6.3 Ground-penetrating radar and magnetic gradiometer results from Cabin A. GPR) Black crosses denote interpreted cabin wall from reflections in the GPR profiles, and areas of high amplitude (indicated by black hatched box is the excavation units). Mag) +/- 20 nT/m data from Cabin A. Strong positive/negative anomaly and nearby small magnetic dipoles were thought to be associated with the chimney (outlined with black dashes). Some trending effects still visible across the grid. Noise in the SW corner of the grid is related to a metal surveying pin.

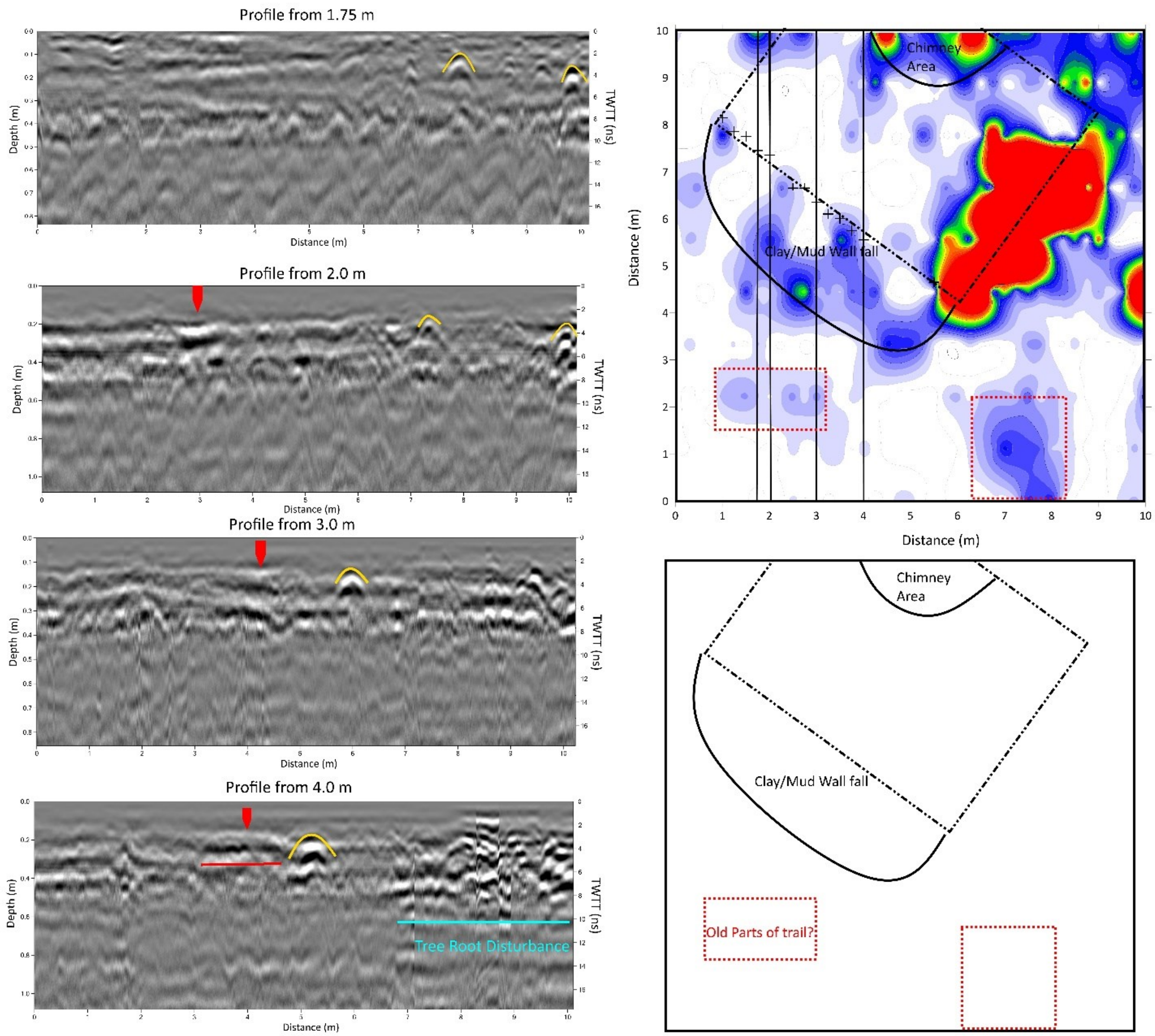


Figure 6.4 GPR interpretation of Cabin A. Left) Profile analysis from the 900 MHz GPR data. Faint hyperbolic reflections were identified as continuation of the cabin walls (yellow) and areas of higher reflectance (red) were determined to be higher clay content. These were interpreted as the mud/clay wall fall off of the cabin walls creating the areas of higher reflectance outside the walls. Profiles 1.75 and 2.0 show diffraction hyperbolae related to both the possible north and west walls of the cabin. Left) Overlaid interpretation over amplitude map (3-5 ns TWTT). Black line across the grid indicate sampled profiles.

Conductivity and magnetic susceptibility surveys were also conducted on the same grid as an experiment to see if these techniques could sense features associated with Cabin A (Figure 6.5). These techniques were added as I was beta-testing TerraPlus' new KT-20 3F sensor (Terraplus 2019). The sensor comes with 3 different frequencies (i.e., 1 KHz, 10 KHz and 100 KHz) that penetrates penetrate different depths (roughly up to 1 cm, 10 cm, and 30 cm). As with every beta-test, there were a number of issues with the implementation of the techniques, namely spatial control and the ability to collect useable data. The KT-20 produced data with GPS coordinates with an error of a +/- 3 m, which made the data useless in terms of denoting structure. That being said, the 30 KHz frequency (expected to reach up to 30 cm depth) provided broadly interesting results when you interpret the data in a 'inside' versus 'outside' cabin mindset (Figure 6.4). Although some authors have found magnetic susceptibility useful for identifying living spaces and use areas (Lynch and Becker 2018), our survey proved to be less informative in this regard. There were slight increases in magnetic susceptibility potentially within the cabin, however, the higher values to the southeast were deemed to be more representative of our modern imprint as these were near the past and current excavation units.

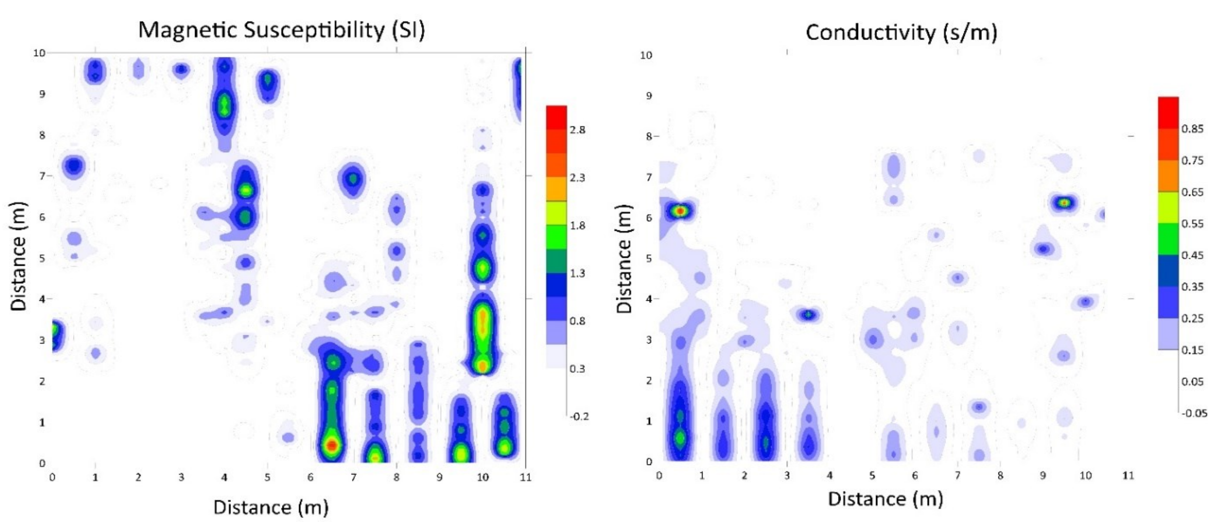


Figure 6.5 Magnetic Susceptibility and conductivity survey results from Cabin A. These were broadly interesting results, but the survey methods were deemed not very reliable for testing specific anomalies.

Electrical conductivity results were slightly more interesting with anomalies occurring within the cabin. Although these techniques proved ineffective at providing information about the cabin due to equipment in development and survey strategy, this data holds promise for a renewed look at these techniques with better equipment in the future.

Excavation units 9 and 11 were placed to locate the wall and chimney based on the geophysical interpretations (Figure 6.6, Appendix D). In excavation unit 9, a large number of chimney stones and flecks of charcoal were found in situ, as well as, large quantities of both burnt and unburnt faunal remains. This evidence led us to confirm that this indeed was the chimney of the Métis cabin, located along the backwall. Excavation unit 11 was able to relocate the wood trench along the west side of the cabin. The wood remains found were larger and more intact than those found the previous season along the south wall. There was also a distinct difference between the soils within and outside the cabin wall. Inside the cabin wall, the wood remains were found in the compact 'C' occupation layer, which does not appear outside the cabin. Outside the cabin, a more clay rich Layer D was found at the same depth as the occupation layer and was interpreted as the clay wall fall.

The archaeological results and geophysical interpretations confirmed the structure of the cabin and allowed the researchers a more nuanced look at its structure and relation within the site. Two out of four walls were found, with another suspected to run alongside of the chimney. With these promising results, the GPR and magnetic surveys were expanded to other areas of the site in the hopes of locating additional structural remains.

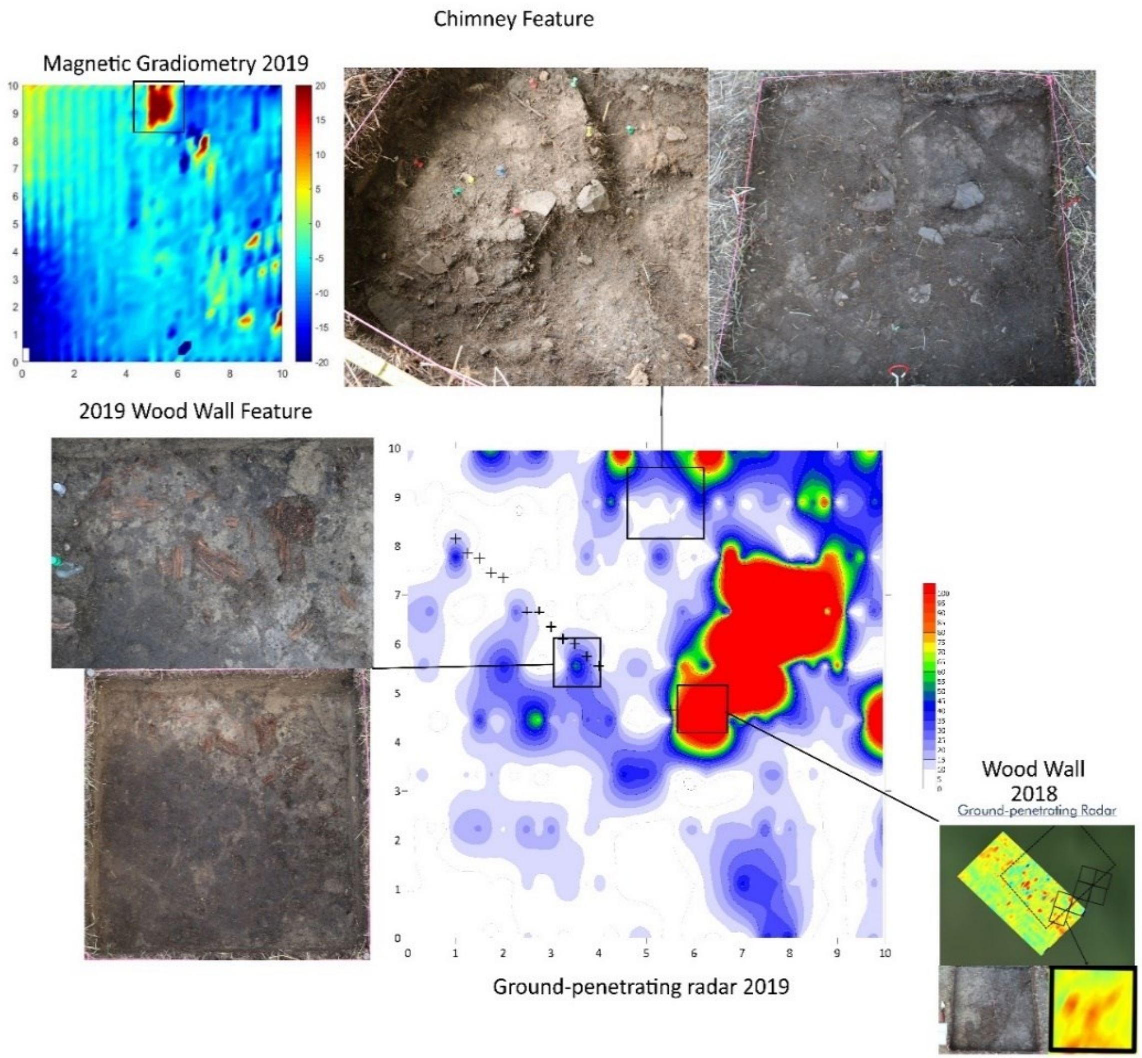


Figure 6.6 A multi-component interpretation of the geophysical and archaeological results from Cabin A. A woody trench feature was identified in 2017 and 2018 by Eric Tebby and was interpreted as the remnants of the wood wall of the cabin by Wadsworth. The area was resurveyed in 2019 with GPR (center) and magnetic gradiometry (top). The Supernant and Tebby's excavation units appear red in the GPR data. A continuation of the wood wall was found in the GPR profiles and plotted on the amplitude map (+). The magnetic gradiometry data successfully identified the chimney feature at the north side of the cabin.

'Cabin B'

Approximately 50 m south of Cabin A, another spot was selected as a potential Métis cabin. A chimney stone was found on the surface nearby a slight mound and surrounding surface depressions. In 2018, GPR and magnetic gradiometry were conducted on the area. The 2018 GPR data was deemed inconclusive due to pure survey strategies and the area was resurveyed in 2019. The magnetic data between both years was effectively duplicated and deemed to be accurate.

Following the survey and interpretation of Cabin A, a second potential cabin was identified in the 2019 data (Figure 6.7). The Cabin B GPR results showed similar radar reflections to Cabin A. Reflections were noted without orientation in the profiles and plotted on the 20 – 30 cm depth amplitude data. While some anomalies identified appear to be unrelated to the overall structure, a general rectilinear pattern was interpreted. This was supported by the higher reflection areas found outside the interpreted cabin, which are likely similar to those found in cabin A (perhaps representing wall fall/clay melt). A chimney area was also located at Cabin B in the magnetic gradiometry data. A positive magnetic anomaly of 20 nT/m was identified and corresponded to the surface mound. GPR profile results from this area also showed a high number of point reflections possibly from chimney stones. The similarity of this feature to Cabin A's chimney led to the same conclusion. Like Cabin A, there were areas identified within the cabin that had GPR point reflections and small magnetic anomalies. These were interpreted as potential artifacts within the living area of the cabin.

No ground-truthing has taken place at Cabin B. Similarly, the anomalies and reflections identified as being related to the cabin were less obvious than Cabin A. Therefore, Cabin B at

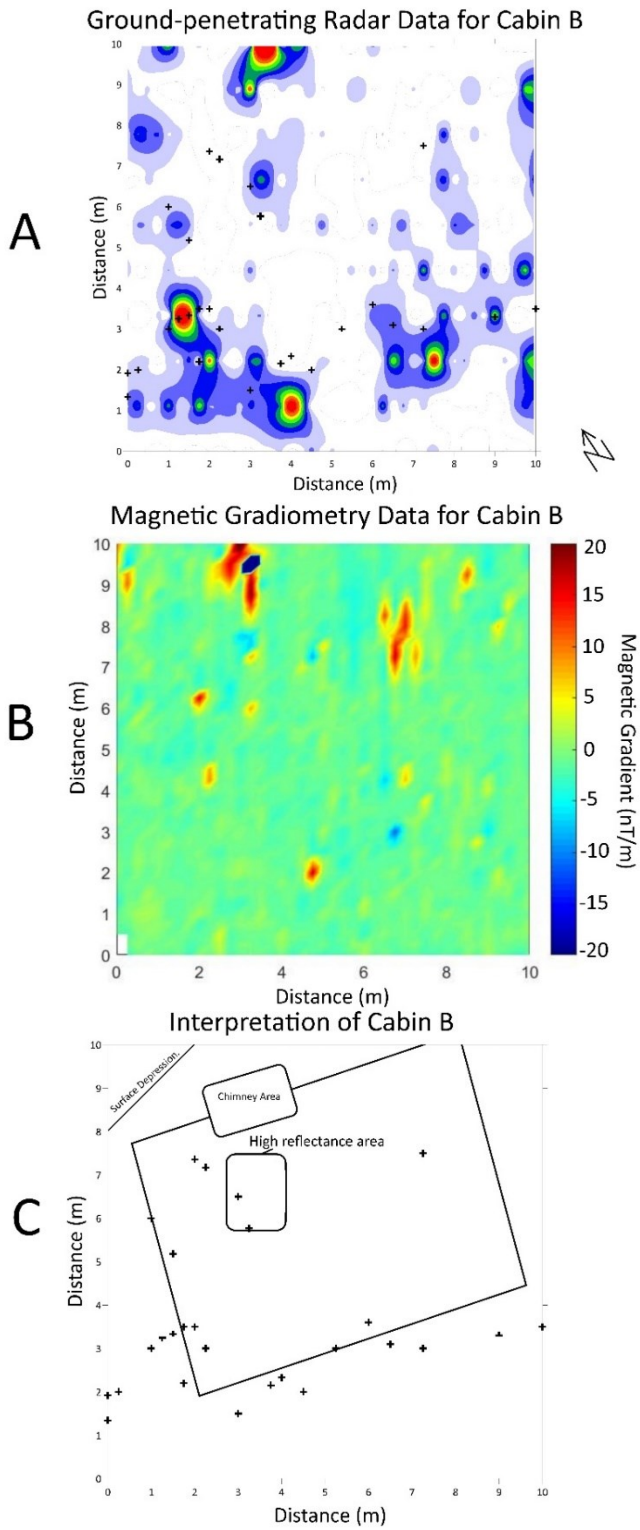


Figure 6.7 GPR and magnetic gradiometry 2019 Results from Cabin 'B'. A) GPR results plotted in Surfer 15, the black crosses are diffraction hyperbolae reflections suspected to be related to structural remains based on Cabin A. Many coincide with higher areas of reflectance found 'outside'. B) Magnetic gradiometry results from the same grid, a higher positive anomaly of around 20 nT/m corresponds with many point reflections in the GPR profiles and may represent the chimney area of this cabin. C) Current un-corroborated interpretation of the geophysics results.

Chimney Coulee can only be regarded as a possible cabin until the interpretations are tested. That being said, the geophysics surveys have provided promising evidence of another Métis cabin at the site, and a beginning interpretation to help focus future archaeological investigations.

NWMP Post and HBC Post

In 2018, a GPR grid was surveyed near Brandon's (1995, 1996, 2001) excavations around the NWMP post and the HBC trader's longhouse. The area selected had visible chimney stones on the surface as well as slight mounds and depressions near the coulee edge. There was also a historic photograph that suggested there were structures in the area (Figure 6.8). Initially, I was excited at the return of promising GPR reflections as it was possible we had identified another Métis cabin (Wadsworth and Supernant 2019). In light of additional historical photos

Figure 6.8 *Historic photograph of Metis men and women outside of what was originally suspected to be a Metis cabin.*

(Figure 6.9), I concluded that the area was likely being used by the NWMP post instead of the Chimney Coulee Métis. Upon consideration of this new evidence and proximity to the Brandon excavations, we re-evaluated our interpretations and decided to re-survey the area in 2019 with our updated methods.

Figure 6.9 Historic photographs of the "East End" NWMP post at Chimney Coulee. Notice the structures are the same as the one in the original photograph. Brandon (1996) called these the NWMP Barracks. The black arrow shows approximately where we believe we surveyed/ which cabin we found. The blue arrow shows the barracks that Brandon archaeologically tested.

When I resurveyed the area, a pile of large chimney stones was found on the surface near the coulee's edge. The number and size of the chimney stones found indicated a feature larger than those found with the Métis cabins on the other side of the site. Once again, a 10 x 10 m grid was staked out, and both GPR and magnetic gradiometry were used to survey the area.

The GPR results from the NWMP area proved to be very informative (Figure 6.10). Although construction techniques would have differed, the overall patterns in cabin structure were found to be the same, with small point reflections from the wood wall remnants. Interestingly, our hypothesized mud/clay areas of higher reflection areas outside the Métis cabins were not found in this area. Higher reflectance areas seemed to focus around the point reflections and one area inside the cabin. The chimney area was also found to contain stronger reflections than those identified in Cabin A. The point reflections identified in the profiles, and found consistently 25-30 cm deep, appear to form two roughly parallel lines interpreted as the north and south walls. The west wall was estimated to be around 1 m in the grid as point reflections and higher reflection areas were found between the two walls, but the walls may continue. The east wall was not located.

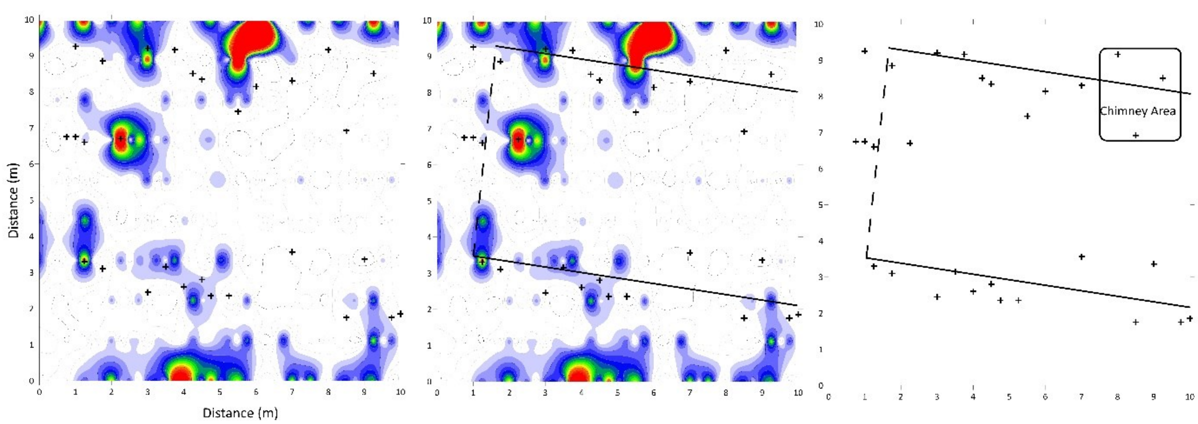


Figure 6.10 GPR results from the NWMP area. Left) GPR time slice results. Middle) Overlaid GPR interpretation of the NWMP area. Right) Interpretation from the GPR results showing a similar pattern to Cabins A and B, however the west wall was not located but hypothesized.

The magnetic gradiometry survey provided mostly inconclusive results (Figure 6.11). In the 1990s, John Brandon had scattered metal washers and rebar to deter looters (which is a significant problem at the site) (Brandon 1996). While I was conducting the survey, I could see where the gradiometer data was becoming distorted and I had Robert Wambold (a volunteer) attempt to sweep the surface with his handheld metal detector (Garrett Pro-Pointer II Pinpointing Metal Detector). Unfortunately, it appears Brandon was very thorough in his efforts to deter looters and some objects creating noise appear to be beneath the surface. There were, however, small magnetically positive anomalies located within the interpreted cabin. The GPR did not find a lot of these apparent anomalies, and with no ground-truthing conducted, there is little to say about these potential objects.

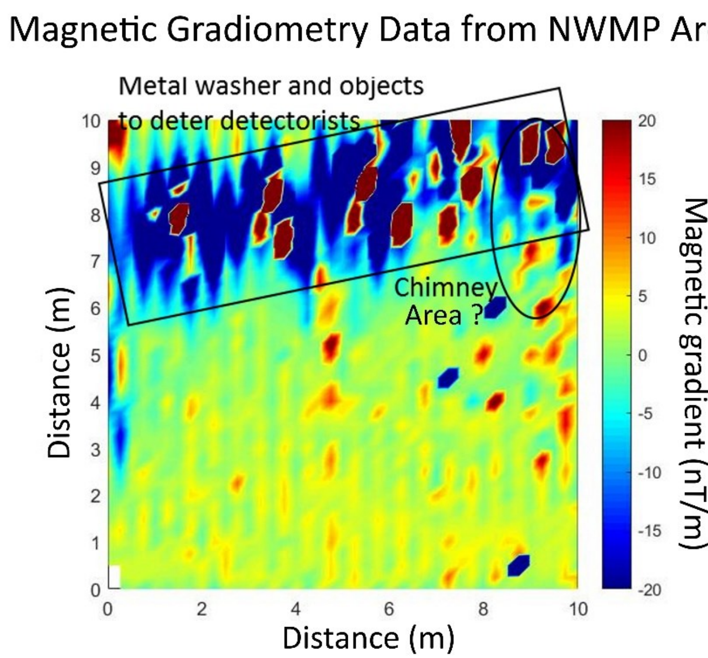


Figure 6.11 Magnetic gradiometry (nT/m) results from the NWMP area. Area of high positives and low negatives are a result of metal washers and objects spread intentionally to deter looters, creating noise in the magnetic results. The chimney area found on the surface is also difficult to identify within the magnetics results.

Despite no excavation to validate my geophysical interpretations, when compared to the historical photographs (Figure 6.8 and 6.9), the thin long cabin shape seen in the data, its orientation, and its position in the photograph appear to corroborate the GPR results. I would be speculating to say that this was the NWMP barracks faintly seen in the photograph, however, the compounding evidence leaves it as a possibility.

6.3 Multispectral UAV Images from the Chimney Coulee Site

Given its promising applications in grassland environments (Bennett et al. 2013), UAV-multispectral data was collected from the Chimney Coulee site in an attempt to identify archaeological features ahead of geophysical/ archaeological investigation. A DJI Matrice 600 UAV was mounted with a Micasense Altum multispectral/thermal sensor. The Altum sensor samples five spectral bands along the electromagnetic spectrum; blue (475 nm center, 20 nm bandwidth), green (560 nmcenter, 20 nm bandwidth), red (668 nm center, 10 nm bandwidth), red edge (717 nm center, 10 nm bandwidth), near-IR (840 nm center, 40 nm bandwidth) (Micasense 2019). It has a resolution of 3.2 MP per band and was flown at a consistent 50 m AGL, creating a 2cm/pixel ground sample distance. An iPad with Drone Deploy was used as our console to control the UAV. The data was then processed in Pix4D and imported into ArcGIS Pro. As this was the first time we collected data using the Matrice 600, initial technical issues prevented us from flying multiple flights. In the following paragraphs, I present the multispectral data from one complete flight over the Chimney Coulee site (approximately 9 hectares or 90000 m^2) (Figures 6.12). Of final note, the Micasense Altum sensor also simultaneously captured thermal imagery, however, the UAV flights did not occur at optimal times for the thermography (i.e., sunset and sunrise)(Casana et al. 2017). The collected thermal data was not analyzed as part of this thesis, although I remain hopeful for future applications with the technique.

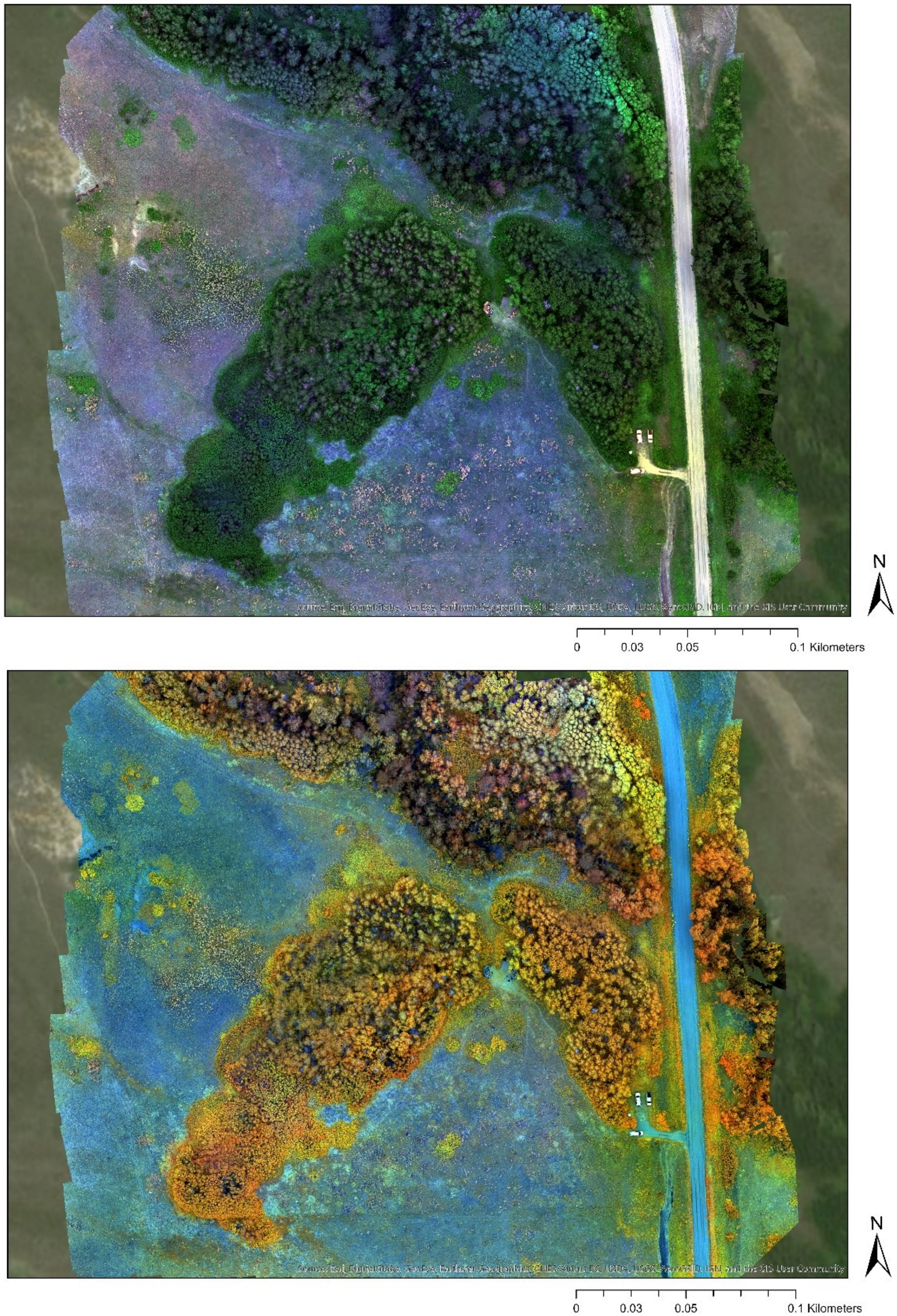


Figure 6.12 Interpolated multispectral maps from the Chimney Coulee Site *(True Colour: Bands 1, 2,3 and False Colour: Bands 5,4 ,3)*

A number of archaeological features were identified within the multispectral data. The first area of interest was the northwest corner of the site (Figure 6.13 and 6.14). In the false colour and NDVI images, three structures were identified within the suspected area. Clustered together around a large potential structure (approximately 20 x 20 m), were two smaller anomalies (8 x 10 m and 15 x 12 m). On the surface and in the true colour images, the area appears nothing more than shrubland. These structures are too large to be associated with Métis cabins, but there was also limited information available (no photographic evidence) to support an interpretation linking them to a different occupation. The most likely interpretations of these structures is that they were either built during the initial occupation of Chimney Coulee by Isaac Cowie (c. 1871) (while structures were being constructed and the settlement expanding), coinciding with the construction of farmsteads in the region following Chimney Coulee's decline, or related to a different occupation that has yet to be realized. Less likely, is that these structures were built during the main occupation phase of the site during the period Métis families were settling Chimney Coulee, or that they are related to the Northwest Mounted Police Post. The anomalies' large size diminishes the likelihood that these were Métis construction, and their absence in the historic photographs (taken to capture the views of the NWMP post) means if these structures were related to the NWMP, then a photograph is missing or these structures were constructed after the photography trip (c. 1875-76). The only occupation that can be ruled out is that they were an extension of the HBC post, since Isaac Cowie's operations at Chimney Coulee appear to be confined to his longhouse and not be official HBC business (Tebby In Prep).

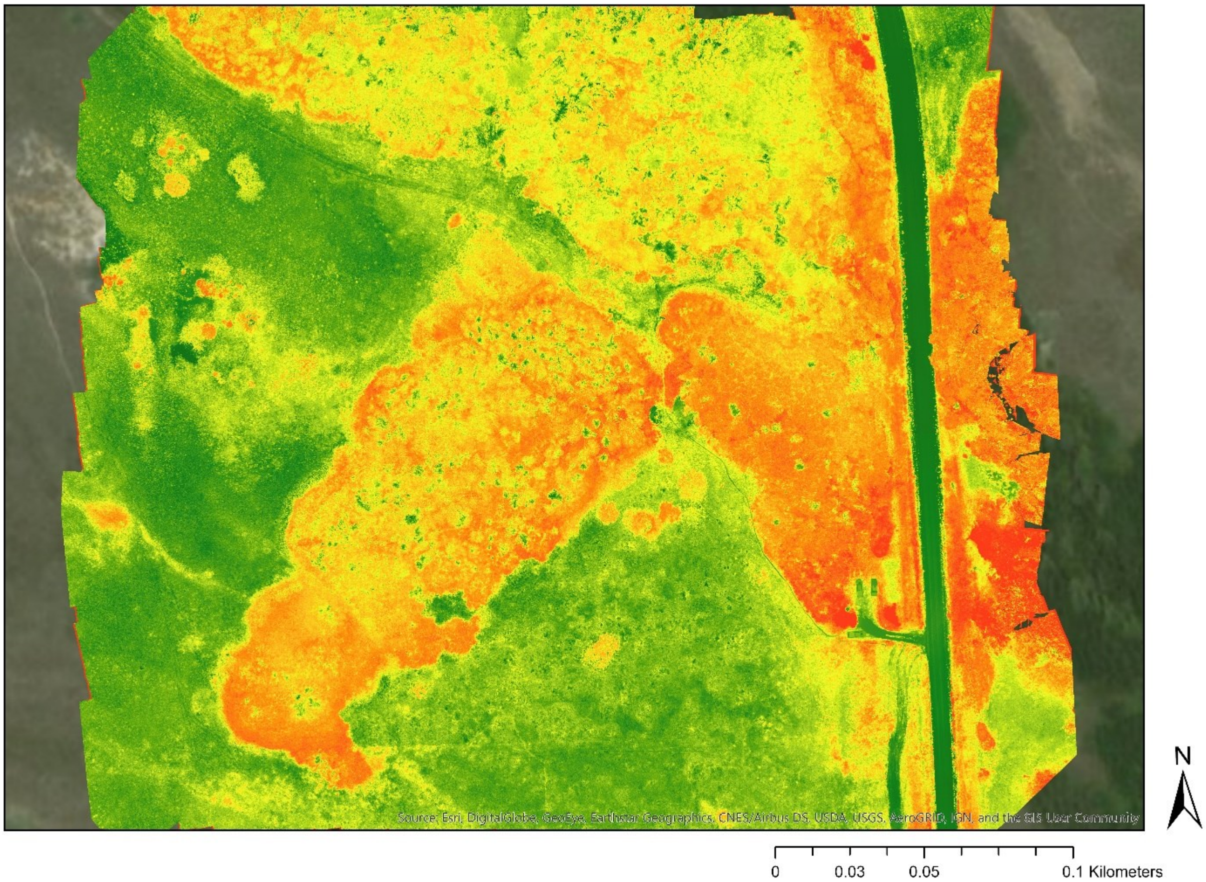


Figure 6.13 A interpolated map of the Chimney Coulee Site (Vegetative Index: NDVI)

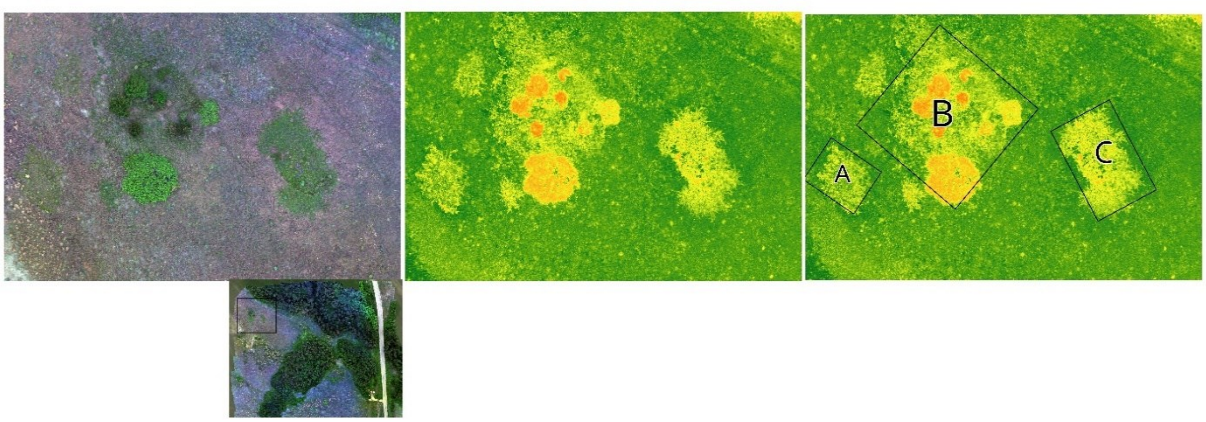


Figure 6.14 True Colour, NDVI and interpreted images from the northwest MS anomalies. Three possible structures were identified, possibly related to the H.B.C post. A = 8 x 10 m, B = 20 x 20 m, C = 15 x 12 m

To the south of our excavations, a Manitoba maple (not native to southwestern Saskatchewan) was found growing in a large depression near the excavations of Cabin A. This non-native tree was generally suspected to be associated with the Métis at Chimney Coulee, who could have brought the seeds from the east. When the area was examined using the multispectral data, false colour and NDVI images help to identify potential cabins (Figure 6.15). Four rectilinear anomalies were found near the Manitoba maple, representing a difference in the vegetation/vegetative health compared to the open prairie. These anomalies varied in size but were all less than 12 x 8 m in area, smaller than the assumed northwestern anomalies. Considering their smaller size and proximity to the excavated Métis cabin, there is little doubt that if these anomalies are representative of structures that they are associated with the Métis. When Métis overwintering settlements are described, the village spatial organization is relatively consistent; the cabins are scattered and lack spatial cohesion beyond being centered around a small chapel (Tebby In Prep).

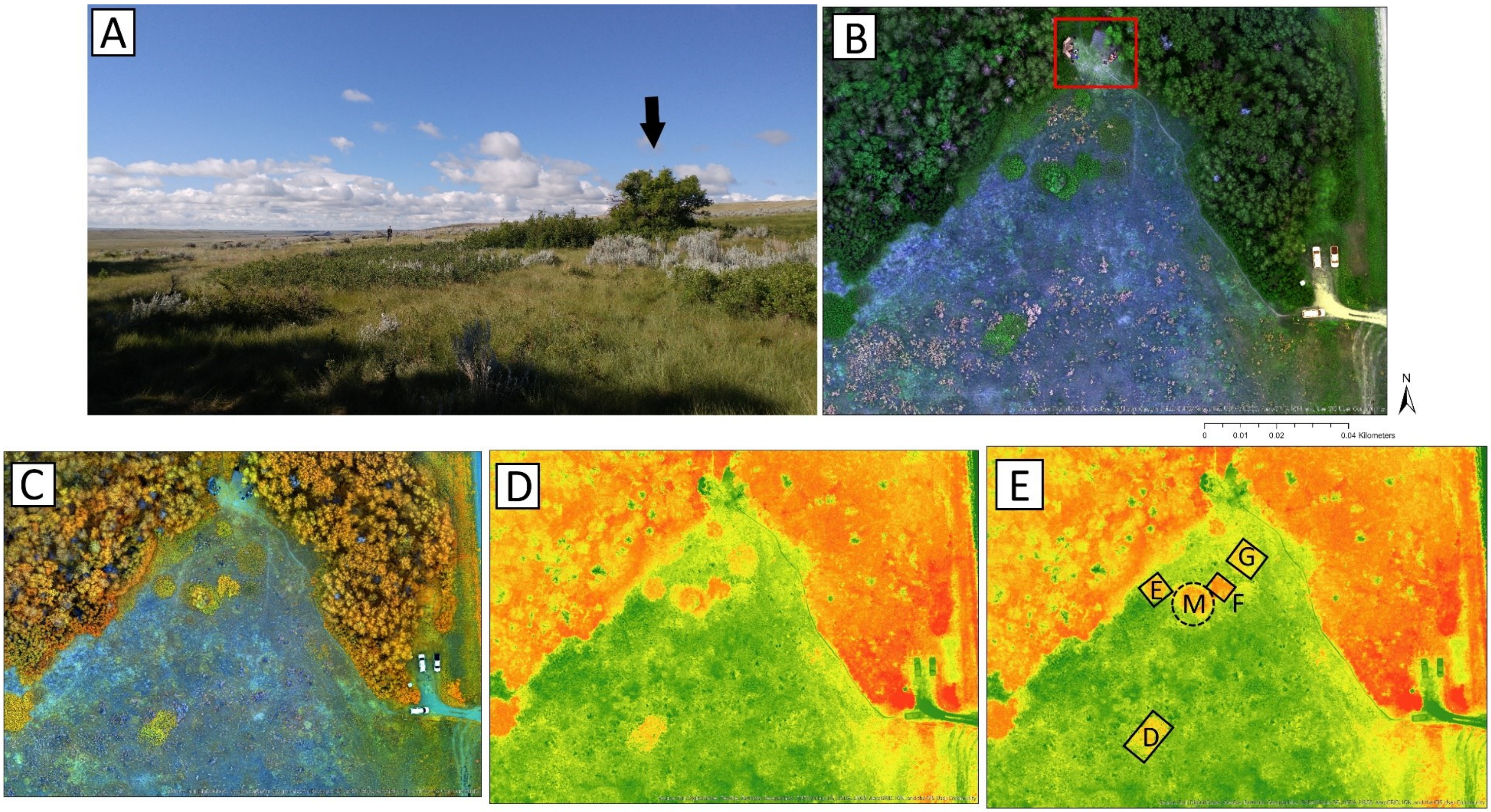


Figure 6.15 The southern area of the Chimney Coulee site contained interesting features that may represent aspects of the Métis occupation. A) As seen in the photograph of taken from the site, the Manitoba maple has grown inside of a large depression with patches of vegetation (sage and other shrubs) surrounding it. B) The True Colour map depicts the active archaeological excavation, and the area of interest is due south. C) A false colour image (bands 5,4,3) of the area D) an NDVI raster of the area. E) Interpreted possible anomalies, their size, difference in vegetation, proximity to other cabins, and shape indicated the need for archaeological testing. Anomaly D was 12 x 7 m, anomaly E was 5 x 5 m, anomaly F was 8 x 6 m, and anomaly G was 8 x 8 m. Anomaly M represents the Manitoba maple.

While it is easier to draw interpretations about the southern anomalies, this is does not make these potential structures more or less real than the northwestern anomalies. The main objective of the multi-spectral survey was to demonstrate its potential benefits of quickly locating potential cabins. It has also identified the main limitation of remote sensing survey, that these anomalies need to be tested before any real conclusions can be drawn. The potential anomalies identified as part of this survey can be considered potential targets for future geophysics and archaeological investigations to confirm or deny hypotheses presented here.

6.5 Future Potential of ARS research on Métis Archaeological Sites

Despite not having a colonially defined 'local' community, compared to examples from Chapters 4 and 5, the surveys at Chimney Coulee have provided the most complete example of a multi-component archaeological remote sensing survey. Traditional archaeological work conducted throughout the 1980s and 1990s (Brandon 1995, 1996, 2001; Burley et al. 1992), enabled the EMITA project to archaeologically test the site in 2013 and 2017, leading to a strong background in archaeological information prior to the initial geophysical surveys in 2018. Furthermore, Eric Tebby, a graduate student at University of Alberta, had completed a comprehensive review of the historical literature, obtained historic photographs of the site, and received oral anecdotes about the site from individuals from the modern town of Eastend. The archaeological and historical information elucidated a better understanding of site processes and, ultimately, led to the design and success of different geophysical/remote sensing surveys. These lines of evidence were then incorporated alongside additional surveys, such as archaeobotanical, to establish a more comprehensive narrative of the Chimney Coulee site.

Methodologically, this chapter has presented a case for the extensive incorporation of ARS techniques to Métis sites in the Canadian Prairies. After the 2019 survey at Chimney

Coulee, I concluded that GPR and magnetic gradiometry were able to successfully sense the remains of Cabin A, helping to establish a hypothesized target for other grids. While, the experimental use of EM conductivity and magnetic susceptibility on Cabin A provided limited information, I am hopeful that future experimentation and the refinement survey strategies may prove beneficial. The hypothesis established by Cabin A was then applied to other areas of the site that were expected to have structures and, although uncorroborated via excavation, the ground-based geophysical techniques produced similar GPR and magnetic signatures that led us to conclude that we had located another Métis cabin and perhaps part of the NWMP barracks. The 2019 Chimney Coulee survey was also the first time the EMITA project employed UAV multi-spectral imagery. The technique proved to be extremely expedient and useful in identifying future areas of investigation. Together, we obtained a better understanding of the site, its structures, and its occupations from the combined surveys. From this I created a hypothesized sketch map of the site (Figure 6.16), spanning different occupations, which has raised questions about relationships within the settlement and focuses future surveys.

A comprehensive interpretation of the Chimney Coulee site still eludes us, as there continues to be questions to be explored regarding the relationships between the Métis and settler occupants (Isaac Cowie and NWMP). Furthermore, what was the outward relationships between the settlement and other Métis and Indigenous communities? While the ARS research has found substantial spatial evidence for the existence of additional structures, corroborating historical narratives, future research will need to focus on dating these occupations in order to establish a true chronology of the settlement (such as, Prentiss et al. 2008). The ARS research has testified to the size and substantial nature of the Chimney Coulee settlement, despite many houses

Figure 6.16 Overall Chimney Coulee site interpretation and sketch map. Yellow boxes denote Brandon's (1996) excavations, red box shows our confirmed Cabin A, black boxes are interpreted possible structures based on purely geophysical evidence, and grey boxes are interpreted from the historic photographs. 1) Multispectral structures (unknown occupation) 2) NWMP Barracks, 3) Isaac Cowie's Longhouse, 4) Cabin A, 5) Cabin 'B', 6) Possible other areas with Métis Cabins based on multispectral imaging. Many more Métis cabins likely exist in the (now) wooded areas; however, this precludes remote sensing investigation.

remaining undiscovered. Many of which are suspected to be located in the wooded areas where it is hard to conduct geophysical surveys. We found evidence to support the assumption that the Métis cabins were much smaller than Isaac Cowie's longhouse and the NWMP police barracks and would have been tightly packed with Métis families. Similarly, it is clear that the majority of the Métis cabins were clustered toward the southern end of the site, adjacent to the Manitoba maple, while Isaac Cowie and the NWMP built their structures to the north. Questions remain concerning the existence of a chapel, mentioned in historical texts, and the origin of the potential structures in the northwest portion of the site. Not only does Chimney Coulee contribute to our archaeological understandings of the region, but also to current peoples' identity and politics. More archaeological evidence to support the Métis presence in the Cypress Hills prevents future detrimental legal disputes about whether or not they were there (e.g., the Hirsekorn decision). The ability to quickly survey sites using remote sensing techniques and locate potential targets for archaeological investigation is critical in this endeavour. This chapter has presented strong evidence to support the application of these techniques in future areas under dispute.

Given the results presented in Chapters 4, 5 and 6, it is unequivocal that archaeological remote sensing can and should be used within community and collaborative frameworks. In the next concluding chapter, I will discuss the methodology's benefits, limitations and future potential as applied to Indigenous contexts.

CHAPTER 7:

DISCUSSION AND CONCLUSIONS

In 2003, Kenneth Kvamme published the seminal paper, *Geophysical Surveys as Landscape Archaeology,* in American Antiquity. In this work, he described how large-scale geophysical data could be used to inform landscape archaeology. At the beginning of this thesis, I argued that despite various calls to action (and nearly two decades since Kvamme's paper), geophysics has yet to play a major role in anthropological archaeology. Approaching the end of this thesis, I maintain that archaeological geophysics was missing a crucial linking step in order to use geophysical data to make anthropological interpretations.

Standing on the shoulders of giants (e.g., Conyers 2013; Gaffney et al. 2015; Goodman and Piro 2013; Kvamme 2003, just to name a few), this thesis has provided a comparative dataset for the future development and implementation of remote sensing practices in archaeology, while providing a new context for its interpretation. I have demonstrated through community-driven and collaborative research projects that archaeological remote sensing techniques can be successfully employed at different sites across western Canada. By doing so, my research has outlined a new methodological framework in ARS research, incorporating principles from Indigenous archaeology, which uses the results from these surveys to contribute to higher order theories. In archaeological terms, this ARS framework is similar to a 'middle-range theory.' Not in the New Archaeology sense of narrowly investigating site-formation processes, but in the *methodological* way of linking low-order empirical data to high-level interpretation (Raab and Goodyear 1984). Echoing Raab and Goodyear's (1984) critique in Chapter 3, I believe that geophysics studies in archaeology have forgotten the reason we do archaeology in the first place, not to investigate mechanical spatial relationships, but to ask meaningful and interpretive questions about culture. The following paragraphs are how I conceptualize this thesis' contributions in terms of methods (low-order empirical methods and results), methodology (ARS frameworks and Indigenous archaeology), and theory (imagined landscapes).

Methods and Results (Research Questions 1 and 2)

In most of the case studies, archaeological remote sensing techniques were successful at locating archaeological remains and resolving patterns of burial and architectural features to both the researchers' and community's satisfaction. While it was already known that GPR is the most effective tool for the non-destructive identification of unmarked graves (Conyers 2012; Gaffney et al. 2015; Ruffell et al. 2009), this thesis represents one of the first times the technique has been extensively employed at the service of Indigenous communities. In Chapter 4, GPR surveys for the Chipewyan Prairie, Enoch Cree and Papaschase First Nations provided case studies that demonstrated GPR's ability in locating unmarked graves in a variety of environments. The GPR methods were designed from reliable published studies and demonstrate its general applicability with minimum survey-specific alterations. Community members provided the majority of information about each survey context, and the different surveys represented different burial types, cemetery populations (i.e., adults and children) and temporal periods. Given the urgency of the projects, and the number/extent of the burial grounds each of the communities wanted to investigate, GPR was the only technique thus far applied across each of the surveys (with the PFN survey incorporating other techniques as well). This has provided a unique and growing comparative GPR dataset that lends itself to future analysis and refinement of the technique. In the future, magnetic gradiometry and UAV-techniques are also planned to be applied in these unmarked grave contexts to test their efficacy and comparative use. At the end of each survey, the communities also received a copy of the data and accompanying report, co-produced with community members, for their archives.

Both the Prince Rupert and Chimney Coulee case studies lent themselves to a more multiple evidence-based approach and demonstrated GPR and magnetic gradiometry's utility in resolving architectural patterns. In Prince Rupert, house depressions previously mapped with a total station were re-surveyed using GPR and magnetic gradiometry. Despite the environment being 'anything but optimal' for these techniques, the survey provided useful results that helped the researchers and the community. I was able to locate hearths, house floors, possible posts, wall zones, and large shell berms surrounding the house. At the Chimney Coulee site, one cabin was successfully mapped using GPR and magnetic gradiometry and its features tested through excavation, while two more potential structures were interpreted. The chimneys of these cabins, large piles of crumbled rocks, burnt bone and charcoal, were represented by strong positively magnetic anomalies and many small GPR reflections. The GPR was also able to locate the remains of the cabin walls. The Chimney Coulee site allowed us to test a new multispectral UAV sensor, which provided an interesting picture of the site and its potential structures. Both the Prince Rupert and Chimney Coulee case studies are evolving interpretations and demonstrate the need for continually returning to interpretations with the addition of other narratives.

Evaluating each case study within its community context led to the creation of survey designs that were appropriate given unique histories, community needs, and external factors. It also led to the creation of the best strategies to apply the techniques within each context. The resulting data was then combined with previously collected archaeological, Indigenous knowledge, and historical information, which led to more holistic site narratives and a greater research impact on the partner communities.

Archaeological Remote Sensing as a Methodology (Research Questions 3 and 4)

This thesis has also provided an alternate way to conceive ARS research design and interpretation, influenced by Indigenous archaeology, community-driven research, and decolonization theory. In Chapter 3, I described how ARS research could push back from a geophysical/ archaeological 'essentialism' by incorporating multiple narratives and basic principles of knowledge co-production (i.e., mobilization, translation, negotiation, synthesis, and application) into its methodology (Raygorodetsky and Chetkiewicz (2017). By reconceptualizing remote sensing data as one narrative to be combined with other lines of evidence, each case study explored co-production elements in their survey design, application, and interpretation by recognizing how knowledge is being produced, what the knowledge is, and how it will impact modern communities. Understanding this, a model was created that balanced the unique factors of community-driven and collaborative ARS work on a continuum. When the case studies are plotted within the model from Chapter 3 (Figure 7.1), each project occupied a unique context that necessitated a different methodological approach. The most urgent of these surveys was the one with the ECN, and to a lesser extent, the PFN surveys, the nature of which directed the approach and outcome. Of less urgency was the surveys with the Chipewyan Prairie First Nation. Although the community was very invested in protecting these sacred spaces, our surveys were completed far in advance of any potential future disturbance and therefore the community was also open to the possible inclusion of additional techniques in the future. With regards to the archaeological projects, the Prince Rupert Harbour Archaeology project strives to include multiple non-invasive techniques and ways of knowing, however, given the challenging environment and erosion of sites, this is not always possible. While being attentive to the communities' wishes, the focus of this particular project was on developing fast and effective survey strategies to create new site chronologies. Finally, the Chimney Coulee site represents a very typical archaeological setting and demonstrated the potential utility of a multi-component ARS approach. The environment was stable and there was no ongoing threat of destruction to the site. The political context of the site, however, created an important need for the creation of new Métis narratives.

The engaged practice of ARS research led to research designs focused around community needs and personal relationships. Approaching each survey with the recognition of their context and potential impact resulted in the creation of productive community relationships and with community members being enthusiastic and excited about the research. Community members

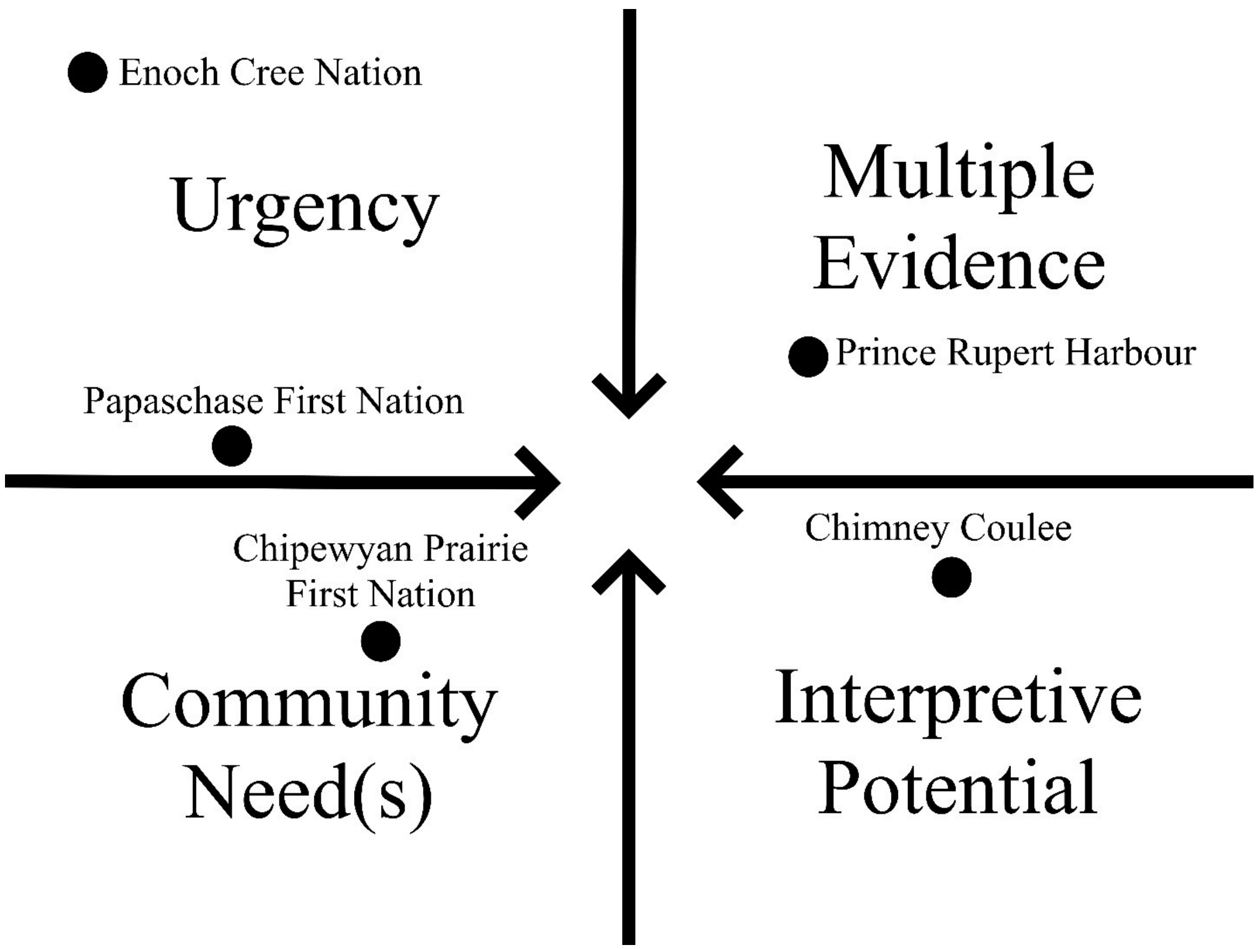


Figure 7.1 A hypothesized map of this thesis' projects on the ARS survey design model. Although each of the projects utilized many of the same techniques, when plotted each required a very different approach that was dependant on their context. This is a graphical representation and does not represent real values. The further from the center a project was the more focused on one force it became.

played active roles throughout many of the surveys, including the design, process, and interpretation. Communities also largely had control over the narratives that were created and how these results were combined with other ways of knowing. Finally, it was with their permission that these case studies were allowed to appear in this thesis. By approaching each of the surveys in this way, these surveys produced physically similar results to other geophysical studies, but drastically different outcomes for both the researchers and the communities. Although multi-instrument surveys were not always possible, the results of these surveys combined with an Indigenous-influenced methodology have allowed for the construction of 'braided' narratives and contributions to grander theories.

Theory-building with ARS (Research Question 4)

With this new middle-range methodology, geophysical/remote sensing results can be 'scaled up' with Indigenous knowledge and other lines of evidence to apply to archaeological theory. In Chapter 3, I described an anthropologically inspired way to view North American landscapes. Drawing on Appadurai (1996), I described how individuals can 'visit' imagined landscapes through representations of places. By synthesizing different narratives together, the combination of remote sensing, archaeology, Indigenous knowledge, and other narratives begins to create imagined worlds that people can experience.

While the identification of unmarked graves can be seen as a simple act to locate graves to be protected, when nuancedly examined, the implications of such a project matter so much more. By creating geophysical representations of the subsurface, and working with communities and their goals, these places are being commemorated as mortuary landscapes linked with stories of people and families. Much anthropological work has been done on the study of mortuary landscapes and their evocative impact on their communities (Cannon 2002). Moreover, these spaces hold further significance in the social memory of the marginalized (Christopher 1995; Young and Light 2016). In this sense, remote sensing survey can be understood as a place-making event. While it is still unclear how the (re)construction of these spaces impacts modern Indigenous communities and the potential trauma or healing it causes, it is clear that these methods can contribute to other theoretical approaches applied to sacred landscapes (see Swenson 2015). While outside the scope of this thesis, the relationships between ARS burial research and Indigenous communities should be considered a topic for future anthropological research to holistically understand our impact and the landscapes we create.

In the Prince Rupert example, I used an ARS framework to build a geophysical template of Tsimshian houses. In the past, household archaeology has been used to link archaeological materials to grander theories of inequality, social organization and cultural interaction (Coupland et al. 2009). Now, with an ARS framework, I hope to continue to refine our results and methods, in the future combining this model of a house with other lines of evidence, to contribute to better understandings of the harbour's landscape at different periods in time. Similarly, in the Chimney Coulee case study, I used similar techniques to identify patterns in Métis overwintering cabins. Combining this information with other historical narratives led to a new understanding of the site's landscape. Our understanding of the Métis at Chimney Coulee, when combined with regional Métis narratives, will help us to form grander theories of their archaeological past. While both of these examples have yet to be extensively explored within larger theories, ARS has helped to position the field in a way to begin making these contributions (Figure 7.2). These sub-site and site level narratives drawn from archaeological remote sensing predicate, and have a cascading effect on, regional and theoretical understandings of landscapes. While this application to higher level theory has not been fully explored in this thesis, I have argued how ARS could be applied to suit this purpose.

Political/ Practical Applications (Research Question 5)

> Getting the story right and telling the story well are tasks that indigenous activists and researchers must both perform. There are few people on the ground and one person must perform many roles – activist, researcher, family member, community leader – plus their day job. The nexus, or coming together, of activism and research occurs at the level of a single individual in many circumstances [Tuhiwai-Smith 2012, 357].

Besides their methodological contributions, these case studies have both directly and indirectly contributed to the political aspirations of Indigenous communities, while having provided useful evidence to help monitor and protect endangered sites. As Raygorodetsky and Chetkiewicz (2017) described, the last part of true knowledge co-production, and the basis of collaborative research, is the application of these results to real world decision-making. The Papaschase First Nation, Enoch Cree Nation and Chimney Coulee case studies demonstrated that archaeological remote sensing could have a direct impact on current politics. The Papaschase First Nation, who are in the process to regain federal recognition, has begun to establish a historical land base. This research has contributed to this goal by providing an ARS narrative of

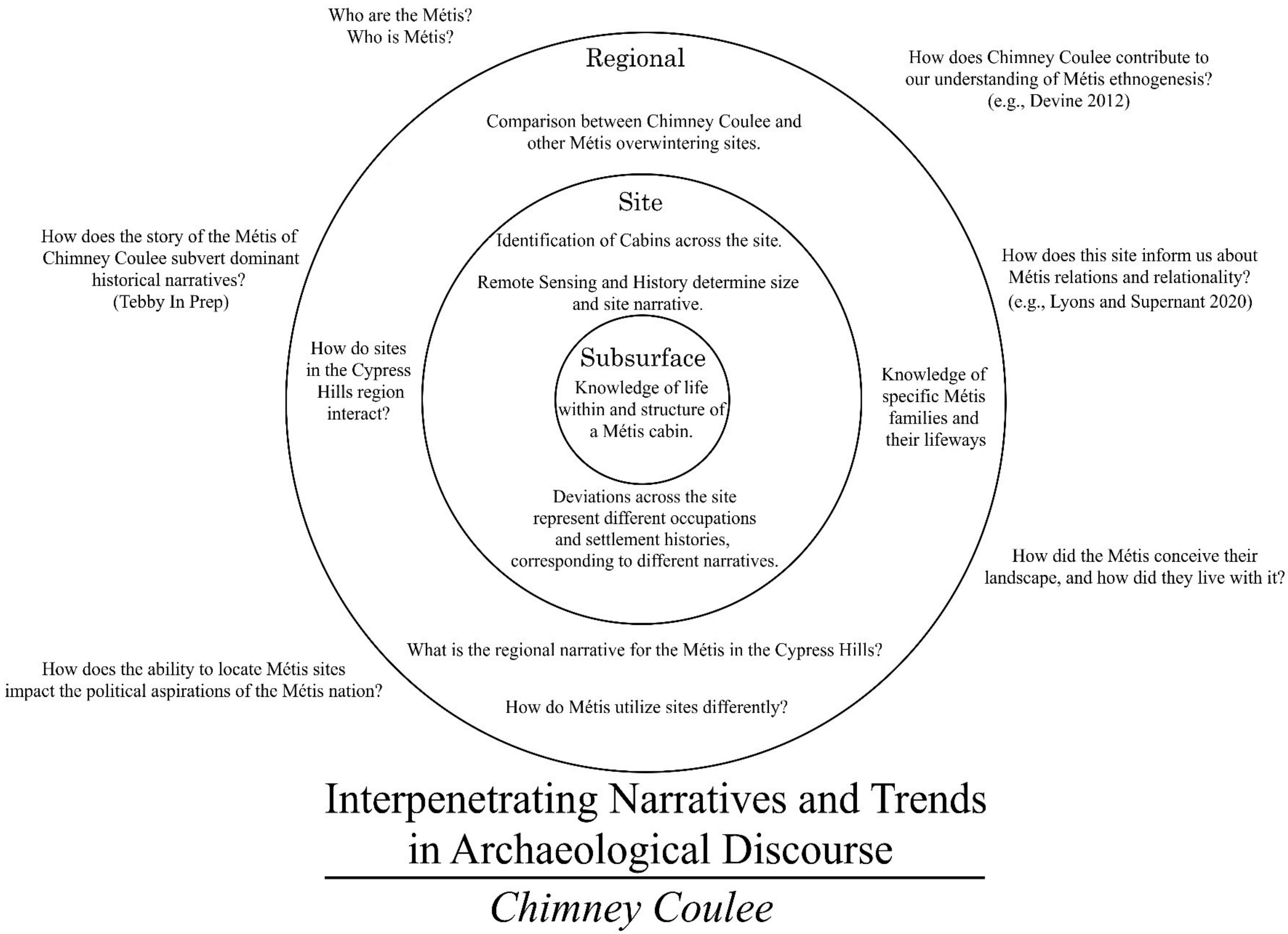


Figure 7.2 Example of how an ARS methodology links low to high order narratives using the Chimney Coulee site. This figure shows how different narratives are interconnected and inform each other. In this way, the development and combination of methods that produce reliable low order results contribute to a cascade of site, regional, and theoretical interpretations and questions about the Métis. This figure shows research questions and interpretations that have and have not been investigated but contribute to the forming of holistic research interpretations and designs.

a site on the NW corner of the former Papaschase reserve. While the unmarked grave study itself may not have a tremendous role in shaping the band's future, it has directly supported the group by generating much needed media attention, recognizing the band's sovereignty and rights to the land, and connecting students, band members, and the public. Similarly, the survey of The Chief's Burial Ground, conducted on behalf of the Enoch Cree Nation, also helped to recognize their sovereignty and the importance of their heritage ahead of the twinning of the TMX pipeline. While it was never the intention of the Nation to stop the pipeline, they have been fighting to mitigate its impacts on their traditional lands. With the completion of our survey, the band is currently in talks with TMX to prioritize the protection of the identified graves and change the pipeline's right-of-way. Finally, the Chimney Coulee project continues to demonstrate the need for effective and quick survey strategies when it comes to Métis archaeology. As previously mentioned, archaeological evidence is becoming increasingly called upon as legal evidence by governments to 'validate' Indigenous claims. Currently, the Métis are struggling to reclaim their homeland and archaeological evidence from Chimney Coulee and future archaeological sites will be critical in preventing future detrimental decisions (e.g., *R. v. Hirsekorn*).

These case studies have also indirectly impacted the aspirations of Indigenous communities by providing community members with the knowledge of these tools to pursue their own goals. This includes the protection of culturally significant areas from both cultural and natural forces. For the Chipewyan Prairie First Nation, who inhabit a region that has been extensively exploited by resource extraction, these techniques contribute to an ongoing effort to identify and protect burial grounds within their traditional territory. In the case of natural forces, the multi-year survey of a community significant site using GPR and other remote sensing techniques may provide useful data in erosion monitoring, such as the Garden Island site (GbTo-

23). While this application was not evaluated in the present research, recent studies has suggested this is possible (Miller et al. 2018). In reality, the complete list of direct and indirect ramifications of ARS collaborations with Indigenous communities and how it impacts sovereignty and self-determination has yet to be explored in-depth but exemplifies the need for reflexivity in project design. For this reason, “getting the story right and telling the story well” are equally and fundamentally important for communities and their needs (Tuhiwai-Smith, 2012:357).

Final Thoughts and Next Steps

When I first set out to write a thesis on archaeological remote sensing projects with Indigenous communities, my original goal was to prove it could be done in a way that was both ethically responsible to archaeological and Indigenous communities. While the results and reception of this research was overwhelmingly positive by the partnered Indigenous communities, it has created a whole host of questions going forward.

First, the vast majority of archaeologists in Canada continue to apply traditional destructive techniques to survey sites. The results of my research have shown that it is possible to drastically alter these techniques and still address archaeological questions, such as questions concerning the location of archaeological features, house architecture, and site structure. Moreover, these techniques need not be limited to archaeological questions, as community goals and perspectives can also be incorporated into remote sensing surveys, such as mapping burial grounds, reducing invasive techniques, and monitoring erosion and developmental impacts. Ultimately, researchers have shied away from using these techniques due to lack of access, training, and uneasiness about efficacy in various environments. Therefore, continued research into emerging community-driven remote sensing is needed. Not only will these future projects produce state-of-the-art contributions to the study of human histories in North America, but will also encourage other archaeologists and Indigenous communities to adopt similar non-destructive and community-driven approaches (Gonzalez 2016). By doing so, researchers can draw from a larger pool of studies to determine the efficacy of remote sensing techniques in various environments and help interested communities reconnect with and non-destructively monitor impacts on their past.

Second, geophysics and remote sensing techniques can no longer be thought of as an 'archaeological afterthought.' As outlined in Chapter 3, and demonstrated in the case studies, remote sensing projects fundamentally rely on similar assumptions and beliefs that influence all research projects. Understanding the nature of geophysics data as subjective reiterates the point that it is a separate body of evidence that creates a particular narrative. This narrative must be combined with other lines of evidence, such as archaeological/anthropological, geospatial, historical, and Indigenous knowledge, to produce more meaningful, ethical interpretations for communities. As this knowledge must be co-produced, I am currently working on new ways to translate geophysics narratives to the community. As more knowledgeable users of these techniques, communities will have more control in research projects.

Archaeological remote sensing professionals also have an ethical duty to the community to be reflexive of the confidence in and impact of their research. Another necessary aspect in the translation of ARS studies is the development of a way to measure results. As these studies more and more become critical lines of evidence, Indigenous communities, law enforcement agencies, and industry professionals need a quantitative way to evaluate and defend interpretations within western knowledge frameworks. Currently, I am working with colleagues to develop a statistical confidence index to quantitatively assess remote sensing interpretation strength. People have been encultured to understand percentages and ratios signifying confidence, thus such a confidence index would also act as a translator of interpretations. Similarly, this also includes using proper algorithms (cf. Singh 2002) to process and model magnetic data (Kravchinsky et al. 2019). Furthermore, as previously mentioned, while the surveys presented in this thesis had many positive impacts for communities, the complete list of impacts remains to be known, particularly with how re-locating grave sites impacts community members. In traumatic instances, does relocating the graves of family members re-surface trauma or bring closure? Additionally, does the re-imagining of landscapes using remote sensing impact or change traditional places?

Third, there is currently no standard concerning the adoption of ARS approaches in Canadian archaeology. Our relationships with Indigenous communities in Western Canada, and case studies presented in this thesis, have revealed a demand for the protection of endangered heritage using ARS surveys and the creation of heritage preservation protocols. While settings and survey strategies need to be modified to suit various environments in Canadian archaeology, the five case studies comprised fairly consistent survey strategies. They have also underlined the need for increased time for the surveying of sites in order to produce high-resolution data. Furthermore, a deeper understanding of the techniques is required to accurately select the appropriate technologies and settings to successfully locate targets. I believe a future voluntary database that stores survey strategies, scientific protocols, and results of ARS surveys (as approved by community) in one location for ARS professionals and Indigenous communities will increase collaboration across the field. As was briefly discussed, standards to increase the success and legitimacy of remote sensing surveys is crucial for Canada, considering the rapid economic development destroying landscapes (for example, the TMX pipeline) and national issues, such as the Indian Residential Schools and missing and murdered Indigenous women and girls (National Inquiry into Missing and Murdered Indigenous Women and Girls 2018; Truth and Reconcilliation Commision 2015).

The purpose of this thesis, at a basic level, has been to call attention to a paucity in research that has the potential to become a new productive way to engage with the past and build relationships that span cultural divisions. The combined results of the outlined future objectives would unequivocally change relationships between Indigenous and non-Indigenous communities and empower community members in the protection of their heritage. Going forward, archaeological remote sensing has the potential to connect individuals and communities to the places, stories, and ancestors that are above, beneath, and within each of us.

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APPENDIX A: Consent Forms

Example Text from our Free and Informed Consent Form.

Free and Informed Consent Form:

Remote sensing/survey off reserve

DATE: November 18th, 2019

PROJECT: Master's Thesis-Archaeological Remote Sensing in Canada

SUB-PROJECT: Search for the Kaskitewâw asiskîy Cemetery

PARTNER COMMUNITY: Papaschase First Nation (PFN)

RESEARCH TEAM

Researcher: William Wadsworth, University of Alberta-Graduate Student, 613-276-4081

Academic Supervisor: Dr. Kisha Supernant, Associate Professor and Director of the Institute of Prairie and Indigenous Archaeology, University of Alberta, 780-248-2082

INTRODUCTION TO THE PROJECT

This project focuses on the use of ground and aerial based geophysical/remote sensing techniques (ground-penetrating radar, magnetometry, multispectral imagery) for community-driven research projects. This includes surveys that seek to identify unmarked graves, archaeological sites, or anything else the community desires. This project form does not involve excavation or ground disturbance.

PROCEDURE

A survey will be conducted at a location selected by the community. Additional historical and archaeological research may be requested or recommended. During these surveys, researchers may ask community members questions about the land, its history, and other potential avenues the community would like to pursue. Afterwards, the researcher will process the data and compile a preliminary report to be given to the community with a copy of the raw data (if requested). At that point, the community has the opportunity to make changes to the preliminary report prior to submission.

RISKS AND BENEFITS

We acknowledge some people may choose to share personal experiences during the open-ended community-driven process. If this occurs, we will ask whether the community member would or would not be comfortable with this information being included in the report, and will act on their wishes. There is also a risk that sensitive topics may arise that could trigger upsetting memories or emotions. If this occurs, please notify the research team and we will endeavour to connect you with professionals and resources that may be able to help. At any time, the community can stop the survey to either reschedule or withdraw from the study.

The benefits of participating in this research is knowing that you are contributing to the development of a master's thesis and publishable contributions that seek to encourage other archaeologists, government officials and consultants to adopt full consultative and collaborative approaches with Indigenous communities and non-destructive archaeological practice. The materials that come out of this research are for the benefit of your community and will be prepared in an accessible manner and provided for your community to keep.

The community understands:

1. The intent and purpose of this research.

2. Participation is completely voluntary and the survey is being conducted at the request of the community. Therefore, they can withdraw from the study at any time without any negative consequences. If they withdraw from the study, the researchers will not use their information or data.

3. No legal rights have been waived in any way. Consent is ongoing and freely given.

   If the community would like the survey/data to remain confidential,

4. As this project is off reserve, there are a number of provincial protocols that need to be followed, which might limit the ability for complete confidentially. Specifically, research permits will be applied for by the researchers to conduct the survey, and report will be

have to be generated for the Archaeological Survey of Alberta and the property owner. Upon the community's request, parts of (i.e., names and locations) the data produced may be omitted from these reports, however *this must be decided in discussion with the Archaeological Survey of Alberta and the property owner*. Although a formal report must be generated, the community can request the researchers not to present, share or publish the results of the survey beyond official requirements. If you wish to have your participation remain confidential but would like to still grant use of the data, *the researcher will take all reasonable steps to record and publish the information in a way that the community feels comfortable*. If the community does not request the results of the survey to remain confidential, the project will be credited to them and the researchers will be able to use all materials in their research.

If the community does not want the survey/data to remain confidential,

5. On their request, community members that take part can be idenitifed in research products. This means when participants are listed in the materials, their names will appear. We also invite interested community members to become active collaborators with our research team and their work can be credited by name in published materials.

6. The community understands the information and data they provide may be published. *Once this information is published, they can no longer withdraw their consent for its use.*

7. The community understands the information they provide will be used in William Wadsworth Master's thesis, along with other communities' data, and that this report will be publicly available through the University of Alberta and copies will be given to the community. This Master's thesis may be used in the development of teaching materials, academic articles and public presentation, as long as the original conditions regarding the giving of consent for this project remain intact.

8. The research will be kept confidential, except for the purposes indicated in this consent form, or when required to be disclosed by professional codes of ethics or law.

9. The researcher(s) will keep records of the survey in a secure location at the University of Alberta, accessible only by the Research Team. The records will be kept until the community requests their destruction or until a reasonable time after publication, in accordance with University regulations.

10. The community will receive a copy of this consent form and the researcher will keep a copy.

CONSENT AND SIGNATURES

By signing this form, it is understood that:

1. PFN understands and recognizes the proposed project and its potential benefits and risks, and consents to the research (as outlined above).
2. The researchers understand that PFN's consent is freely given, ongoing and represents their partnership, thus consent can be withdrawn by the community at any point prior to the publication of the research.
3. Any data, publications and/or other materials produced as part of this collaboration will also be given to PFN for their records.

Signature of Community Official ____

Printed Name of Community Official ______________________________________

Signature of Researcher ____

Printed Name of Researcher ______________________________________

Signature of Academic Supervisor ____

Printed Name of Academic Supervisor ______________________________________

APPENDIX B: Geophysical Settings

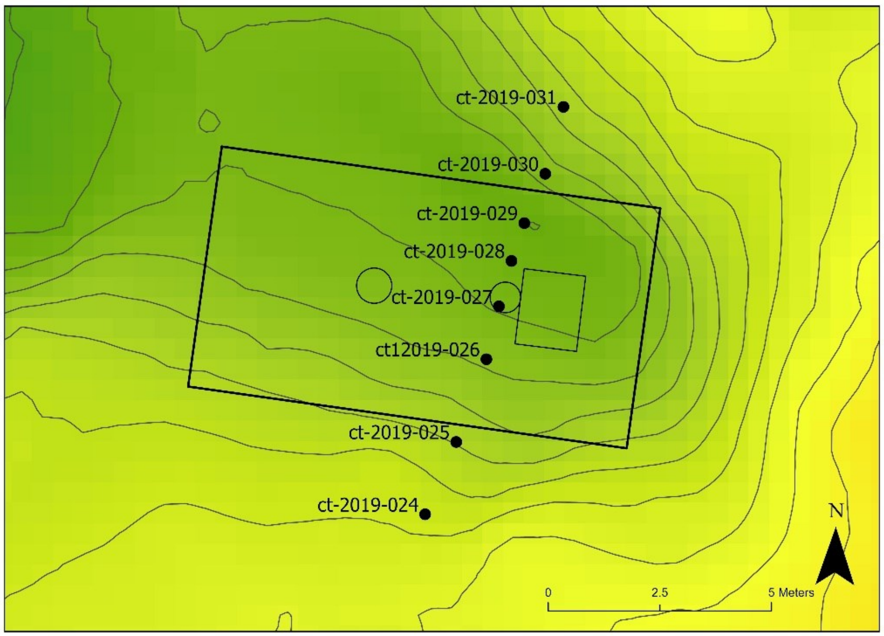
GPR													
Project	Community	Objective	Equipment	Antenna	Range	T-Rate	Samples	Scans /Unit	In-field Dielectric Constant	Post-Field Dielectric Constant	GP 1	GP 2	GP 3
CPFN Burial Ground	CPFN	Locate Unmarked Graves	GSSI SIR 3000	400 MHz	60 ns	100 KHz	1024	50	8	11	-20	36	51
PFN Burial Ground	PFN	Locate a lost cemetery	GSSI SIR 3000	400 MHz	70 ns	100 KHz	1024	50	8	10	-20	48	60
ECN Burial Ground	ECN	Determine extent of a cemetery	GSSI SIR 3000	400 MHz	60 ns	100 KHz	1024	50	8	11	-20	44	51
Prince Rupert Harbour	Lax Kw'alaams and Metlakatla	Resolve architectural patterns and features in Tsimshian Houses	GSSI SIR 3000	400 MHz	90 ns	100 KHz	1024	50	8	20	-20	42	60
Chimney Coulee	Métis	Locate Métis Overwintering Cabins	GSSI SIR 3000	900 MHz	20 ns	100 KHz	1024	100	6.25	10	-20	36	49

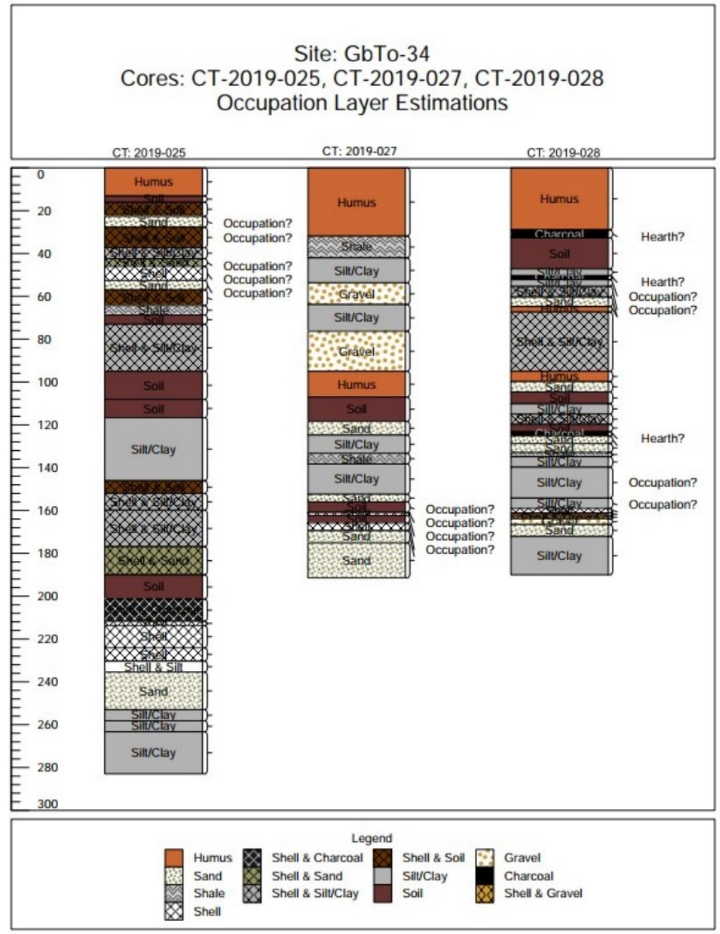
Magnetic Gradiometry											
Project	Community	Objective	Equipment	GPS	Mode	Tuning	AC Filter	Cycling	Set Distance between Sensors	Actual Distance between sensors	Distance between bottom sensor and ground
PFN Burial Ground	PFN	Locate a lost cemetery	GEM Systems GSM-19GW	yes	walkgrad	Auto	60 Hz	0.002	55 cm	55 cm	20 cm
Prince Rupert Harbour	Lax Kw'alaams and Metlakatla	Resolve architectural patterns and features in Tsimshian Houses	GEM Systems GSM-19GW	no	walkgrad	Auto	60 Hz	0.002	100 cm*	55 cm	30 cm
Chimney Coulee	Métis	Locate Métis Overwintering Cabins	GEM Systems GSM-19GW	no	walkgrad	Auto	60 Hz	0.002	100 cm*	55 cm	30 cm

* Set at 100 cm to record the actual difference and calculate the gradient manually later.

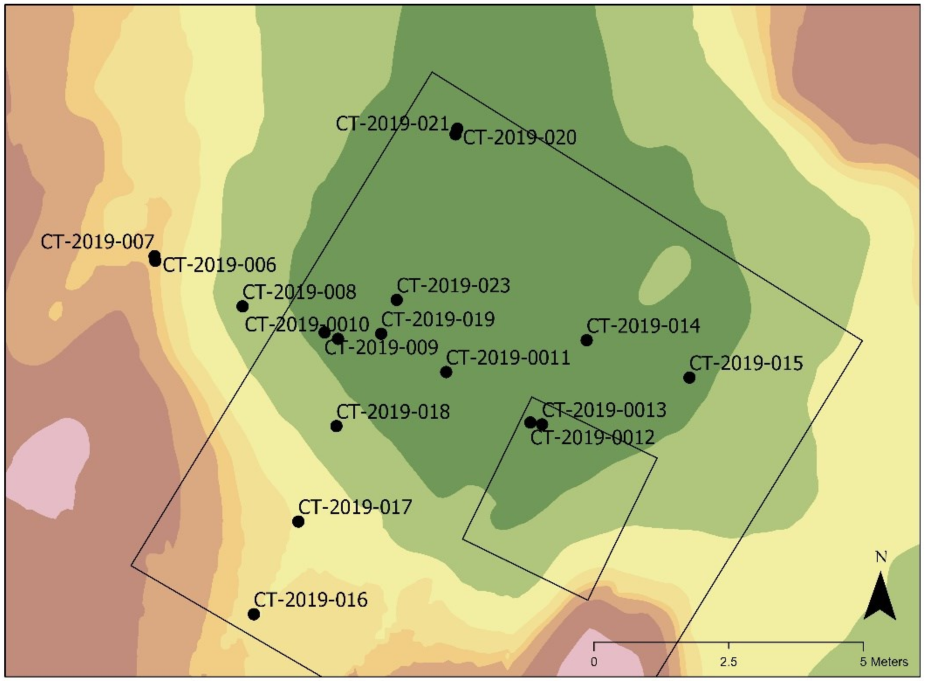
APPENDIX C: Preliminary Coring Results from GbTo-34 and GbTo-4

GbTo-34

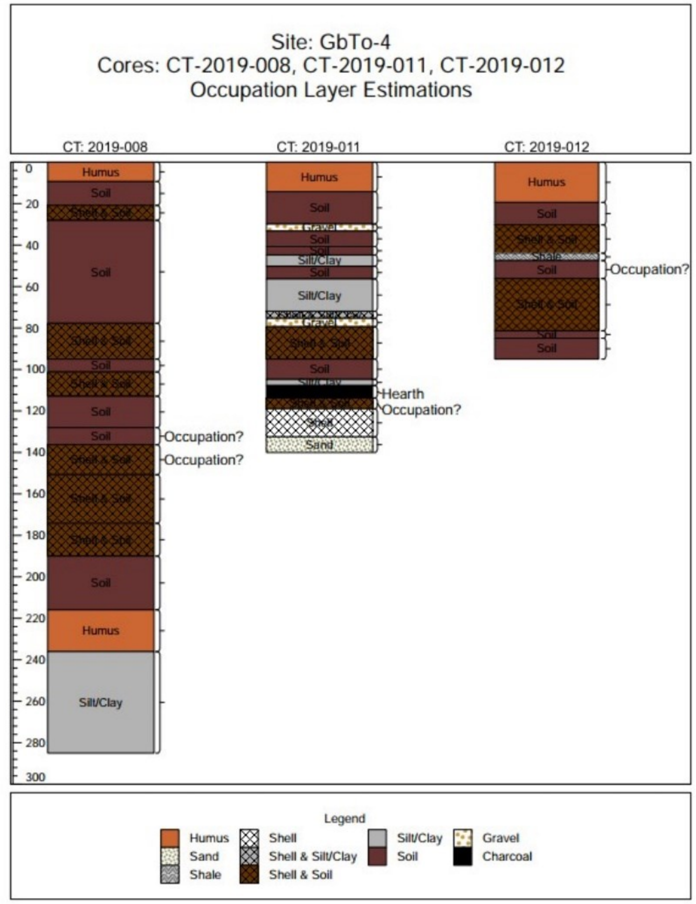




GbTo-4



CT-2019-021
CT-2019-020
CT-2019-007
CT-2019-006
CT-2019-008
CT-2019-023
CT-2019-0010
CT-2019-019
CT-2019-009
CT-2019-014
CT-2019-0011
CT-2019-015
CT-2019-018
CT-2019-0013
CT-2019-0012
CT-2019-017
CT-2019-016
N
0
2.5
5 Meters



Site: GbTo-4
Cores: CT-2019-008, CT-2019-011, CT-2019-012
Occupation Layer Estimations
CT: 2019-008
CT: 2019-011
CT: 2019-012
Occupation?
Occupation?
Hearth
Occupation?
Occupation?
Legend
Humus
Sand
Shale
Shell
Shell & Silt/Clay
Shell & Soil
Silt/Clay
Soil
Gravel
Charcoal

APPENDIX D: Additional Photos from Chimney Coulee Excavation Units 9 and 11

Excavation Unit 9: The 50 x 50 cm (then, 1 x 1 m) Chimney unit

The surface of Layer B1, after topsoil (Layer A) was removed.

Another photo of B1, rodent disturbance discovered in the unit.

Surface of B2. Beginning to see feature emerge. Many artifacts start to be found.

Chimney feature uncovered. Many large stones, charcoal, and animals are found.

Close up photograph of the beginning of the feature. Thumbtacks denote artifacts.

When the feature was found, the unit was expanded to 1 x 1 m. More large stones were found. Thirteen of these were sampled by a University of Alberta Physics professor to evaluate their magnetic character.

Excavation Unit 11: The 50 x 50 cm wood wall unit

The surface of Layer B1, after topsoil (Layer A) was removed.

The surface of Layer B2, artifacts starting to appear (denoted by thumbtacks). Beginning to see diagonal separation between NE and SW sides of the unit. Also, small pieces of wood are being uncovered.

The middle of Layer B2. Clear separation in soil between outside and inside the cabin. Larger pieces of wood remains being found.

The top of the thin Layer C1 (occupation layer). Very clear separation in soil between outside and inside the cabin. Larger pieces of wood remains.


NE Corner of EU11 profile photograph. Wood wall visible in the profile between Layer B2/D transition.


NW Corner of EU11 profile photograph. Wood wall visible in the profile between Layer B2/D transition.

N Profile of EU 11. Wood wall clearly visible between Layer B2/D transition.