Sensing Houses: New Investigations of Ground-penetrating Radar at Tsimshian Village sites on the Northern Northwest Coast

William T.D. Wadsworth, Institute of Prairie and Indigenous Archaeology, University of Alberta; Andrew Martindale, University of British Columbia; Kisha Supernant, Institute of Prairie and Indigenous Archaeology, University of Alberta; Colin Grier, Washington State University*

Summary

Archaeologists have embraced GPR as a powerful tool for exploring subsurface spatial patterns in the archaeological record without excavation. Yet, remote sensing technologies have not been widely applied on the Northwest Coast of North America, largely because the most common anthropogenic site matrix is the heterogenous shell-bearing site (shell midden). The Prince Rupert Harbour (PRH) region (Figure 1), home of the Coast Tsimshian is an example of this geophysical challenge. It has been systematically mapped for over five decades, creating a large inventory of massive shell terraced villages at which geophysical surveys have not been widely employed. The Tsimshian have inhabited PRH for millennia, building monumental winter villages that are represented in the archaeological record and detailed Indigenous oral histories. The Tsimshian had a highly specialized yet diverse marine economy, a keystone resource was shellfish, which resulted in village sites engineered with shell matrices through recurrent deposition from food consumption, but also as a result of massive short-term terracing projects. In this paper, we describe our initial efforts to resolve architectural patterns in this complex archaeological and environmental context and compare the radar results to magnetic gradiometry and low impact ground-truthing results, including sediment coring and mapping of erosion faces. We also discuss the challenges, potential benefits, limitations and efficacy of developing a GPR-based feature confidence index to predict the identity of subsurface archaeological features from geophysical signals in such complex subsurface components. Finally, we consider the utility of GPR as a tool for community heritage management.

Introduction

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) (Ames and Martindale, 2014). They had a highly specialized yet diverse marine-based economy focused on shellfish, salmon, oolichan (or eulachon), herring and a suite of other resources obtained from both sea and land. The focus on shellfish created dense shell matrices in and around village sites, and the footprint of ancient houses are often clearly defined by ridges of shell matrix. The winter villages at PRH appear to have denser shell matrices than elsewhere on the NWC (Ames and Martindale, 2014). Previous excavations have recorded complex feature associations across occupational surfaces within and beyond houses; complex house construction strategies including sequential rebuilding, floor rejuvenations, and subsurface excavations; and shell terrace construction that occurs beneath, within, and above occupational components (Martindale, 1999). In addition to this heterogeneity, shell terraces contain a wide range of materials including burials, stone features, paleosols, and an uneven subsurface of bedrock outcrops and wetlands. In addition, the area has extremely high annual precipitation (+3 m) and is densely forested. While this unique setting represents a challenge for GPR and other remote sensing approaches, it is also a context in which traditional excavation is inefficient due to the unconsolidated nature of shell, which requires horizontal stepping or shoring.

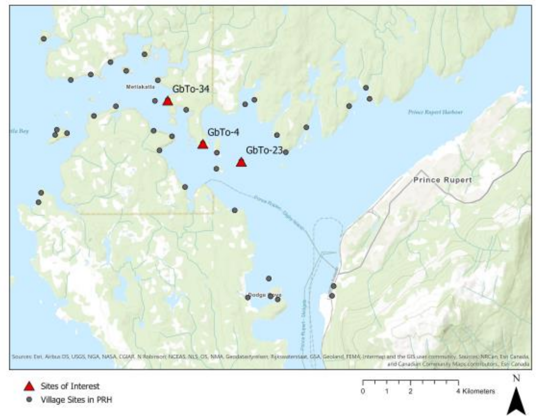

Figure 1: A regional map of Prince Rupert Harbour, British Columbia with archaeological sites. Red triangles represent the sites that were surveyed as part of this study.

Given the remarkable preservation, investigating Tsimshian houses and settlements has long been a focus for archaeology in the region (concerted excavation of village sites in PRH began in 1966) (Ames and Martindale, 2014). It is from these years of excavation, that household features and structure are well understood archaeologically (Martindale, 1999). In 2011, Andrew Martindale (UBC) and Kenneth Ames (PSU) began the current PRH project in the hopes of departing from intensive excavations toward a low-impact and multilinear data collection methodology in order to improve the breadth of data available and to emphasis Tsimshian objectives for the study of their own past. An extension of this objective, in 2019, geophysical surveys began to be conducted to explore the possibility of developing a feature confidence index, which seeks to establish predictable correlations between geophysical signals and inventoried features in order for the future identification of features using remote sensing alone.

The Sites

While the PRH region has been consistently mapped for over five decades, few geophysical studies have been conducted (but see Cross 1996), and no ground truthing efforts have been undertaken to evaluate geophysical data quality. Our current project seeks to develop a new methodological approach to apply archaeological remote sensing techniques to expedite the survey and mapping of village sites. In 2019, geophysical exploration was conducted on three village sites in PRH to test the efficacy of GPR and magnetometry in locating Tsimshian archaeological features at three large and previously documented village sites: GbTo-23 (Garden Island), GbTo-34 (Kitandach) and GbTo-4 (Figure 1).

Garden Island is the smallest site of the three village sites, located on an island at the eastern outlet of PRH (Ames, 2005). The site is represented by one house row including four houses defined by shell-rich ridges and is dated to approximately 1200-4200 BP (Ames, 2005). The site has been disturbed by coastal erosion and the impact of a modern cemetery (Ames, 2005). Significant community interest exists 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 from the same exposure.

Kitandach (GbTo-34), a much larger village site, has been the subject of significant archaeological investigation. The site has three house rows, 17 house depressions and has radiocarbon dates with a median date range of 313 to 5721 cal. BP (Letham et al 2017). Given Kitandach's prominence and importance in the archaeological record of the harbour, the current PRH project has collected high resolution topographic data, systematic percussion cores, and radiocarbon dates from GbTo-34 in order to establish its occupation history.

GbTo-4 is also a significant and substantial village for Coast Tsimshian peoples and archaeologists. 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. The site includes two house rows and 12 house depressions that date to 240-3180 cal BP (Letham et al. 2016). Beyond these dates, GbTo-4 is historically known to have been occupied into the later historic period, up to the 1830s. Our geophysical survey mapped the house that is associated with Ligeex.

Methods

At Garden Island, a GSSI SIR 3000 GPR console with a 400 MHz center frequency antenna was used to systematically survey the erosional profile. The same GPR set up, paired with a GEM Systems GSM-19 overhauser magnetometer, was used to survey one house depression at both the Kitandach and GbTo-4 sites. These sites had been previously mapped and sediment cores had been obtained prior to our geophysical survey (Letham et al. 2017), providing baseline data with which to compare geophysical results and evaluate collection strategies. Both GPR and Magnetic gradiometry were conducted on the same grids that covered the depression and beyond (approximately 10 x 15 m (Kitandach) and 15 x 20 m (GbTo-4)), with transects spaced 25 cm apart and conducted in X and Y directions. Given the substantial topographic variation of the house depressions when moving from external ridges to interior floor areas, the ground-penetrating radar data was corrected for elevational differences. Elevations were sampled from high-density topographic maps produced in previous years of the project. GPR profile analysis was conducted with GPRViewer (Conyers and Lucius, 2016) (Figure 2), and time slices were created with GPR Process (Conyers and Lucius, 2010). SIGKit, a MATLAB based data modeling and processing software developed at the University of Toronto (Kruse et al. 2017), was used to analyze the magnetic data (Figure 2). Some features interpreted in the geophysical results, primarily the possible central hearths, were then ground-truthed with percussion cores. While this ground-truthing is still preliminary, hearths are suspected to be indicated by layers of dark sand/soil layers, containing charcoal and plant materials, above or interspersed between shell layers,

Results

In regions other than the NWC, significant survey of shell-rich matrices has taken place (Miller et al., 2018), but values for the dielectric constant of these matrices have not been regularly reported. Moreover, the dielectric constant of particular shell deposits can vary based on their constituents and many other local factors. As a result, it is necessary to determine a suitable approximate value for each site under study (Miller et al., 2018). An erosion profile at Garden Island was surveyed and used as a test site to compare real-life stratigraphic measurements to GPR data. By solving for radar velocity using observed stratigraphic depths and the two-way time produced from the GPR, an estimated dielectric constant of 20 for the profile was determined. Comparing this to hyperbolae estimation values from other sites around the harbor led to an estimated range of 20-23.

Analyzing the stratigraphic profile and the GPR data from Garden Island also led to basic conclusions about how radar

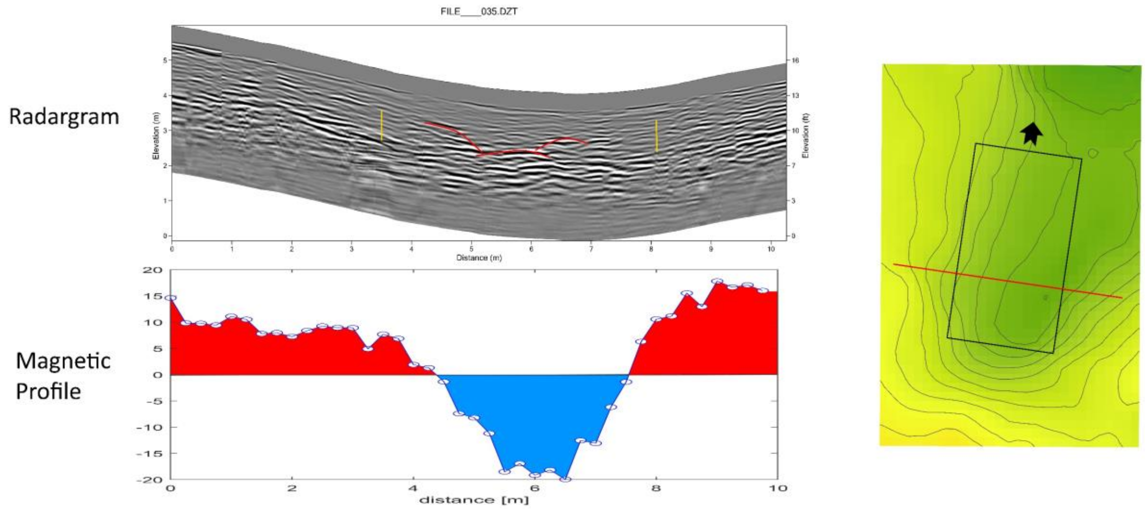

Figure 2: Cross-sectional profile of GbTo-34's House 16. Left) Elevation corrected GPR radargram and interpreted hearth, and magnetic profile (nT/m). The interpreted hearth corresponded with magnetically negative values (-15 to -20 nT/m). Outside the interpreted house boundaries (approximate yellow lines) were highly reflective and overlapping shell midden layers that corresponded with positive magnetic values (+10 to +20 nT/m). Right) Profiles (red) over interpreted house on an elevation map, the black arrow denotes the entrance to the house.

reacts in dense shell and saturated environments. First, the higher water content slows radar waves' velocity which results in fewer (due to worse energy penetration/reflection) and laterally defined diffraction hyperbolae (Conyers 2016). Second, the variation between different shell layers drastically changes the GPR signal. Specifically, depending on how crushed and dense the shell layers are, determines how they appear in the GPR data. The knowledge obtained from Garden Island was then applied to the investigation of house depressions at GbTo-34 and GbTo-4.

The goal at Kitandach and GbTo-4 was to identify commonly excavated Tsimshian architectural features, such as hearth features, using geophysical survey, and compare geophysical signals with the depositional record as observed through percussion coring of site deposits. Of most importance to the PRH archaeology project was the identification of hearths so that houses could be percussion core tested and radiocarbon dated to establish occupational chronologies. Drawing on archaeological and ethnographic depictions, central basin-shaped depressions found in the GPR profiles were interpreted as hearths. These large hearth features spanned several meters and correlated with the lowest negative values in magnetic data (-20 to -30 nT/m) (Figure 2). Percussion cores from these identified hearths contained layers of burned sand and pieces of charcoal at the expected depths, supporting our conclusion these were hearths.

While impossible to discuss at length here, indications of other architectural features were found at both Kitandach and GbTo-4. Combining both GPR and magnetic data allowed for the dimensions of the houses to be interpreted and features potentially identified (Figure 3). Among these features were possible posts or post molds, the interface between house 'walls' and shell middens that surrounded the house, and magnetically negative house 'floors'. When percussion cored, these geophysical interpretations of features and the ground-truthing results were found to be it broadly corroborative.

Conclusions

Methodologically speaking, most Northwest Coast sites would not typically provide a favourable environment for remote sensing techniques. Nonetheless, our results indicate that Prince Rupert Harbour sites are conducive to geophysical study. GPR and magnetic gradiometry surveys have proven effective, when applied in high resolution survey strategies, at identifying Tsimshian architectural features in a variety of archaeological contexts. Using an erosional profile at Garden Island, we established an approximate dielectric constant range for use at PRH sites. At Kitandach and GbTo-4, geophysical signals were correlated with hearths and other expected archaeological features, suggesting a consistent and potentially predictable relationship between the two realms. Corroborated with previous archaeological excavation results and preliminary percussion coring analysis, the 2019 results are optimistic for the future development of a feature confidence index for the harbour.

The PRH project 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.

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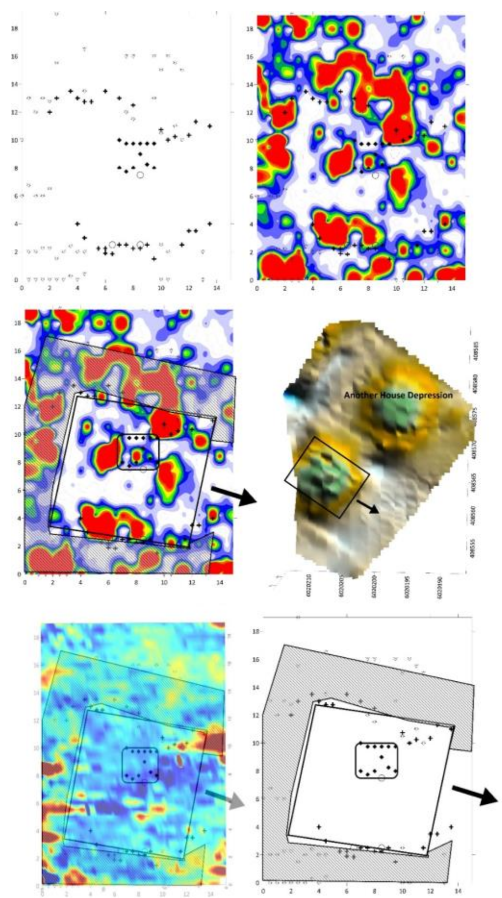

Figure 3: GbTo-4 Results from Chief Ligeex's House. Top) Post map with identified features from GbTo-4 and then the post map overlaying 30-35ns TWTT amplitude map. Middle) Interpretation of the house overlaying the amplitude map, as well as elevation map of the GbTo-4 site. Bottom) Site interpretation over magnetic map and resulting interpretation map.

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