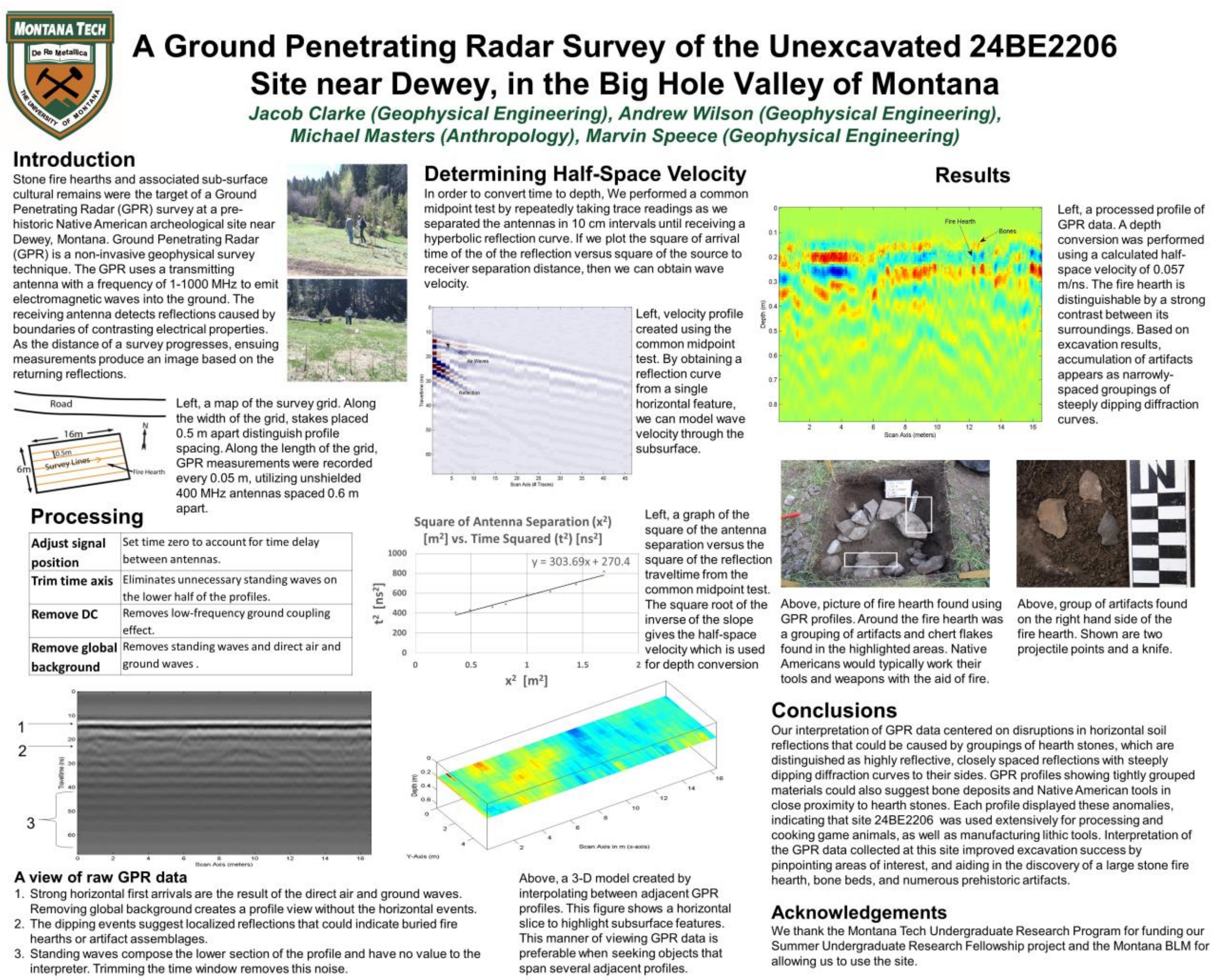
Summer Undergraduate Research Fellowship (SURF) Testimonial:

"A Ground Penetrating Radar Survey of the Unexcavated 24BE2206 Site near Dewey, in the Big Hole Valley of Montana", Jacob Clarke & Andrew Wilson (Geophysical Engineering), M. Masters & M. Speece

"Our involvement with the Montana Tech SURF educated us in a geophysical method and gave us valuable background experience in the field of geophysics. We were under the guidance of two professors at Montana Tech, Dr. Mike Master (Liberal Studies) and Dr. Marvin Speece (Geophysical Engineering). The ability to collaborate and seek advice from these two was invaluable and gave us the ability to be in a constructive work environment. Our project was to utilize Ground Penetrating Radar (GPR) and an Electromagnetic (EM) field based geophysical method to explore electrical properties of the near subsurface. The goal was to use GPR to locate archeological targets such as fire-cracked rock groupings or stone fire hearth as well as numerous diagnostics artifacts such as projectile points and bone tools. With this career development promoted through Tech's SURF program, we feel confident going forward with our career choice and have the necessary background experience for seeking industry employment."



A Ground Penetrating Radar Survey of the Unexcavated 24BE2206 Site near Dewey, in the Big Hole Valley of Montana

Jacob Clarke (Geophysical Engineering), Andrew Wilson (Geophysical Engineering), Michael Masters (Anthropology), Marvin Speece (Geophysical Engineering)

Introduction

Stone fire hearths and associated sub-surface cultural remains were the target of a Ground Penetrating Radar (GPR) survey at a pre-historic Native American archeological site near Dewey, Montana. Ground Penetrating Radar (GPR) is a non-invasive geophysical survey technique. The GPR uses a transmitting antenna with a frequency of 1-1000 MHz to emit electromagnetic waves into the ground. The receiving antenna detects reflections caused by boundaries of contrasting electrical properties. As the distance of a survey progresses, ensuing measurements produce an image based on the returning reflections.

Left, a map of the survey grid. Along the width of the grid, stakes placed 0.5 m apart distinguish profile spacing. Along the length of the grid, GPR measurements were recorded every 0.05 m, utilizing unshielded 400 MHz antennas spaced 0.6 m apart.

Processing

Adjust signal position	Set time zero to account for time delay between antennas.
Trim time axis	Eliminates unnecessary standing waves on the lower half of the profiles.
Remove DC	Removes low-frequency ground coupling effect.
Remove global background	Removes standing waves and direct air and ground waves .

A view of raw GPR data

1. Strong horizontal first arrivals are the result of the direct air and ground waves. Removing global background creates a profile view without the horizontal events.
2. The dipping events suggest localized reflections that could indicate buried fire hearths or artifact assemblages.
3. Standing waves compose the lower section of the profile and have no value to the interpreter. Trimming the time window removes this noise.

Determining Half-Space Velocity

In order to convert time to depth, We performed a common midpoint test by repeatedly taking trace readings as we separated the antennas in 10 cm intervals until receiving a hyperbolic reflection curve. If we plot the square of arrival time of the of the reflection versus square of the source to receiver separation distance, then we can obtain wave velocity.

Left, velocity profile created using the common midpoint test. By obtaining a reflection curve from a single horizontal feature, we can model wave velocity through the subsurface.

Square of Antenna Separation (x^2) [m^2] vs. Time Squared (t^2) [ns^2]

$y = 303.69x + 270.4$

Left, a graph of the square of the antenna separation versus the square of the reflection traveltime from the common midpoint test. The square root of the inverse of the slope gives the half-space velocity which is used for depth conversion

Above, a 3-D model created by interpolating between adjacent GPR profiles. This figure shows a horizontal slice to highlight subsurface features. This manner of viewing GPR data is preferable when seeking objects that span several adjacent profiles.

Results

Left, a processed profile of GPR data. A depth conversion was performed using a calculated half-space velocity of 0.057 m/ns. The fire hearth is distinguishable by a strong contrast between its surroundings. Based on excavation results, accumulation of artifacts appears as narrowly-spaced groupings of steeply dipping diffraction curves.

Above, picture of fire hearth found using GPR profiles. Around the fire hearth was a grouping of artifacts and chert flakes found in the highlighted areas. Native Americans would typically work their tools and weapons with the aid of fire.

Above, group of artifacts found on the right hand side of the fire hearth. Shown are two projectile points and a knife.

Conclusions

Our interpretation of GPR data centered on disruptions in horizontal soil reflections that could be caused by groupings of hearth stones, which are distinguished as highly reflective, closely spaced reflections with steeply dipping diffraction curves to their sides. GPR profiles showing tightly grouped materials could also suggest bone deposits and Native American tools in close proximity to hearth stones. Each profile displayed these anomalies, indicating that site 24BE2206 was used extensively for processing and cooking game animals, as well as manufacturing lithic tools. Interpretation of the GPR data collected at this site improved excavation success by pinpointing areas of interest, and aiding in the discovery of a large stone fire hearth, bone beds, and numerous prehistoric artifacts.

Acknowledgements

We thank the Montana Tech Undergraduate Research Program for funding our Summer Undergraduate Research Fellowship project and the Montana BLM for allowing us to use the site.