

Archaeology: Combining mapping techniques with digital technology

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By combining traditional mapping techniques with digital technology, archaeological researchers aim to provide a comprehensive package for understanding domestic space and everyday lives.

In North America, the Bad Pass Trail runs for miles along the western side of rugged Bighorn Canyon in southern Montana and northern Wyoming. Today it consists of numerous rocks piles or cairns, which once helped guide travelers along the treacherous canyon country.

People also left behind rocks that once held down the bottoms of lodges at campsites along the trail, which remind us of where tipis once stood. Archaeologists call these circular arrangements of rocks that cover much of the North American Plains, tipi rings or stone circles (see Fig. 1). These sites provide essential information about the past lives of Plains inhabitants. Of the many indigenous groups who followed the Bad Pass Trail, the Crow still live closest to Bighorn Canyon. According to Crow Studies scholar Timothy McCleary, the word for prehistory in the Crow language is translated as "when we used stones to weigh down our lodges." Research at stone circle sites in Bighorn Canyon is a highly effective way to combine anthropological inquiry, interpretive and innovative public outreach, and Native American participation.

For the last three summers, we have directed archaeological field schools at Bighorn Canyon National Recreation Area (NRA) in Carbon County, Montana. Students assist with documenting stone circle sites using 21st century technology (see Figs. 2 and 3). This work is part of a larger research project, Exploring Historical and Social Landscapes of the Greater Yellowstone Ecosystem, which involves researchers and students from Indiana University (Bloomington, Indiana), Northwest College (Powell, Wyoming), and Little Big Horn College (Crow Agency, Montana).



Fig. 1: Tipi rings at Mustang Flat, 2007.

By combining traditional mapping techniques with digital technology, we provide a comprehensive package for understanding domestic space and everyday lives. Data from individual rings reveal information about past economic and social organisation, domestic and ritual use of space, and worldview. This information can be summarised and provided to park visitors. Among the Crow, or Apsáalooke, who traditionally occupied Bighorn Canyon, stone circles are becoming synonymous with the past and ancient lifeways. We hope that our research on these sites will create a springboard for further dialogue between archaeologists and Crow community members.

Bighorn Canyon NRA provides a unique setting to address questions about stone circles as a record of domestic life. First, the canyon country served as a natural travel corridor between

the Bighorn Basin and High Plains to the south and the unglaciated Missouri Plateau to the north for thousands of years. Domestic activity was a strong component of travel, evidenced by numerous stone circles located within the park boundaries. Second, Bighorn Canyon lies at the heart of Crow territory. The Crows immigrated to the area as recently as the late 16th century. During this time, they were in transition from a semi-sedentary horticultural life to one as nomadic bison hunters. These changes brought about transformations in social and ritual life. Soon afterward, Crow Indians made contact with the first Euroamerican explorers. Impacts of 19th century culture contact and colonialism reverberated with extant transformational trends in Crow life as they changed from a nomadic hunting culture with horticultural roots to a sedentary ranching and reservation-



Fig. 2: Field school students map tipi rings at Mustang Flat, Bighorn Canyon NRA, overlooking Bighorn Canyon and the Bighorn Mountains to the east. L-R: Evan Lewis, Karina Black, Catherine Page, Ashley Howder, Ed Herrmann, Patrick Hill, Kirk Chambers, Zac Muller, Kelly Branam and Ted Preator.



Fig. 3: Graduate student Maureen Boyle gives a GPS demonstration to the 2007 archaeology field school. L-R: Patrick Hill, Ted Preator, Karina Black, Catherine Page, Kelly Branam, Ed Herrmann, Zac Muller, Jake Gee, Kirk Chambers and Ashley Howder.

based lifeway. Domestic campsites in Bighorn Canyon bear witness to these transitions.

Stone circle studies

Stone circles are recognised as one of the few forms of preserved indigenous domestic architecture on the North American Plains, dating at least to 5000 years ago. Prior to the historic use of wooden stakes as tent pegs, Plains Indians used stones as tipi weights. Once moved, stones often stayed in place, preserving the superstructure characteristics of the lodge. Stone circles at Bighorn Canyon supply abundant archaeological data while also linking contemporary Crow Indians

to their own history and cosmovision through vast oral traditions. Between 1968 and 1974, nearly 120 stone circle sites were documented at Bighorn Canyon NRA and the surrounding area, as described by Larry Loendorf and Lori Weston in a 1983 Plains Anthropologist article. We estimate that as many as 1000 stone circles within the park boundaries require reinvestigation under the current National Park Service condition assessment mandate. Loendorf and Weston attributed sparse or absent artifacts at sites along travel corridors like the Bad Pass Trail to brief occupational durations. We propose instead that the variation is a product of a hundred years of recreational

artifact collection. We believe our current fieldwork paints a positive picture for stone circle research, and the sites at Bighorn Canyon are a perfect test-case for this approach.

We developed a four-stage data collection methodology that allows us to conduct analysis at distinct complimentary levels. First, we teach our students how to hand-draw accurate planview maps of each stone circle using graph paper, measuring tapes, protractors, and compasses. Planviews capture the singularity of individual rocks that make up the stone circles (see Fig. 4).

Second, we record information on each rock, feature, and artifact using Dell Axim X51v Personal Data Assistants (PDAs) and Magellan (formerly Thales) ProMark 3 survey-grade Global Positioning System (GPS) receivers. PDA data recording is an efficient, high-speed process that reduces human transcription error and provides immediate program compatibility with Microsoft Access (see Fig. 5). The Windows Mobile version of Access called Data on the Run allows researchers to create drop down menus to record qualitative data such as artifact material type, which again reduces typing errors. PDA attribute collection covers a wide range of descriptive and quantitative data for each stone circle, including diameters, orientations, and presence or absence of doorway openings and associated features such as cooking hearths.

The ProMark 3 equipment provides fine-grained, sub-centimetre location data on individual stones, features, and artifacts. The use of the ProMarks also allow us to fine-tune our methodologies in the field, particularly to choose appropriate duration of shots depending on satellite coverage and feature type (see Fig. 6). Thus, all stones in a circle can be shot at a consistent 15-second interval that streamlines our data across circles, sites, and field seasons. Locational data from the receivers are uploaded to ArcMap 9.1 GIS software on a Dell D610 laptop computer (see Fig. 7). We daily plot the GPS data, which are joined to attribute information for each item in an Access data table.

Geophysical survey is the third analytical level that provides an important window into subsurface deposits. David Maki from Archaeo-Physics conducts gradiometry surveys using a Geoscan Research

FM256 fluxgate gradiometer (see Fig. 8). Data are collected in transects spaced at 0,50 m, with 8 samples collected per linear metre for an overall data sample density of 16 samples per square metre. This step is particularly informative for guiding excavation decisions as it measures the differential magnetic properties of cultural features (stone circles and fire hearths) buried within unmodified geological matrices.

Small targeted excavations provide the final analytical level, which allows us to collect essential datable charcoal samples from domestic hearths. Taken together, these archaeological data provide a baseline for understanding occupational chronologies of stone circle sites and American Indian domestic life.

Using survey-grade GPS for archaeology

We use three GPS receivers to record spatial information from stone circle sites. The first receiver is set up as a base, collecting static data in a stable location throughout the day. Base location is fixed at each archaeological site in order to increase accuracy among rover data collection events (e.g. between filenames and collection days) and to ease post-field data correction with permanent regional base stations, or continuously operating reference stations (CORS). The two additional receivers act as rovers, collecting stop-and-go survey data at individual points. The stop-and-go survey mode allows the GPS operator to move quickly and efficiently from point to point at a consistent recording interval. This mode also facilitates in-field data collection by allowing the GPS operator to alter recording intervals when appropriate, to stop between collection shots for any length of time, and presents a user-friendly educational mode for field school students. We average 6 mm accuracy vertically and horizontally with this data recovery system.

Both advantages and disadvantages exist for the use of this equipment and should be considered by anyone who is considering using survey grade GPS for archaeological research.

Commendations

- The system is ideal in flat or rolling topography and sparsely vegetated environments (e.g. high-altitude desert and open plains) with excellent satellite coverage.
- The equipment is fairly easy to use,



Fig. 4: Measuring diameters of each rock in a tipi ring with a standard tape measure. Data are then entered directly into PDAs.



Fig. 5: Data entered directly into a PDA.

and students benefit from training in GPS technology.

- The ProMark 3s provide phenomenal confidence intervals in spatial coordinates.
- These coordinates are tied into the UTM system not arbitrary grids, which are necessary when using a total station.
- The Global Satellite Navigation Systems (GNSS) Solutions software offered by Magellan in concert with the ProMarks is relatively user friendly.

Cautions

- Poor satellite coverage in topographic basins with tree cover means that single frequency GPS systems such as the one we are using are not as consistently useful

in remote wilderness areas where we are also working, although mission planning alleviates some of these problems.

- The set-up from site to site and day to day is a trial-and-error process. Using a fixed base point is necessary to facilitate later post-processing.
- The base tripod set-up is highly critical. High winds can knock over the base station.
- Although attribute data can be recorded directly onto the GPS receivers using the mobile mapping program, we chose to use the GNSS Solutions survey software for post-processing because the confidence levels are a few mm as opposed to about 20 cm. This means



Fig. 6: Judson Finley and Maureen Boyle (in back) record artifact locations with the GPS while Ashley Howder (in front) collects attribute data for each flake and tool.



Fig. 7: Tipi ring locational data overlay on orthophoto map using ESRI ArcGIS. Individual stones shown in green, centres shown in yellow.



Fig. 8: David Maki walks with a gradiometer over a tipi ring, measuring sub-surface thermal alterations.

Maki has surveyed 22 700 m² with subsurface remote sensing equipment. We performed limited excavations within several stone circles, revealing occupations that span between 2500 and 300 years ago. We have laid the foundation for a successful multi-year program that will assist Bighorn Canyon NRA in meeting its programmatic needs while advancing our research program.

Archaeology along the Bad Pass Trail is a combination of academic research, education, heritage, and resource management. We recommend that archaeologists consider adopting similar protocols if they are working in open country, are interested in household-level archaeological analysis, want to maximise and standardise archaeological site recording across landscapes, and wish to incorporate educational science programs that provide GPS/GIS skill sets useful across disciplines. Our methodologies allow for increased accuracy in spatial analysis and for increased coverage of archaeological landscapes at fine-grained scales that aid in site conservation for future generations. We also bring the accessibility of geographic knowledge in digital spatial models such as GIS to diverse audiences. Finally, our work is primarily a non-invasive surface mapping technique, which only minimally impacts the archaeological sites we hope to protect.

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that the attribute and coordinate data for each object need to be merged later, and that keeping the log points consistent is absolutely critical.

- Data must be post-processed every evening to ensure that all of the receivers collected data for the day and to ensure that the assigned GPS log points correspond with associated PDA attribute log points.
- The fixed base station coordinate data must be post-post processed against the CORS stations, available online through the National Geodetic Survey. Because we are staying in remote locations and do not have access to the internet during our fieldwork, we

cannot perform this task until after we leave the field, often months later.

Results of the Bighorn Canyon stone circle study

Two years ago we implemented our staged approach to stone circle analysis along documented travel segments of the Bad Pass Trail with funding from the Western National Parks Association, Indiana University Office of the Vice President for Research, Bighorn Canyon NRA, and Northwest College. Students have recorded 3782 rocks from 72 stone circles and 65 features at five archaeological landscapes. We also documented attribute data on 2109 stone tools and debitage. David