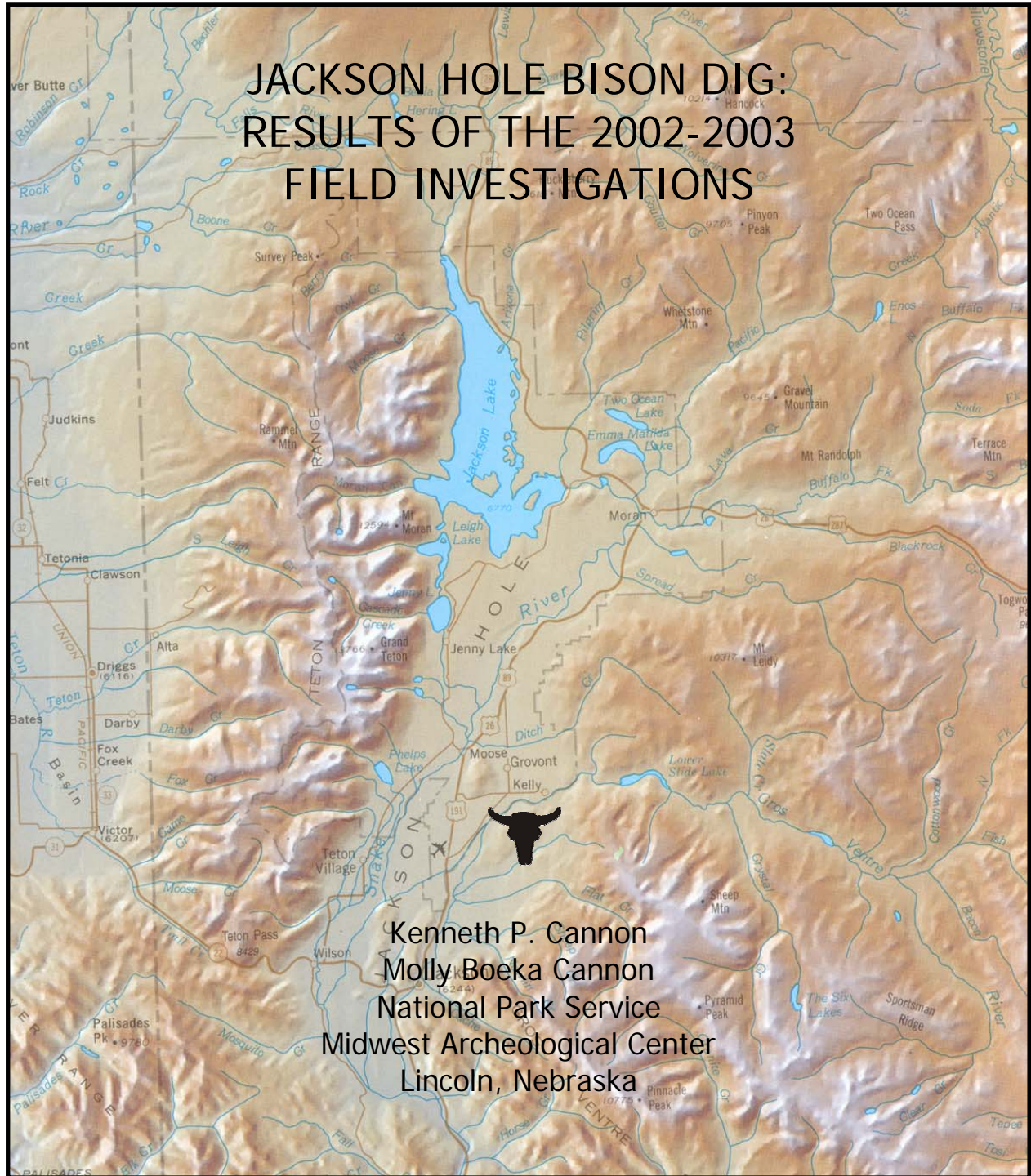


JACKSON HOLE BISON DIG: RESULTS OF THE 2002-2003 FIELD INVESTIGATIONS



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UNIVERSITY OF NEBRASKA-LINCOLN**

**JACKSON HOLE BISON DIG
22 JULY – 16 AUGUST 2002
16 JUNE – 13 JULY 2003**

**US FISH AND WILDLIFE SERVICE
NATIONAL ELK REFUGE
JACKSON, WYOMING**

**19 EARTHWATCH VOLUNTEERS (2002)
16 EARTHWATCH VOLUNTEERS (2003)**

4 November 2003

HIGHLIGHTS

2002 Field Season

The summer of 2002 was the second year of field work at the Goetz site. This field work built upon the knowledge gained from the 2001 season, but also expanded to new areas of the site. As we have discussed in numerous forums (e.g., Cannon et al. 2001), our understanding of the precontact Native American groups and their economy in Jackson Hole is limited and biased towards investigations along Jackson Lake and within Grand Teton National Park, so the information we uncover at the Goetz site adds tremendously to this database.

In addition to hand-excavation techniques, we applied the technology of geophysical survey in attempting to detect the presence of buried cultural deposits and more efficiently direct our subsurface investigations. Geophysics has many applications and uses many different technologies that range from measuring the earth's magnetic field to measuring the resistance of buried deposits to an electric current. At the Goetz site we used an instrument called a Fluxgate gradiometer. The Fluxgate is an instrument that measures deviations in the earth's magnetic field. These data can then be plotted to produce an image of magnetic anomalies found beneath the surface. These anomalies have positive and negative values that are compared to known values of archeological significance, such as fired rock (hearth) features and other ground disturbances. If one of these anomalies is identified and fits within our criteria for precontact deposits we "ground truth" the deposit through hand excavation.

The 2002 excavations confirmed the 2001 work that there is a much longer, and more diverse occupation represented at the Goetz site than the 1971 excavations indicated. The geomorphic setting, depth, and diagnostic artifacts indicate we have periodic occupations throughout the Holocene, or the last 10,000 years. The details of the occupations, such as the activities at the site and how these occupations may have changed through time, will come through comprehensive analysis of the recovered artifacts and ecofacts.

The excavations of 2002 uncovered a wide range of cultural deposits and material types. Analysis of the faunal remains has not been completed, but the species identified to date from the 2002 investigations includes elk, bison, deer or sheep, plus numerous rodents. It is apparent from the recovered faunal assemblage that more than just bison were hunted.

A 1-m-x-2-m test unit was excavated in an area adjacent to the existing spring in order to delineate the extent of 1971 dragline excavations and spoil pile deposits. Not only were we able to discern the presence of the spoil pile, but we also uncovered intact deposits. The intact deposits were water-logged and produced a large amount of lithic debitage, large mammal bone, and plant remains. Sediments from the water-logged deposits were water-screened. Due to the extensive nature of the deposits and the potential for them to produce high-quality paleoenvironmental data, we limited our excavations to only two levels. This area will be a high priority for excavations in 2004 when we can devote more resources to maximize recovery of cultural and environmental data.

A fired rock feature, probably used to cook plants or animals, was identified in 2001 and excavated in 2002 eroding from the intermittent drainage cutbank. Excavations indicated the feature was heavily eroded, but produced charcoal in association with the fired rock that will be used for radiocarbon dating. Stone tools, possibly used in processing game, were recovered in association with this feature.

Another aspect of the project, begun in 2001, was the mapping and collection of surface artifacts. Typically, surface artifacts can provide evidence of buried materials. What was amazing about the area where we found the highest concentrations of surface collected artifacts is that it was along the western

side of the drainage on the steep slopes of the valley wall. The surface artifacts represent large flakes and cores of local quartzites that were being reduced in order to make stone tools. Our initial impression of the artifact assemblage is that it represents the procurement and early stages of stone tool production.

In 2002 we hand excavated nine 1-m-x-1-m units for a total of 7.4 m³. We recovered 2,501 artifacts from the excavated units, 512 of which were piece-plotted in three dimensions. The density of excavated materials is 337.97 artifacts/m³. Nearly 700 lithic artifacts were mapped and collected from the surface (Table 1).

Table 1. Summary of results of excavations from 2002 and 2003 field investigations at the Goetz site (48TE455). Numbers are based upon preliminary analyses and cataloging and are expected to change following detailed laboratory analyses.

Year of Fieldwork	Units Excavated	Total Excavated m³	Number of Artifacts Excavated	Number of Artifacts Piece Plotted	Number of Surface Artifacts
2002	9	7.4	2,501	512	693
2003	7	3.6	2,871	955	627
Totals	16	11.0	5,372	1,476	1,320

July in Jackson Hole during 2002 was again hot and dry. Wildfires were again present in the region, although not as dramatic as the 2001 Green Knoll fire in Wilson. The hot-dry weather also produced fire bans on public lands. While it limited some of our cooking options, Patty was still able to keep us well fed and happy. Thanks Patty!

Figure 1. From left, Molly Boeka Cannon, Patty Jackson, and Michelle Cloud during a cool June night (6 June 2003).



Our campsite in the backcountry of Jackson Hole also allowed us a few surprises from the local quadrupeds. The coyotes serenaded us almost every night. We once again had a bull bison walk up the valley and use the spring, as well as a group of mule deer bucks and a moose cow and calf.

2003 Field Season

The 2003 field season had four goals: (1) to expand excavations around the 1,900-year-old feature uncovered in 2001; (2) further assess the deposits around the spring; (3) expand our surface collection; and (4) to conduct additional geophysical surveys using the Fluxgate gradiometer. Each of these goals was met. During the 2003 field season we excavated seven 1-m-x-1-m units for a total of 3.6 m³. This work produced 2,871 artifacts, of which 955 were piece-plotted. The high density of artifacts, 797.5/m³, mainly reflects the excavations around feature F01-01 which produced a large amount of fired rock, bone, and flaked lithic debris. We also mapped and collected 627 artifacts from the surface (Table 1).

The excavations (Units 24-26) adjacent to the spring produced a meter of deposits with a large amount of lithic debitage and bone. A large mammal bone from 90 cmbs was submitted for radiocarbon dating. This sample produced an age of 3,360 yrs BP. This radiocarbon date provides us with a minimum age for dating the landform, as well as providing additional data for interpreting the cultural remains within a more precise time frame. Radiocarbon dates are important because they represent one of the important initial steps to understanding more complex issues of subsistence, climate change, and post-glacial community structure is the development of a site chronology. Our current understanding of the site stratigraphy is largely circumstantial, based upon projectile point styles and stratigraphic context.

Because we began earlier in the summer in 2003 the weather was more variable than in the past (Figure 1). Our first week was cold and rainy with snow in the higher elevations. However, the weather rapidly turned warm and dry.

During the 2003 field season we had the good fortune of hosting students from the Redtop Meadows School in Jackson. Frank Meek from the local NBC affiliate in Jackson, KJWY, spent an afternoon videotaping our work. A short segment of the interviews was shown on the morning news. Molly and I also presented a poster on the ongoing work at the Goetz site at the Sixty-eighth annual meeting of the Society for American Archaeology in Milwaukee, Wisconsin.

ACKNOWLEDGEMENTS

To begin we would like to extend our gratitude to the Earthwatch Institute and the 35 volunteers who generously provided the funding, labor, and good humor that made this project not only possible, but also great fun (Table 2). Many thanks to Laurie Belton, Dana Abro, Jim Chiarelli, Katie Bryant, Sean Britt, Carla Handley, Phillip Johansson, and Blue Magruder of Earthwatch. You each contributed greatly to the success of this project. While financial support is always a key, logistical support and access to the Goetz site was provided the staff of the National Elk Refuge: Barry Reiswig, Ann Blakely, Jim Griffin, and Steve Brock. Thanks especially to Ann for taking the time from her numerous other duties to track our funds. Rhoda Lewis, the regional archeologists for the US Fish and Wildlife Service (USFWS), has been a good friend and without her support this project would not have succeeded. We would also like to extend our thanks to Brent Loflin and Galen Burgett, archeologists for the USFWS, who took time from their normal hectic schedules to help move some dirt. The USFWS also provided financial support for the 2003 field work through a Challenge Cost Share Grant.

Table 2. Earthwatch volunteer members for 2002 and 2003.

Team I 2002	Team II 2002	Team I 2003	Team II 2003
Kenneth Benson	Van Foster	Lauren Childs	Ewa Erickson
Glenda Cresto	Lucinda Foster	Michelle Cloud	Anne Fretz
Peter Etu	Peter Kuchar	Sophia Maria Garbarino	Jack Greenshields
Stacy Lapinski	Robert Lennartz	Mary Lochtefeld	Jordan Levinson
Michael Lowden	Jessica Lessing	Kathleen Moore	James Macomson
Jose Macias	Anthony Rogers	Sally Newcomer	Cynthia Nostrant
Albert Martins de Oliveira	Mary Rowe	Doreen Simon	Carla Spencer
Millie Parmalee	David Wasley		Blaise Whitman
Kerrodwen Parslow			
Matthew Sciarrotta			
Wesley Swaffer			

Ralph Hartley, Midwest Archeological Center (MWAC), has always been a supporter of our research, as well as a good friend. Thanks Ralph. Bonnie Farkas, also at MWAC, was responsible for tracking all the bookkeeping nightmares. Thanks Bonnie for helping us make this work. We would also like to thank Linda Zumpfe and Jill Bauers.

We would also like to thank Stephanie Crockett for her talents in keeping everyone amused. We miss the rubber snake. We also had some extra help in 2003 from the Watkins family. Jim, Susan, Will, and Sam spent a wonderful week with us. Thanks to y'all.

We would also like to extend our thanks to Patagonia, Inc., for their donation of outerwear to the field crew. Lynn and Jim Bama also provided a very generous donation to our project.

While it is obvious that this report is the result of the labors of many individuals, we, the authors, must take full responsibility for any errors or misinterpretations in the data reporting.

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OBJECTIVES

2002 Field Season

The 2002 investigations should be considered exploratory in nature (Figure 2). While the 2001 investigations focused upon trying to determine if there was additional evidence of the 1971 recovered material, the 2002 investigations were focused on understanding the distribution of precontact occupation both vertically and horizontally across the site.

The summer of 2002 was the second year of field work at the Goetz site. This field work built upon the knowledge gained from the 2001 season, but also expanded to new areas of the site. As we have discussed in numerous forums (e.g., Cannon et al. 2001), our understanding of the precontact Native American groups and their economy in Jackson Hole is limited and biased towards investigations along Jackson Lake and within Grand Teton National Park, so the information we uncover at the Goetz site adds tremendously to this database.

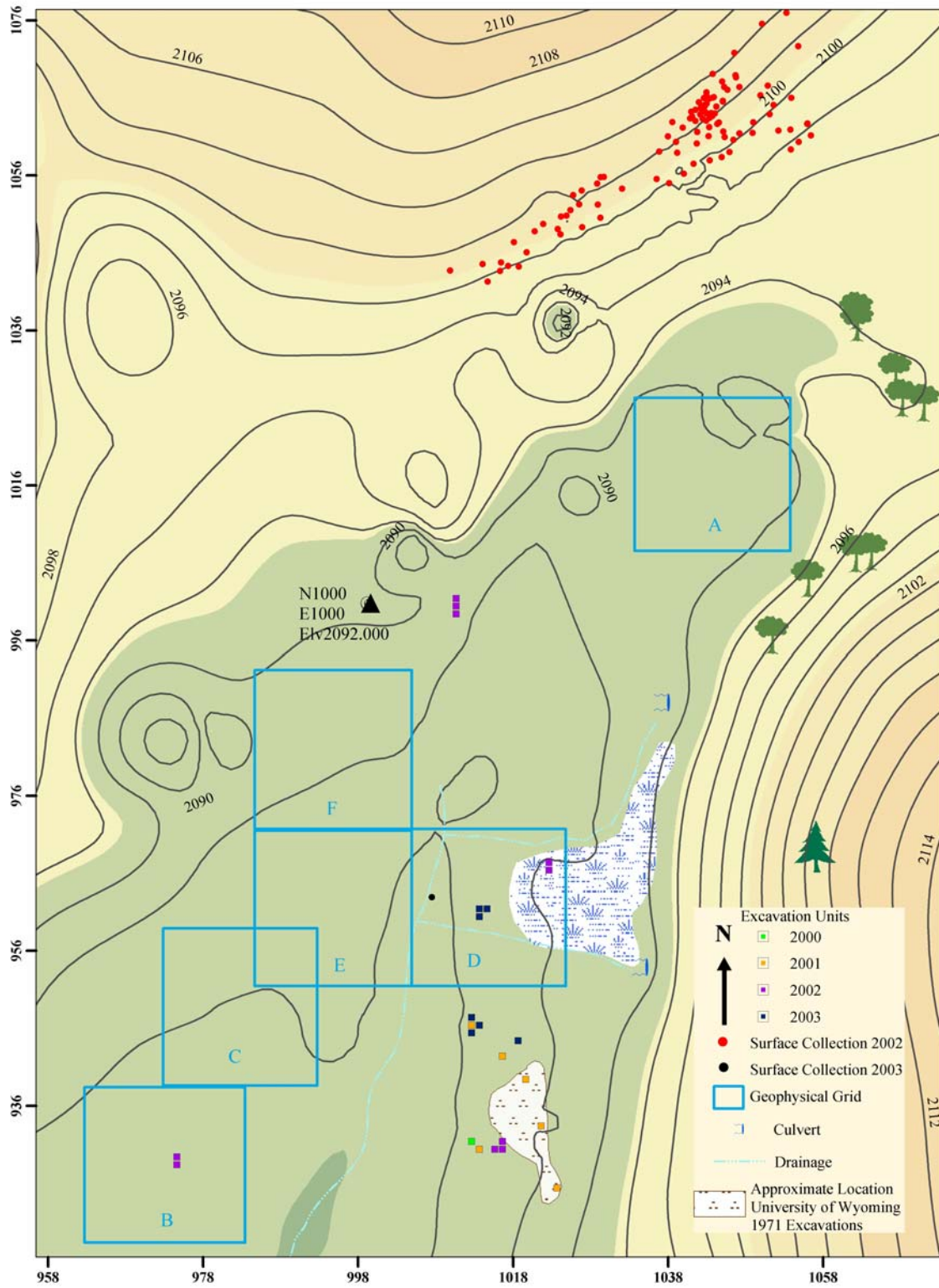
In addition to hand-excavation techniques, we applied the technology of geophysical survey in attempting to detect the presence of buried cultural deposits and more efficiently direct our subsurface investigations. Geophysics has many applications and uses many different technologies that range from measuring the earth's magnetic field to measuring the resistance of buried deposits to an electric current. At the Goetz site we used an instrument called a Fluxgate gradiometer. The Fluxgate is an instrument that measures deviations in the earth's magnetic field. These data can then be plotted to produce an image of magnetic anomalies found beneath the surface. These anomalies have positive and negative values that are compared to known values of archeological significance, such as fired rock (hearth) features and other ground disturbances. If one of these anomalies is identified and fits within our criteria for precontact deposits we "ground truth" the deposit through hand excavation. Because it was the first field season we applied this technique, and the application of magnetometer survey to hunter-gatherer sites is limited, we were learning right along with the volunteers.

The 2002 excavations confirmed the 2001 work that there is a much longer, and more diverse occupation represented at the Goetz site than the 1971 excavations indicated. The geomorphic setting, depth, and diagnostic artifacts indicate we have periodic occupations throughout the Holocene, or the last 10,000 years. The details of the occupations, such as the activities at the site and how these occupations may have changed through time, will come through comprehensive analysis of the recovered artifacts and ecofacts.

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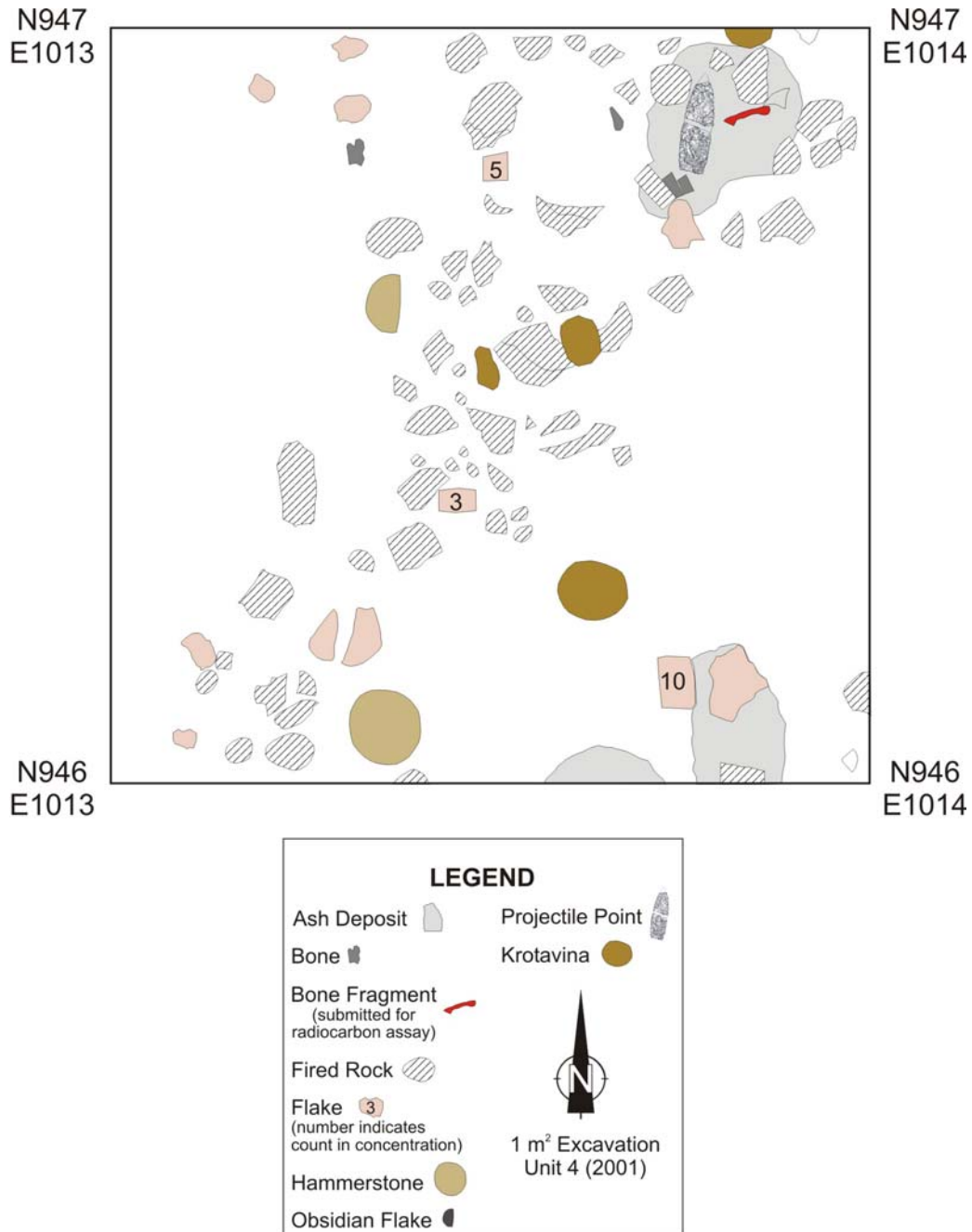
Figure 2. Map of the Goetz site illustrating the location of the past three year's investigations.



2003 Field Season

The 2003 field season had four goals: (1) to expand excavations around the 1,900-year-old feature uncovered in 2001 (Figure 3); (2) further assess the deposits around the spring; (3) expand our surface collection; and (4) to conduct additional geophysical surveys using the Fluxgate gradiometer. Each of these goals was met.

Figure 3. Plan view of feature F01-01 excavated in 2001.



METHODS

Introduction

Over the past 20 years, there has been a tremendous effort by archeologists to improve our ability to understand and interpret site formation processes in order to more completely understand human behavior. Foremost in this endeavor has been the detailed excavation of bone beds (e.g., Todd 1987). Therefore, our work at the Goetz site follows the protocol established by Todd (1987) and modifications made by colleagues, for example Todd and Rapson (1991) and Burgett (1990). All artifacts and ecofacts uncovered during excavation were mapped in three-dimensions, with dip and strike being recorded, as well as other characteristics of the specimen.

Specific attributes of the elements were also recorded in the field. These included information concerning completeness and portion of the specimen, breakage, and condition. All sediments were dry-screened through $\frac{1}{8}$ -inch mesh hand-shaker screens. Sediments recovered from Units 10-11 in 2002 were water-screened through $\frac{1}{16}$ -inch mesh.

Procedures that are more standard were also conducted. These included the drawing of excavation plan views prior to removal of artifacts and bone, the photographing of all excavations with color slide film, black-and-white print film, and digital. More detailed collection of special samples was also conducted. These included pollen and phytolith, blood and protein residues, and radiocarbon dating. A detailed discussion of these collection methods is presented below, and is also available in Cannon and Crothers (1998).

All artifacts, maps, field notes, photographs, and databases are being curated at the National Park Service's Midwest Archeological Center, Lincoln, Nebraska under MWAC Accession numbers 992 (2002) and 1023 (2003).

Mapping

The mapping at the Goetz site was accomplished by using an arbitrary coordinate system laid out in meters and oriented on magnetic north. The primary datum, Station 1, was established at N1000/E1000. The datum, a metal surveyors cap in concrete, was recorded using a PLGR Global Positioning System unit on 24 July 2001. The GPS coordinates are 531585 m E 4856291 m N with an elevation of 2092 ± 6.4 m. We assigned the datum the elevation of 2092 m AMSL. The purpose of the coordinate grids is to relocate previously mapped items and to establish surface collection and excavation units. Mapping was executed using a Sokkia Total Station and an SDR33 electronic field book.

Mapping hubs are referred to as stations, and excavation unit elevation markers are referred to as datums (Table 3). Two additional mapping stations were established and consist of metal surveyors caps in concrete. Excavation unit datums are wooden stakes. The Total Station height was measured from the top center of the stake or marker to the center of the viewing scope. The range pole and prism height was measured from the base point to the center of the prism, and changes in height were noted in the electronic field book.

Types of points collected include stations, datums, excavation units, shovel tests, surface artifacts, major physiographic features and contours, roads, fence lines, and other cultural features. All piece-plotted artifacts were also mapped with the EDM and kept in a separate database entitled "PIECE-PLOT" (Figure 4) The contour shots consist of points at regular intervals along rough transects. Major breaks in relief, such as drainages and road cuts, were also mapped in detail.

Figure 4. Earthwatch volunteer James Macomson holding prism while artifact is mapped with EDM (3 July 2003).



Each excavation was laid out within the site’s grid system. Block datums were also established in relation to the grid and main datum elevations. Excavation levels and piece-plotted artifacts were referenced to the block datum.

Table 3. Mapping stations established in 2001 at the Goetz site (48TE455).

Station	North	East	Elevation (m AMSL)
1	1000	1000	2092.00
2	960.357	1018.904	2089.521
3	819.443	958.814	2084.047
Backshot	1005.032	1000	

Geophysical Research

Background for the Geophysical Survey

A variety of geophysical instruments have been used since the middle of the 20th century to locate major archeological features. The bulk of the early work was concentrated in England and elsewhere in Europe (Atiken 1961, 1974; Scollar et al. 1990; Clark 1996; Nickel 1993; Hesse 2000), but a few geophysical surveys of archeological sites were attempted in North America in the early years (Bevan 2000, De Terra 1947). Following work by Johnston and Black (Johnston 1964), as well as work by Ralph, Bevan and their colleagues at the University of Pennsylvania, a slow but steady increase in the application of geophysics to North American archeology took place. However, the literature focused on New World applications is still relatively sparse (Bevan 1998; Kvamme 2003). These instruments, originally

designed for applications in geology, engineering and military defense, have been adopted and, in some cases, adapted for use on archeological sites. All of them detect differences in some magnetic or electrical property of the target feature compared with the soil matrix in which the feature is buried. In some manner all these instruments facilitate what Clark (1996) termed the ability to “see beneath the soil.” This view, even if less than perfect, allows archeological features to be studied while the historic fabric and its matrix is left undisturbed, and can allow excavation results to be interpreted in a broader framework.

The Instruments and Their Operation

A Geoscan FM36 fluxgate gradiometer is used at the Goetz site (Clark 1996:69, 77-91; Figure 5). The use of magnetometers in archeological contexts or other cultural resource applications requires measurements be made at rather close intervals (0.1m to 1.0 m) and preferably on a regularly spaced grid. The FM36 magnetometer has two magnetic field sensors mounted about 50 cm (1.5 ft) apart in a vertical tube. It detects differences in the strength of the magnetic field at the height of each of the two sensors. This instrument can take and store as many as eight measurements of magnetic field strength in a second. If it is carried at a steady pace along a grid line, the result is eight evenly spaced measurements across each meter (3.3 ft) of the site. At Cove Creek (10LH144), a precontact site on the Salmon River in Idaho, the gradiometer was set to record variations of 0.1 nT (nanotesla) in the magnetic field. It was operated at eight measurements per meter along lines in the grid that were spaced one half meter apart. A similar strategy was applied at the open precontact Goetz site (48TE455) in Jackson Hole, Wyoming. MWAC archeologists have applied the use of gradiometers at numerous precontact and historic Euroamerican sites in North America over the past three decades. The data from the fluxgate magnetometer survey will be processed with Geoplot software (ver. 3.00a). Magnetometers are quite sensitive to the anomalous magnetic fields that surround iron and steel objects and to alternating-current power lines, but in many cases magnetometers can also detect the much weaker changes in magnetic fields associated with subtle cultural modification of natural soils. In some cases the magnetometer's sensitivity to iron can be used to advantage (mapping historic building sites), but when the main target is a subtle soil feature such as a human-made pit or grave, the presence of iron can be a serious source of “noise” that limits the instrument's effectiveness.

Field application of the geophysical equipment and post-field processing will be conducted by Molly Cannon (MWAC). Ms. Cannon has training from Lewis Somers and several years of field and post-field experience (e.g., Fort Laramie Historic Site and the Goetz site, both in Wyoming) with the Fluxgate gradiometer.

Reasons For Geophysical Survey

- ▼ The nature and distribution of the archeological record at the Goetz site is poorly understood. Information provided by hand excavations indicate the presence of buried deposits.
- ▼ Surface manifestations of buried deposits are difficult, if not impossible, to discern. Placement of test unit excavations is largely a random process.
- ▼ Geophysical mapping may potentially provide more precise information on important deposits.
- ▼ Will be better able to direct data recovery excavations.
- ▼ Good survey conditions:
- ▼ In general, the Goetz site lies within eolian deposits that are gently sloping with open, although sagebrush and other vegetation is dense in areas.
- ▼ Sediments are generally deep, except in areas of shallow bedrock, and will probably not interfere with data interpretation. Shallow bedrock can often complicate interpretation of the data, but hand excavations indicate sediments to a depth of at least one meter.

Although the application of geophysical survey has been conducted sparingly, but extensively in North America, each region has its own particular and specific environmental contexts. Therefore, it is important to develop a baseline database of soil characteristics (e.g., magnetism) with accompanying ground truthing through subsurface testing. In other words, use of geophysical survey at the Goetz site should be considered an initial or pilot study and probably will not provide us with a definitive signature of cultural resources. This will require additional field work. We do believe, however, that geophysical survey is a useful tool and should be applied as a standard tool in assessing cultural resources in northwestern Wyoming (cf., Kvamme 2003).

Figure 5. Molly Boeka Cannon conducting Fluxgate gradiometer survey in 2002 (12 August 2002).



VOLUNTEER TASKS AND ACCOMPLISHMENTS

Earthwatch volunteers were involved in all segments of the project. This included the hand-excavation of deposits and the recording of the recovered data (Figure 6). Earthwatch volunteers also participated in a pedestrian survey of the site and the location, mapping, and collection of the identified specimens. Laboratory assignments included the washing, labeling, rebagging of artifacts, and the entering of data into a field catalog.

In 2002 the two Earthwatch volunteer teams combined for 1,520 hours. We also had the assistance of two US Fish and Wildlife Service archaeologists, Rhoda Lewis and Brant Loflin for four days for a total of 64 hours. In 2003 the two Earthwatch volunteer teams combined for a total of 1,280 hours. US Fish and Wildlife Service archeologists Rhoda Lewis and Galen Burgett worked with us in 2003. They each contributed four days of their time for a total of 64 hours.

Figure 6. Earthwatch volunteer Jessica Lessing recording dip-and-strike on an artifact prior to removal (13 August 2002).



RESULTS OF FIELD INVESTIGATION

Introduction

One of the more intriguing archeological sites to produce bison remains in Jackson Hole is the Goetz site (48TE455). Despite only a descriptive analysis of the faunal and lithic assemblage being presented in Love's (1972) master's thesis, it has been interpreted in the literature as either a "a game trap and quartzite quarry" (Wright and Marceau 1981:13) or merely a "bison trap" (Wright 1984:Table 3).

The Goetz site is located in a narrow drainage in the northeastern portion of the National Elk Refuge that heads on the flanks of Sheep Mountain in the Gros Ventre Wilderness. The mouth of the drainage opens onto Long Hollow, a sagebrush-grassland underlain by loess. Many species have plants have been identified and include several of which are of economic importance (Figure 7; Table 4). The walls of the valley contain lag deposits of glacial boulders and may easily have served as a natural bison trap. The valley is probably Bull Lake in age with an inset bench of late Pleistocene Pinedale age. Holocene eolian and colluvial deposits overlie the older Pleistocene deposits and contain the archeological material (Kenneth Pierce, personal communication 2003).

Figure 7. View of the Goetz site vegetation around area of field investigations. View is to the north (20 June 2003).



Table 4. Plants identified at the Goetz site.

Common Name	Scientific Name	Common Name	Scientific Name
Arrowleaf Groundsel	<i>Senecio trianularis</i>	Oblongleaf Bluebells	<i>Mertensia oblongifolia</i>
Big Sage	<i>Artemisia tridentata</i>	Prairie Smoke	<i>Geum triflorum</i>
Bristly Black Currant	<i>Ribes lacustre</i>	Rabbitbush	<i>Chrysothamnus nauseosus</i>
Dandelion	<i>Teraxacum officinale</i>	Silvery Lupine	<i>Lupinus argenteus</i>
Death Camas	<i>Zigadenus nuttallii</i>	Skyrocket	<i>Ipomopsis aggregata</i>
Goldfields	<i>Lasthenia chrysostoma</i>	Sticky Geranium	<i>Geranium viscosissimum</i>
Grouseberry	<i>Vaccinium scoparium</i>	Sulphur Buckwheat	<i>Eriogonum umbellatum</i>
Hairy Golden Aster	<i>Chrysopsis camporum</i>	Trembling Aspen	<i>Populus tremuloides</i>
Harebell	<i>Campanula rotundifolia</i>	Twinberry	<i>Lonicera involucrata</i>
Limber Pine	<i>Pinus flexilis</i>	Wasatch Penstemon	<i>Penstemon cyananthus</i>
Mountain Brome	<i>Bromus carinatus</i>	Wild Blue Flax	<i>Linum perenne</i>
Mountain Lover 'Oregon Boxwood'	<i>Paxistima myrsinites</i>	Wood's Rose	<i>Rosa woodsii</i>
Needle-and-Thread	<i>Stipa comata</i>	Yampah	<i>Perideridia gairdneri</i>
Northern Sweetvetch Crazyweed	<i>Oxytropis lambertii</i>	Yarrow	<i>Achillea millefolium</i>
Nuttal's Pussytoes	<i>Antennaria parvifolia</i>	Yellow Goatsbeard	<i>Tragopogon dubius</i>
Sego Lily	<i>Calochortus nuttallii</i>		

The 2002 and 2003 field seasons were generally exploratory in nature. Our work over the past three years has slowly progressed based upon knowledge gained from the previous season's work. Our main focus has been to try and delineate the length of time represented at the site, as well as determine the range of activities preserved, and how our investigations can be redirected. The information presented in this section is descriptive in nature; any interpretations discussed should be considered preliminary and will probably be revised as new data is compiled.

2002 Field Season

As noted above we excavated nine 1-m-x-1-m units for a total of 7.4 m³. We recovered 2,501 artifacts from the excavated units, 512 of which were piece-plotted in three dimensions. The density of excavated material is 337.97 artifacts/m³. Nearly 700 lithic artifacts were mapped and collected from the surface (Table 1).

Unlike other sites in Jackson Hole, the Goetz site lithic assemblage is dominated by quartzites. Over 90% of the piece-plotted artifacts were manufactured of quartzite (Table 5). As is typical of hunter-gatherers sites in the region, flaking debris predominate—the Goetz site is no exception. Of the piece-plotted artifacts, over 56% are flakes, followed by fired rock (Table 6).

Table 5. Number of piece plotted artifacts by material type.

Year of Fieldwork	Number of Artifacts Piece Plotted	Bone	Quartzite	Chert	Obsidian
2002	512		477	6	1
2003	955	113	433	8	12
Totals	1,476	113	510	14	13

The most interesting aspect of the 2002 field season involved the excavation near the spring. A 1-m-x-2-m unit was excavated to the south of the exiting spring in order to assess the nature of spring mound and the extent of disturbance from the 1971 dragline excavations. The excavations indicated the presence of spoil material overlying intact deposits. These deposits were intriguing because they produced water-logged deposits of bone, lithic debris, and plant remains (Figure 8). The material is still undergoing analysis, but this area will a major part of the 2004 investigations when we can devote more resources to the recovery of cultural and environmental information.

Table 6. Number of piece plotted artifacts by artifact type.

Year	Number of Artifacts Piece Plotted	Flake	Core	Biface	Nodule	Retouched Flake	Ground Stone	Fired Rock	Charcoal	Proj. Point
2002	512	290	17		28	2	2	87	6	
2003	955	251	6	7	6	2		203	8	2
Totals	1,476	541	23	7	34	4	2	290	14	2

2003 Field Season

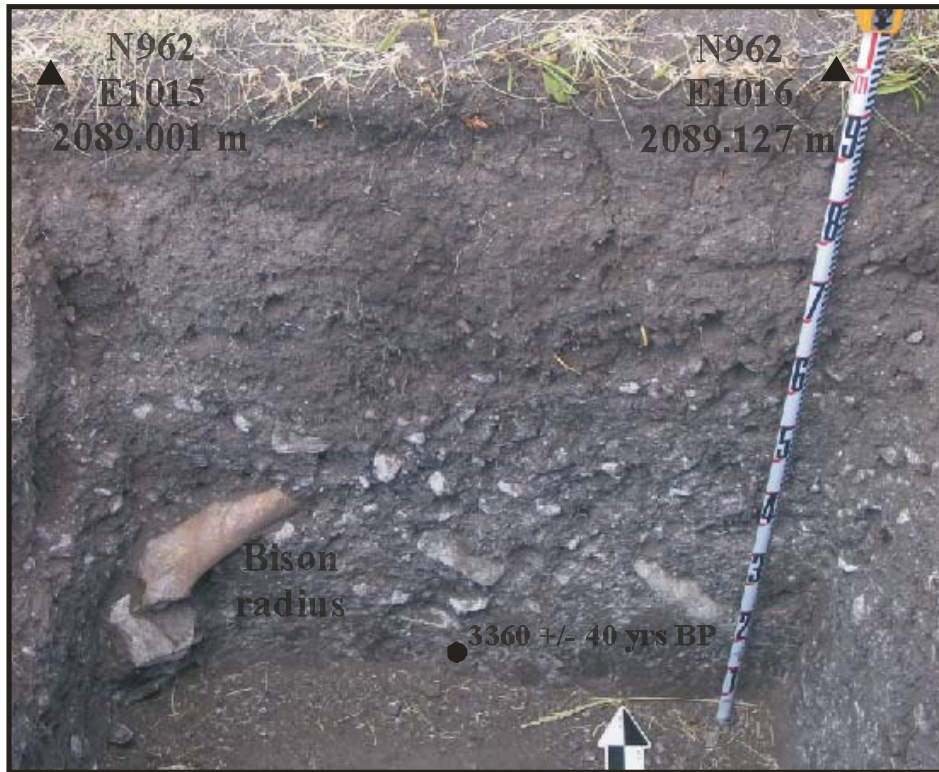
The 2003 field season had four goals: (1) to expand excavations around the 1900-year-old feature uncovered in 2001; (2) further assess the deposits around the spring; (3) expand our surface collection; and (4) to conduct additional geophysical surveys using the Fluxgate gradiometer. Each of these goals was met. During the 2003 field season we excavated seven 1-m-x-1-m units for a total of 3.6 m³. This work produced 2871 artifacts, of which 955 were piece-plotted. The high density of artifacts, 797.5/m³, mainly reflects the excavations around feature F01-01 which produced a large amount of fired rock, bone, and flaked lithic debris. We also mapped and collected 627 artifacts from the surface (Table 1).

The excavations (Units 24-26) adjacent to the spring produced a meter of deposits with a large amount of lithic debitage and bone (Figure 9). A large mammal bone from 90 cmbs was submitted for radiocarbon dating. This sample produced an age of 3,360 yrs BP. This radiocarbon date provides us with a minimum age for dating the landform, as well as providing additional data for interpreting the cultural remains within a more precise time frame. Radiocarbon dates are important because they represent one of the important initial steps to understanding more complex issues of subsistence, climate change, and post-glacial community structure is the development of a site chronology. Our current understanding of the site stratigraphy is largely circumstantial, based upon projectile point styles and stratigraphic context.

Figure 8. South wall profile of Unit 10 adjacent to existing spring.



Figure 9. North wall profile of Unit 24. Radiocarbon date was obtained from long bone fragment of medium artiodactyl such as deer or sheep. Photo taken 11 July 2003.



A total of 113 bone specimens were piece-plotted in 2003 that include identifiable specimens of bison and other large and medium mammals (Table 5). As with the 2002 material, quartzite is the predominant material type (45%). The assemblage consists almost exclusively of flaking debris followed by fired rock. The amount of fired rock is reflective of our emphasis of excavations around feature F01-01 (Table 6).

Diagnostic Artifacts

The projectile point assemblage from the site is limited, and to date only four have been recovered (Figure 10). These include the base of an obsidian lanceolate specimen (FS106.04.002) recovered from Unit 6 in 2001. The base is flat and expanding towards the blade. The specimen is broken laterally with an impact fracture (Figure 10a). Similar specimens have been associated with late Paleoindian contexts in the region (Frison 1991). The second point was recovered in 2002 in Unit 18 and is also manufactured of obsidian. The point has a slightly concave base and has been heavily reworked (Figure 10b). This point was geochemically sourced, but the geochemistry did not match any geologic sources in our database.

Two projectile point fragments have been recovered from the surface of the site. These include the midsection of an obsidian point (FS400.00.1000) recovered in 2001 that has yet to be geochemically sourced (Figure 10c). In 2003 we mapped and collected another broken obsidian projectile point (FS400.00.3017) from the surface. This point has a concave stem with an impact fracture on the proximal end. The point is similar to specimens recovered in Level 30 ($4,090 \pm 140$ and $4,420 \pm 150$ yrs BP) at Mummy Cave (Husted and Edgar 2002) and the 4,000-year-old levels from Medicine Lodge Creek (Frison 1991:Figure 2.46e).

A broken biface (Figure 11) manufactured of a translucent chalcedony was recovered in 2001 in association with Feature F01-01 (Figure 3). The point was very friable due to heating and was covered with calcium carbonate deposits. Both fragments of the biface were recovered and subjected to immunological analysis. The results for both fragments returned positive reactions to both bear and rabbit. Bear remains have been recovered from the 1971 excavations.

Figure 10. Obsidian bifaces recovered from the Goetz site: (a) FS106.04.002 (2001) was geochemically sourced to an Unknown source; (b) FS118.01.002 (2002) has not been geochemically analyzed; (c) FS400.00.1000 (2001) was geochemically sourced to Teton Pass. Artifact drawings by Janet Robertston.

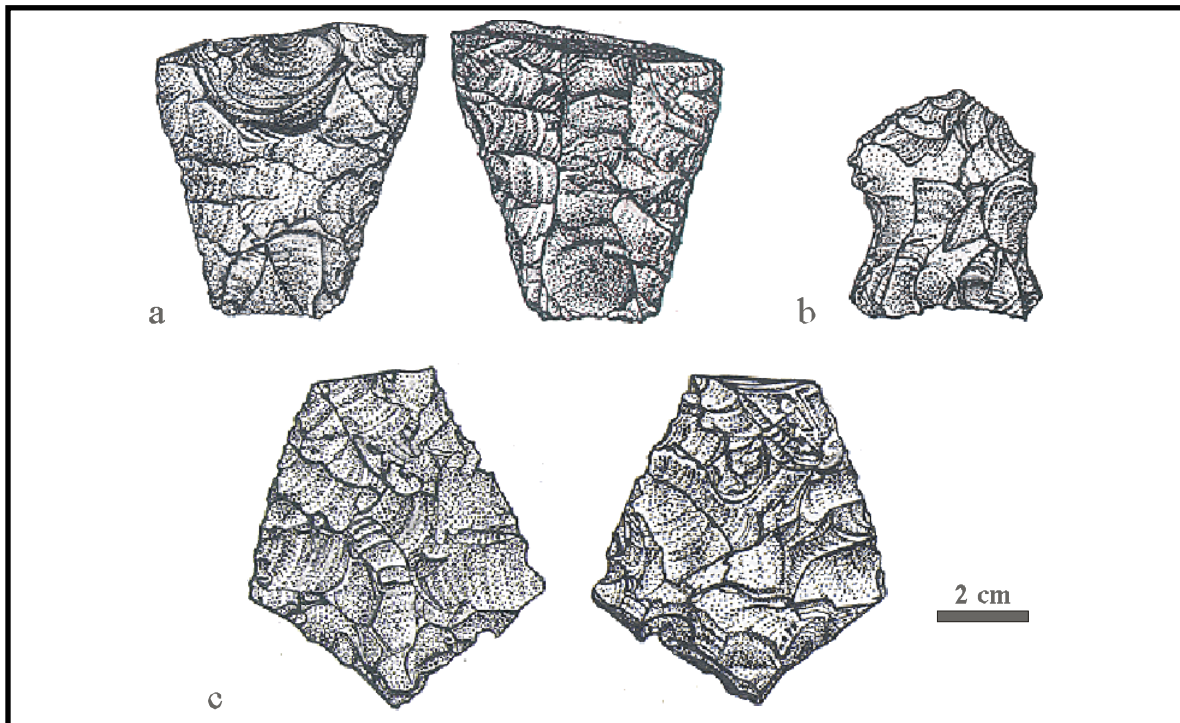
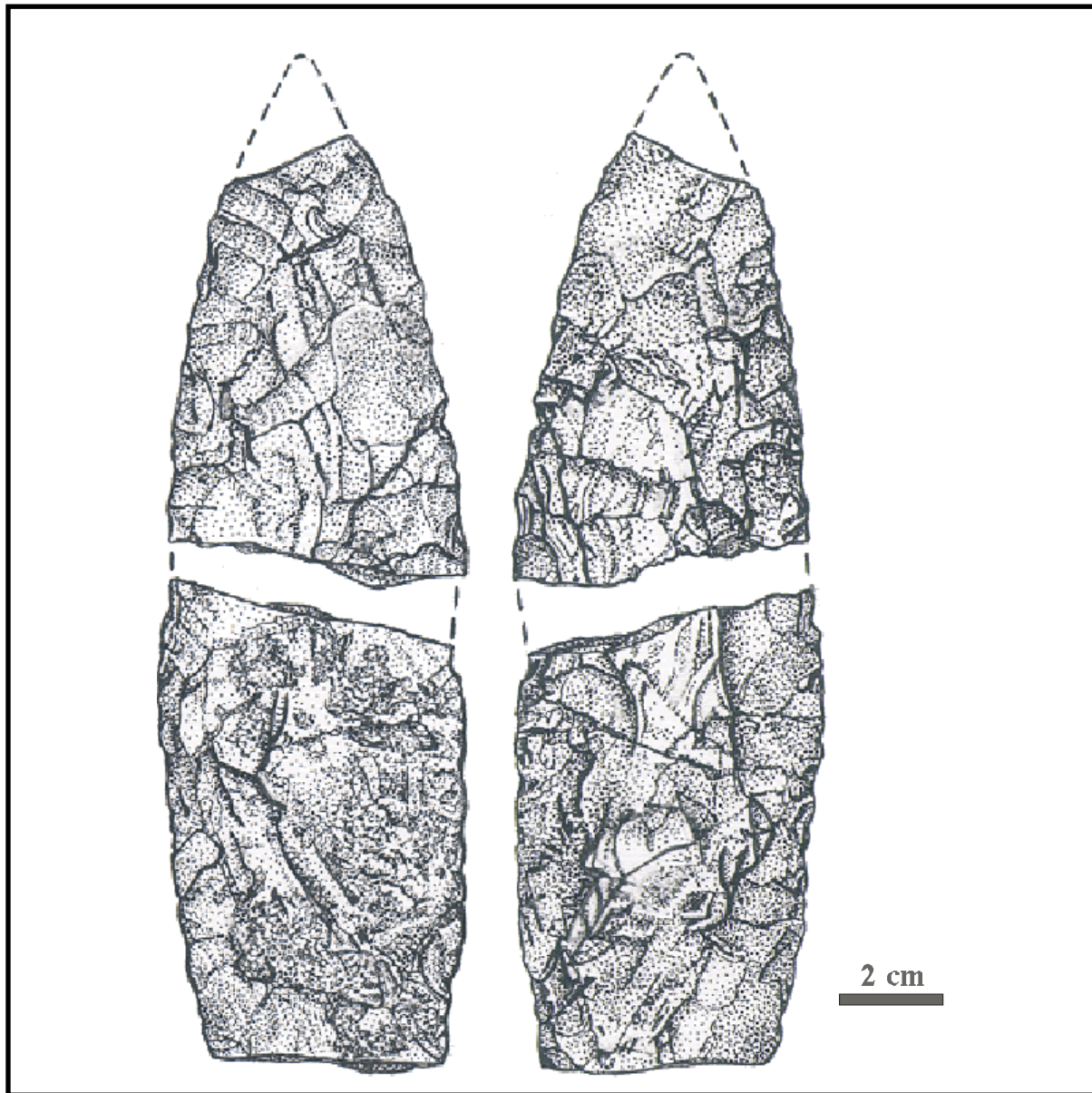


Figure 11. Chalcedony biface (FS104.04.007 and 104.04.008) recovered in association with fired rock feature F01-01. The feature was radiocarbon dated to 1900 ± 40 yrs BP. Both fragments of the biface were subjected to immunological residue analysis and produced positive reactions for bear and rabbit antisera. Artifact drawings by Janet Robertson



Results of Geophysical Survey

Geophysical prospecting at the Goetz Site was completed for the second season in 2003. A total of six 20x20 meter grids have been surveyed at 0.25 meter traverse intervals collecting data readings at 0.125 meter intervals (Figure 2). The hopes of 0.25 meter traverse interval are that data will be rich enough to distinguish prehistoric features of the size of post holes and small hearths. The vegetation at the Goetz site does not lend itself to other geophysical prospecting methods (i.e. ground penetrating radar). The magnetometer provides usable data to infer places of prehistoric activity that are presently under the ground surface.

The ground was covered by a sequence of traverses adjacent to one another (Geoscan Research 1987:43-48, 1993:5/1-5/7) using the Fluxgate FM/36 magnetometer. The survey was conducted in a zig-zag fashion beginning at the southwest corner of each grid unit. The zig-zag method reduces the time required to conduct the survey by eliminating the return walk back to the beginning of the next traverse. The traverse interval was set at one meter (E-W) intervals along the 20 meter wide grid. Three Metric tapes were used to guide the surveyor. Two tapes were placed across the baseline at the bottom and top of each grid unit between the east and west corner stakes. The remaining tape was laid out along the traverse direction beginning at the first line between the north and south corner stakes. The last line (n=20) ended in the traverse line before the north and south stakes at the east end of the 20x20 meter grid unit. When the instrument memory was filled, the individual grid unit data files were downloaded in to a laptop computer and processed using the GEOPLOT ver. 3.00g software (Geoscan Research 1999).

Interpretation and map generation of the grid units are still on going. Once completed, the grids will be combined into one file, termed a composite file. The composite files will be exported in the XYZ format for processing and display in SURFER for Windows (Keckler 1994). Contour, 3D surface, and shaded plots will be generated. The analysis of these data will be used for planning the excavations of 2004 field season.

RESULTS OF EXTERNAL ANALYSES

Radiocarbon Assay

Three samples from the Goetz site were submitted to Beta Analytic of Miami, Florida, for radiometric assay. A discussion of each radiocarbon date, its context, and its interpretation is presented in this section and summarized in Table 7.

Each date is presented as a conventional radiocarbon age as reported by Beta Analytic. Calendar calibrations are also presented at the 2-sigma, or 95 percent confidence, level. Calendar calibrations of radiocarbon ages extending back approximately 19,000 years have been published by Stuiver et al. (1998), following the cubic spine fit mathematics published by Talma and Vogel (1993), and incorporated into the CALIB calibration program (Stuiver and Reimer 1993 version 4.2). Calibrated dates are reported as cal BC and cal BP. Caution should be applied to the interpretation of calibration results beyond 10,000 years since these are still considered “best fits.”

All samples were processed and analyzed by Beta Analytic using the AMS technique. Pretreatment of each sample was conducted using the laboratory’s standardized techniques. For example, all charcoal and plant materials were processed using the “acid/ alkali/acid” pretreatment. Initially the sample is gently crushed in deionized water, followed by hot hydrochloric (HCl) acid washes to eliminate carbonates, and alkali washes (NaOH) to remove secondary organic acids. The alkali washes are followed by a final acid wash to neutralize the solution prior to drying (Beta Analytic 1999).

The protocol for collagen extraction of bone specimens involved the initial assessment of the material for friability or softness. Specimens of very soft bone usually do not have collagen fraction for dating and will most likely not provide reliable ages. If a bone is judged to have sufficient collagen fraction, > 5 percent original collagen remaining (Hedges and van Klinken 1992), it is washed in deionized water and gently crushed. Next, dilute, cold HCl acid is repeatedly applied and replenished until the mineral fraction (bone apatite) is eliminated. The collagen is then dissected and inspected for rootlets. If rootlets are found, they are also removed when replenishing the acid solutions. If a sufficient quantity of collagen is present, NaOH is applied to ensure the absence of secondary organic acids (Beta Analytic 1999). Hedges and van Klinken (1992) review the pretreatment of bone for AMS dating. In their opinion, “the methods that date carefully extracted and purified [collagen] gelatin, and can demonstrate analytically that the material dated corresponds to the composition expected for gelatin, are adequate for the great majority of bones that have lost up to 95 percent of indigenous protein” (Hedges and van Klinken 1992:290). Beta Analytic adheres to these standards.

Hedge and van Klinken warn that contamination must always be suspected for poor or intermediate preservation, and if the specimen lacks evidence of a recognizable collagen signature, there is no longer any support for believing that the extracted organic material is indigenous. Contamination can come from a number of sources depending upon the particular environment. However, any, and probably all, buried bone is liable to have incorporated exogenous soluble and insoluble organic materials, such as rootlets, soil humics, or other molecules mobilized in groundwater. Bone is particularly susceptible to absorption of these contaminants due to its high surface area ($10\text{m}^2\text{g}^{-1}$). Fortunately, the “humic” fraction is nearly always extractable from bone with alkali, and generally provides an accurate or younger date (Hedges and van Klinken 1992:284).

Sample FS455.1.49

The right metatarsal (FS455.1.49) from the 1971 excavations was submitted to Beta Analytic for radiocarbon assay. Unfortunately we do not have provenience information on the specimen. A small sample of bone was removed from the element and processed using the AMS technique. Processing produced good quality collagen and analytical steps proceeded normally. An age of 800 ± 40 yrs BP (Beta-133690; $\delta^{13}\text{C} = -21.0\text{‰}$) was returned on the specimen (Hood 1999). The two-sigma calibrated range is cal AD 1175 to 1285. This age is approximately 400 years earlier than the age of AD 1560 reported by Love (1972).

Sample FS104.04.009

A mid-shaft fragment from a large artiodactyl, possibly elk, was recovered from in association with the fired rock feature F01-01 in 2001. The fragment represented a green bone fracture and weighed 6.8 grams.

The specimen was submitted to Beta Analytic for radiocarbon assay with pretreatment for bone collagen extraction. The specimen was processed using the AMS technique. Processing produced good quality collagen and analytical steps proceeded normally. An age of 1940 ± 40 yrs BP (Beta-165942; $\delta^{13}\text{C} = -19.2\text{‰}$) was returned on the specimen (Hood 2002). The two-sigma calibrated range is 30 BC to AD 130.

This specimen provides an age for a large feature complex, as well as providing an age for bison remains recovered in association with feature in 2003.

Sample FS124.09.007

The mid-shaft fragment from either the tibia or femur of medium-sized artiodactyl (deer or sheep) was recovered from level 9 in Unit 24 in 2003. The bone fragment was piece-plotted prior to removal. The specimen is a green bone break with score marks from possible butchering, as well as carnivore-gnawing marks. The maximum length is 48.66 mm with a maximum width of 21.56 mm and maximum cortical thickness of 5.34 mm. The weight of the specimen is 5.2 g.

The specimen was submitted to Beta Analytic for radiocarbon assay with pretreatment for bone collagen extraction. The specimen was processed using the AMS technique. Processing produced good quality collagen and analytical steps proceeded normally. An age of 3360 ± 40 yrs BP (Beta-183741; $\delta^{13}\text{C} = -21.1\text{‰}$) was returned on the specimen (Hood 2003). The two-sigma calibrated range is 1740 to 1530 BC.

Table 7. Radiocarbon assay samples collected from the Goetz site (48TE455). UB stands for unburned bone.

Sample	Beta Analytic Lab. No.	Horizontal Provenience	Vertical Provenience	Material	14C Age	Calibrated Age	$\delta^{13}\text{C}\text{‰}$
455.1.49	133690	-	-	UB	800 ± 40	AD 1175 to 1285	-21.0
104.04.009	165942	EU4, F01-01	Level 4	UB	$1,940 \pm 40$	AD 130 to 30 BC	-19.2
124.09.007	183741	N961.044 E1015.501	2088.271 m	UB	$3,360 \pm 40$	1740 to 1530 BC	-21.1

Summary

Three radiocarbon ages have been received for dating the cultural deposits at the Goetz site. The ages provide us with the beginnings of a chronology that we can use to build on and develop more sophisticated research questions. These dates also provide us with some important limiting ages that the geomorphic history can be developed.

Energy Dispersive X-Ray Fluorescence

Since 1989, the Midwest Archeological Center and Dr. Richard Hughes of Geochemical Laboratory, Portola Valley, California, have investigated geochemical characterizations of obsidian artifacts in order to identify parent obsidian formation (cf. Cannon and Hughes 1993, 1999). The purpose was to assess patterns of landscape use and the scale of settlement patterns or range size, as well as temporal patterns of settlement change. An integral step in addressing these topics is the identification of obsidian source utilization, the predominant raw material for flaked-lithic tools.

However, geologic processes have only produced volcanic glass deposits in areas from northwestern Wyoming and eastern Idaho, limiting our knowledge and our speculations about prehistoric travel to those areas. Understanding movement of people to the east and south is thereby excluded from this system and must be investigated by the less reliable macroscopic identification of source locales for cryptocrystalline materials. This statement should not, however, detract from the value of obsidian source studies, but provide a caveat under which interpretations are made.

Prior to our work, archeologists from the State University of New York, Albany (SUNY-A), had conducted geochemical analyses on limited samples which had been recovered during archeological investigations in northwestern Wyoming (e.g., Wright 1984; Reeve 1989). The results of their studies, as well as the seminal studies by the University of Michigan in the 1960s (Wright 1968; Frison et al. 1968; Griffin et al. 1969; Wright et al. 1969; Gordus et al. 1971; Davis 1972; Frison 1974), indicated aboriginal use of three geochemically distinct sources: Obsidian Cliff, Teton Pass, and the unprovenanced F.M.Y. 90, now identified as Bear Gulch along the Idaho–Montana border. Since this time, at least five geochemically distinct sources in the immediate Grand Teton–YNP area have been identified archeologically (Connor 1986; Kunselman 1991, 1994; Cannon 1993; Cannon and Hughes 1993). And, contrary to previous research, which identified only local source utilization, our studies have identified utilization of at least 10 chemically distinct geologic sources — some over 280 km from Yellowstone — the use of which varied in frequency over the past 10,000 years (Cannon and Hughes 1993, 1997a).

The earlier studies have significantly influenced the way in which studies of local and long-distance conveyance have been approached. For example, recent research on the Midwestern occurrence of obsidian (Anderson et al. 1986; Hatch et al. 1990) still refers uncritically to the original source data collected by the University of Michigan team. Not only are the results of these pioneering studies compromised by the limited inventory of sources, but also by the failure of earlier studies to report results in internationally recognized standard units, such as parts per million (ppm) and weight percent, which limits our ability to replicate and build on this research (cf. Hughes 1989).

In southern Jackson Hole, the distribution of obsidian has been complicated by the redeposition of cobbles downstream by Pleistocene glaciation. This redeposition has provided numerous locales for the same geochemical type, making interpretations of lithic procurement difficult. As Pierce and Good (1986:168) observe:

Several obsidian sources are present in southern Jackson Hole, but the best obsidians for tool making are from the “Love Quarry” source about a mile south of Teton Pass and a much larger area underlain by the

“McNeeley Ranch” source about 2 miles south of Wilson. ... Obsidian from the McNeeley Ranch source was carried southward by older, very extensive glaciation of Jackson Hole, and is common in till and outwash of this glaciation. Indians may have picked up this obsidian from glacial and other surficial deposits for several miles south of the McNeeley Ranch source.

Schoen (1997) provides a recent overview of the various identified obsidian geochemical types in Jackson Hole. At the time of his article, four geochemical types had been identified in southern Jackson Hole. One of the notable aspects of the history of the work presented by Schoen, is the inconsistent naming of geochemical types and locales, and the lack of descriptive information concerning the geologic context of the obsidian. Cannon and Hughes (1999; Hughes and Cannon 1997) have articulated these concerns, as well as methodological inconsistencies in data reporting; Hughes (1984) provides background and additional information.

X-Ray Fluorescence Laboratory Analysis Conditions

Laboratory analysis of the YNP artifacts was performed on a Spectrace™5000 (Tracor X-ray) energy-dispersive x-ray fluorescence (XRF) spectrometer equipped with a Rh x-ray tube, 150 kV x-ray generator with microprocessor-controlled pulse processor (amplifier) and bias/protection module, a 100 MHz analog-to-digital converter with automated energy calibration, and a Si(Li) solid-state detector with 150 eV resolution at 5.9 keV in a 30 mm² area. The x-ray tube was operated at 35.0 kV, .25 mA, using a 0.127 mm Rh primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity data for zinc (Zn), gallium (Ga K ∞), rubidium (Rb K ∞), strontium (Sr K ∞), yttrium (Y K ∞), zirconium (Zr K ∞), and niobium (Nb K ∞). Barium (Ba K ∞) intensities were generated by operating the x-ray tube at 50.0 kV, .35 mA, with a .63 mm copper (Cu) filter at 300 seconds livetime. Titanium (Ti K ∞) and manganese (Mn K ∞) and total iron (Fe₂O₃^T) intensities were generated by operating the x-ray tube at 15.0 kV, .30 mA, with a .127 mm aluminum (Al) filter at 300 seconds livetime.

Trace-element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from analysis of up to 26 international rock standards certified by the U.S. Geological Survey, the U.S. National Institute of Standards and Technology, formerly National Bureau of Standards, the Geological Survey of Japan, and the Centre de Recherches Petrographiques et Geochimiques, France. Further details pertaining to x-ray tube operating conditions and calibration appear in Hughes (1988).

Trace-element measurements in the XRF data tables are expressed quantitatively as parts per million (ppm) by weight, and matches between unknowns and known obsidian chemical groups are made on the basis of correspondences at the 2-sigma level in diagnostic trace-element concentration values — in this case, ppm values for Rb, Sr, Y, Zr, Nb, and, when necessary, Ba — that appear in Anderson et al. (1986), Baugh and Nelson (1988), Hughes (1984), Hughes and Nelson (1987), Nelson (1984), and Jack and Carmichael (1969). Artifact-to-obsidian source (geochemical type) correspondences were considered reliable if diagnostic mean measurements for artifacts fell within 2 standard deviations of mean values for source standards. The term “diagnostic” specifies those trace elements that are well measured by x-ray fluorescence, and whose concentrations show low intra-source variability and marked variability across sources. In short, diagnostic elements are those whose concentration values allow one to draw the clearest geochemical distinctions between sources (Hughes 1990; Hughes and Lees 1991).

Although Zn, Ga, and Nb ppm concentrations also were measured and reported for each specimen, they are not considered “diagnostic” because they don't usually vary significantly across obsidian sources (Hughes 1982, 1984). This is particularly true of Ga, which occurs in concentrations between 10 and 30 ppm in nearly all parent obsidians in the study area. Zn ppm values are infrequently diagnostic; they are

always high in Zr-rich, Sr-poor peralkaline volcanic glasses, but otherwise they do not vary significantly between sources in the study area.

The trace-element composition measurements presented in the data tables are reported to the nearest ppm to reflect the resolution capabilities of non-destructive energy-dispersive x-ray fluorescence spectrometry. The resolution limits of the present x-ray fluorescence instrument for the determination of Zn is about 3 ppm, Ga about 2 ppm, for Rb about 4 ppm, for Sr about 3 ppm, Y about 2 ppm, Zr about 5 ppm, Nb about 3 ppm, and Ba about 13 ppm. When counting and fitting error uncertainty estimates, which are the “±” value in the tables, for samples greater than calibration-imposed limits of resolution, the larger number is a more conservative indicator of elemental composition and measurement error due to variations in sample size, surface and x-ray reflection geometry (Hughes 1988).

The following section is a discussion of the local Jackson Hole geochemical sources that have been used by precontact groups for stone tool production. This discussion follows that presented in Cannon et al. (2001).

Teton Pass Geochemical Type

The Teton Pass site, 48TE960, also referred to as “Love Quarry,” was the collection site for samples in the early neutron activation (NAA) studies conducted by the University of Michigan (Wright 1968; Gordus et al. 1971). Love (1972:42) may have been the first to describe the site in print as a quarry based upon the presence of a number of pits:

At higher elevations, three small vents outcrop, two of which still exhibit shallow pits on the surface. The third vent is so small that only small pebbles of unworked float could be discovered. The surface of the largest vent, perhaps 50 yards across, shows some 8 or 10 separate pits, the average being about 8 to 12 feet across and up to a foot deep. The largest pit, in a nearby stand of timber, was about 4 feet deep and 12 feet across.

Frison (1974:62-63) later described the site:

Two sources are actually present, about 100 yards apart, but these are probably part of the same vent. ... The site was apparently a location of considerable workshop activity with large quantities of waste flakes and a number of broken bifaces and other forms. The debitage ... was under 1 to 2 inches of soil. ... The obsidian from both the source and the site is of excellent quality. Pieces of material 7 to 9 centimeters in diameter are abundant, and they show excellent flaking qualities. ... The isolated nature of the site, and the difficulty of access suggest that it was a location where material from the quarry was being manufactured into blanks of various shapes, probably to reduce the weight of materials to be transported. The site location presents no features that could in any way make it a desirable location for any other purpose; and it is one of the few available spots near the quarry that are level and protected.

Recent fieldwork (Cannon, Hughes, Pierce, and Morgan 1999) has begun to clarify the physical locations of the Teton Pass geochemical types, known as “Teton Pass” and “Crescent H.” In 1992, field collections were made at several exposures in the Teton Pass vicinity, both on the pass and in the valley. It is clear that the sampling locations identified by the site numbers 48TE930 and 48TE960 both represent the same geochemical variety of obsidian, and that the same chemical type is represented some distance away in a different geologic context at the McNeeley Ranch/Fish Creek locality on the valley floor. By contrast, although not a primary geologic source, the Phillips Ridge locality provided evidence of a second variety of obsidian in the Teton Pass locality. This locality contained a mixture of Teton Pass glasses, confounding the interpretation, and additional fieldwork will be necessary to clarify the primary geologic source for this second variety of Teton Pass glass.

The lower elevation deposits of obsidian were also described by Love (1972:39-41):

In the southern Tetons, a cluster of four of these obsidian sources occurs in a series of what appear to be obsidian vents. ... These pipes have been planed off and reduced by erosion. The largest exposure occurs at low elevation west of the Snake River, and possibly erosional debris from this makes up the cobbles available in Mosquito Creek. The vent and the Mosquito Creek gravels represent the two most accessible sources in southern Jackson Hole. ... The vent produced banded smoky obsidian in pieces up to about 10 cm. in length, while the largest cobble from the glacial debris was about 25 cm.

Schoen (1997:218) questions the interpretation that the reported pits are the result of prehistoric quarrying activities, but does suggest that this locale is “the main source location for this type.” Based on our work at 48TE1079, we believe this is arguable. For one thing, this high-altitude location is accessible only for short periods of time during the summer, while the valley location is accessible for much of the year, except the winter months. Also, the tremendous amount of material excavated from the Crescent H Ranch site and the time depth indicate to us this may have been a more important locale for extraction of obsidian cobbles and biface production. Excavations at 48TE960 will have to be conducted in order to test the ideas raised by Love, Frison, and Schoen.

According to our current understanding of the distribution of Teton Pass glass, the geochemical type “Teton Pass” corresponds to the two vents on Teton Pass (48TE930 and 48TE960), as well as in the valley exposure near Fish Creek on the McNeeley Ranch. Obviously, more detailed mapping and collection in this area are necessary, not only for understanding the geologic occurrence of the obsidian, but also the pattern of human procurement.

The Teton Pass geochemical type is well represented in local collections, roughly 34 to 47 percent, but drops off significantly outside the valley. For example, along the north shore sites of Yellowstone Lake less than 2 percent of the artifacts were sourced to Teton Pass, while further to the north and east on the Beartooth Plateau none of the 107 projectile points were sourced to Teton Pass. To the south in the Green River Basin this pattern is the same, with only 2 of 200 artifacts sourced to Teton Pass.

Crescent H Geochemical Type

The Crescent H geochemical type is similar in composition to the Teton Pass geochemical type, and the two have been identified together in secondary deposits (Cannon, unpublished field notes; Hughes 1995a). The Crescent H geochemical type is distinguished from Teton Pass by higher levels of strontium and zirconium, and is named for its initial identification at a collection site on the Crescent H Ranch. This geochemical type was initially identified during the geochemical analysis of artifacts from YNP. Hughes (1991) noted at the time that the trace element chemistry was unlike any in his comparative collection at the time, but, being similar to Teton Pass, it was provisionally labeled *Teton Pass, Variety 2*. Recent fieldwork (Hughes 1995a, 1995b) has provided evidence of the distribution of this geochemical type in low-elevation secondary deposits on the east slope of the Tetons, and in mixed deposits on Phillips Ridge north of Teton Pass.

Kunselman collected obsidian samples from surface exposures on the McNeeley Ranch in 1989 (Schoen 1997). His analysis indicated the sample contained a mixture of the original Teton Pass geochemical type with a lesser number of samples that had higher levels of strontium and zirconium. This geochemical type was labeled as Fish Creek Second Variety (Kunselman 1991). Field collections and geochemical analysis from the same location in 1993 produced only samples of the Teton Pass geochemical type (Hughes

1995a). This collection locale is mapped by Love et al. (1992) as upper Miocene (8.06 Ma) rhyolite with intrusive black, glassy, translucent obsidian.

The *Crescent H* or *Fish Creek Second Variety* appears as an important component in local site assemblages, despite having what appears at this time to be a more limited geologic distribution in the southern Tetons. Artifacts manufactured from this geochemical type are found outside of Jackson Hole at sites in YNP, at the Lookingbill site in the Absarokas to the east, and to the south in the Green River Basin.

West Gros Ventre Butte Geochemical Type

A third local geochemical type was identified in the Wilson–Fall Creek Road assemblage (Cannon et al. 2001). This geochemical type is identified from collections on the west side of West Gros Ventre Butte in 1996 and reported by Hughes (1997). The material collected was of poor flaking quality with phenocrysts and weathering fractures common. Schoen (1997) reports on this location.

Modeling Human Movement Through the Identification of Lithic Resources

Raw material procurement is related to the larger issue of overall procurement strategies and group mobility. Geochemical analysis of obsidian artifacts provides a basis for delineating these patterns. While distances to sources cannot be used directly as evidence for group mobility, it is direct evidence for how far materials traveled (Beck and Jones 1990). Distance can be combined with other evidence to unravel changes in prehistoric procurement strategies and group mobility.

Seven artifacts were submitted to Richard Hughes (2002) for geochemical fingerprinting. The sources identified include local southern Jackson Hole sources, as well as Obsidian Cliff to the north in Yellowstone National Park. The limited sample size does not allow us to make any interpretations at this time. However, geochemical analysis will continue to be an important research topic for this project.

Table 8. Results of EDXRF analysis of artifacts from the Goetz site (48TE455).

FS Number	Horizontal Provenience	Vertical Provenience	Artifact Type	Geochemical Source
104.03.002	Unit 4	Level 3		Crescent H
105.07.030	Unit 5	Level 7		Crescent H
106.04.002	Unit 6	Level 4	Projectile Point	Unknown
107.04.001	Unit 7	Level 4		Phillips Pass area
400.00.1000		Surface	Projectile Point	Teton Pass
400.00.1249		Surface		Obsidian Cliff
400.00.1526		Surface		Crescent H

Immunological Residue Analysis

In recent years there has been an increased use of molecular, biomolecular, and biochemical techniques in the analysis of archeological materials (cf. Downs and Lowenstein 1995). Immunological methods have been used to identify plant and animal residues on flaked and ground-stone lithic artifacts (Downs 1985; Hyland et al. 1990; Kooyman et al. 1992; Newman 1990; Newman and Julig 1989; Yohe et al. 1991). Plant and animal residues on ceramic artifacts have been identified by their amino acid sequences (Broderick 1979) and by analysis of lipid and fatty acids (Fredericksen 1988; Heron et al. 1991; Hill et al. 1985), while serological methods have been used to determine blood groups in skeletal and soft tissue

remains (Heglar 1972; Lee et al. 1989) and in the detection of hemoglobin from 4,500-year-old bones (Ascenzi et al. 1985). Human leukocyte antigen (HLA) and deoxyribonucleic acid (DNA) determinations made on human and animal skeletal and soft tissue remains have demonstrated genetic relationships and molecular evolutionary distances (Hansen and Gurtler 1983; Lowenstein 1986; Pääbo 1985, 1986, 1989; Pääbo et al. 1989). It has become evident that data obtained from these analyses can contribute valuable information to archeologists—information that cannot be obtained by other means. However tantalizing the evidence, the archeological application of these techniques has been met with skepticism (cf. Thomas 1993).

Several immunological methods have been utilized in the analysis of archeological materials including Ouchterlony (OCH [Downs 1985]), cross-over-immunoelectrophoresis (CIEP [Barr 1989; Newman 1990]), radioimmunoassay (RIA [Lowenstein 1980, 1986]), and enzyme immunoassay (ELISA [Hyland and Anderson 1990; Hyland et al. 1990]). These methods differ only in degrees of sensitivity, with OCH being the least and RIA as the most sensitive. However, the use of RIA is limited to a facility and person(s) licensed for nuclear medicine. Immunological techniques were first used in medico-legal work in the early 1900s and despite some dissenters at that time (Gaensslen 1983:223) have continued to play an integral role in forensic medicine. Although the application of these techniques to archeological materials has been questioned, literature reviews of forensic studies (Arquembourg 1975; Haber 1964; Gaensslen 1983; Lee and DeForest 1976; Macey 1979; Sensabaugh et al. 1971a) demonstrate that old and denatured bloodstains will still result in a positive precipitin test (Gaensslen 1983:225). While these studies generally deal with relatively recent stains, at least in comparison to the age of most archeological materials, it has been shown that various efforts to remove bloodstains from clothing and other materials, using solutions such as bleach, harsh detergents, or boiling, are generally unsuccessful (Gaensslen 1983:225; Lee and DeForest 1976). Species identification has also been made on tissues recovered from a sewer (Milgrom and Campbell 1970) and on body tissues (Bjorklund 1952; Milgrom et al. 1964). Chemicals present in soils (e.g., tannic acid, aluminum chromate, or organic solvents) may result in non-specific precipitation of antiserum (i.e., false positive). However, routine testing of site soils will indicate the presence of substances that may interfere with, or give false positive results in, the analysis of artifacts.

One of the pioneers in the field of forensic medicine was George Nuttall. During the course of his studies he carried out the most extensive testing of antisera in order to determine the relatedness of animals (Nuttall 1901a, 1901b, 1904). In this work more than 16,000 precipitin tests were carried out on over 500 animal species, which included mammals, birds, reptiles, and fish. When one considers that these experiments were carried out over 90 years ago, it is a truly remarkable piece of work, and moreover, has been substantiated to a great extent by recent work in molecular evolution. It is interesting to note that many of the problems and sources of error experienced by Nuttall and other researchers are still applicable today. Such problems as the strength and reliability of antisera, the pH of the medium, bacterial contamination, the difficulty of re-solubilizing dried blood, and the fact that blood heated to 100° C will not give a positive reaction often occur today as they did in the past (Nuttall 1904). However, he also noted “that dried bloods give reactions after the lapse of a considerable time, months, or even years has been fully established by Uhlenhuth and confirmed by others” (Nuttall 1904:120).

Currently, results of residue analyses of archeological materials are appearing regularly in the literature (e.g., Loy 1983; Loy and Wood 1989; Newman and Julig 1989; Hyland et al. 1990; Yohe et al. 1991; Newman et al. 1993) providing encouragement for archeologists to partake of these techniques as routine procedures in the interpretation of archeological remains (Downs and Lowenstein 1995). However, a basic understanding of the long-term preservation, mechanical and chemical breakdown that occurs to blood protein is not precisely understood. Downs and Lowenstein (1995:12), in quoting Sensabaugh et al. (1971a, 1971b), note that in time amino acid chains, which make up the blood proteins, break down into shorter peptide chains and become modified proteins which are intermediate between natural and

degrading forms continuing to react “to chemical, physical, and biological testing, but in different or unpredictable ways.” The effects of this breakdown, especially when considering centuries-old artifacts, and how it might respond to identifying tests is imperative if this is to become a useful and interpretable tool for archeologists (Downs and Lowenstein 1995:12).

Materials and Methods

The method of analysis used is cross-over-immunoelectrophoresis (CIEP). Minor adaptations to the original method were made following procedures used by the Royal Canadian Mounted Police Serology Laboratory, Ottawa (1983) and the Centre of Forensic Sciences (Toronto). Although this test is not as sensitive as RIA, it has a long history of use in forensic laboratories, does not require expensive equipment, is reasonably rapid and lends itself to the processing of multiple samples (Culliford 1964). In this test the antigen and antibody are driven together by an electrophoretic force instead of simple diffusion as in the OCH test. The test is performed in agarose gels with a pH of 8.5, by this the antigen is positively charged and the antibody is negatively charged. Paired wells, roughly 1.5 mm in diameter are punched in the agarose gel approximately 5 mm apart. The antigen (unknown extract) is placed in the cathodic well of the pair and the antiserum in the anodic one. The gel is placed in an electrophoresis tank containing a barbital buffer, pH 8.6, and triple thicknesses of filter paper are used as wicks to connect the ends of the slides with the buffer. The application of an electrical current, set at a constant 100 v, moves the two reactants towards each other. If the unknown sample contains protein corresponding to the species antiserum against which it is being tested, an extended lattice forms as a result of cross-linking, and a precipitate forms where they reach equivalence concentrations. Weak positive reactions, common in archeological samples, are more readily observed if the gel is dried and stained with a protein stain, such as Coomassie Blue. Appropriate positive and negative controls, prepared in 5 percent ammonia solution, are run with each gel. These are: positive-blood of species being tested for e.g, deer blood for deer antiserum and negative-blood of species in which antiserum is raised e.g., rabbit if raised in that animal. Duplicate testing is carried out on all positive results.

The specific substances tested for in CIEP are immunoglobulins, or antibodies, a group of glycoproteins present in the antiserum and tissue fluids of all mammals (Roitt et al. 1985). There are five known immunoglobulin groups in normal human serum, IgG (70-75 percent), IgM (10 percent), IgA (15-20 percent), IgD (<1 percent), and IgE (in trace amounts). IgA is the predominant immunoglobulin in serosecretions such as saliva, tracheobronchial secretions, colostrum, milk, and genito-urinary secretions (Roitt et al. 1985). These are present in varying amounts in all vertebrates, but are absent in invertebrates (Roitt et al. 1985).

Antisera obtained from commercial sources are developed specifically for use in forensic medicine and, when necessary, these sera are solid phase absorbed to eliminate species cross-reactivity. However, these antisera recognize epitopes shared by closely related species and will often identify other species within the individual family. The antiserum to elk, raised against serum from modern species (*Cervus elaphus*) is species-specific, while antiserum to trout, raised against samples from modern species provides family level identification only. The relationship of animal antisera to potential prey species identified is shown in Table 9.

Table 9. Relationship of antisera to possible prey species.

Antisera	Possible Species Identified
Bear	Black, Grizzly
Bovine	Bison, Cow
Cat	Bobcat, Lynx, Mountain Lion, Domestic Cat
Chicken	Chicken, Turkey, Quail, Grouse, Pheasant

Antisera	Possible Species Identified
Deer	Mule of White-tailed Deer, Elk, Moose, Caribou, Pronghorn
Dog	Coyote, Wolf, Domestic Dog, Fox
Guinea Pig	Porcupine, Squirrel, Beaver, Guinea Pig
Rabbit	Rabbit, Hare, Pika
Rat	Rat (all species), Mouse (all species)
Sheep	Sheep, Goat

Results

The results are very promising and suggest blood residue analysis has the potential to address a number of issues for not only the reconstruction of past subsistence patterns, but for understanding tool use patterns (e.g., ground stone for processing items other than plants), presence of species, and environmental reconstruction. Seven flaked lithic artifacts recovered from the Goetz site were submitted for immunological analysis of protein residues (Table 10). Control soil samples were submitted with each of the artifacts. Residues were removed from the artifacts as discussed above. Initial testing of artifact and soil samples was carried out against pre-immune serum (i.e., serum from a non-immunized animal). A positive result against pre-immune serum could arise from non-specific protein interaction not based on the immunological specificity of the antibody (i.e., nonspecific precipitation). No positive reactions were obtained and complete testing of artifacts was continued against the antisera. Antisera from Cappel, produced for use in forensic medicine, provides family level identification only. The relationship of antisera to possible prey items has been developed by Dr. Margaret Newman. Immunological relationships do not necessarily bear any relationship to the Linnaean classification scheme although they usually do (Gaensslen 1983).

Four of the seven artifacts submitted for immunological residue analysis returned positive reactions to antisera (Newman 2001, 2002). A retouched flake (FS102.03.003) tested positive to rabbit antiserum. Any member of the Order Lagomorpha may be represented by this result, but cross-reactions with other Orders do not occur with this antiserum. A second retouched flake (FS103.03.002) elicited positive reaction to deer antiserum. Although all members of the Family Cervidae may be represented by this result negative reactions to pronghorn and elk antisera indicate that the most likely species identified is deer.

Positive reactions to bear and rabbit antisera were found on both portions of the biface (FS104.04.007 and 104.04.008). These results indicate the presence of two distinct species on these specimens as cross-reactions do not occur. Thus hunting and processing of bear and lagomorphs is suggested, however specific identifications for either species cannot be currently made. A reasonable interpretation would be that this biface was used in hunting or processing of bear and that rabbit blood or protein may suggest the use of rabbit sinew for hafting. Bear remains have been found associated with the materials recovered in 1971.

Table 10. Results of immunological analyses conducted by Dr. Margaret Newman.

FS Number	Artifact Type	Result
102.03.002	Retouched Flake	Negative
102.03.003	Retouched Flake	Rabbit
103.03.002	Biface	Deer
103.03.003	Retouched Flake	Negative
103.03.004	Retouched Flake	Negative
104.04.007	Biface	Bear, rabbit
104.04.008	Biface	Bear, rabbit

SUMMARY OF FIELD INVESTIGATIONS

Field investigations over the past three years have shed light on some of the research topics we proposed originally:

▼ **What is the context of the bone bed uncovered in 1971?**

The 1971 bone bed is probably an isolated event that occurred 800 years ago and involved the hunting and butchering of four bison, at least two of which were males. Field notes and photographs from the 1971 excavations have not been located.

▼ **What was the method of bison procurement used by the prehistoric groups?**

Due to the lack of documentation from the 1971 excavations, the method of procurement still remains elusive, but may have involved some type of ambush.

▼ **What is the time depth of the site?**

The occupational history of the site is probably co-extensive with the Holocene based upon the geologic context and projectile point styles. The geologic setting within a mid-Pleistocene valley capped with late Pleistocene and Holocene sediments suggests a much longer history is potentially present. We currently have three radiocarbon ages that date cultural deposits and landforms. These include: 800 ± 40 yrs BP from a bison metatarsal from the 1971 excavations; 1,900 ± 40 yrs BP on a large mammal bone in association with fired rock feature F01-01; and 3,360 ± 40 yrs on a long bone fragment from a medium artiodactyl from level 9 in Unit 24. Possible Late Paleoindian and mid-Holocene projectile points have been recovered and provide some evidence of the cultural history of the site.

▼ **Are there other deposits present at the site, or was this a single event?**

The occupational history at the Goetz site is long and involves a wide range of activities that include, but are not limited to, plant processing based upon the presence of ground stone artifacts, the hunting and processing of large and small mammals, and biface production from locally occurring quartzites.

▼ **What was the precontact ecology of the bison?**

The precontact ecology of bison is still undergoing study and will continue to be a major focus of field and laboratory analyses.

▼ **What was the demographic profile of the bison killed at the site?**

Four bison are represented in the 1971 assemblage, two of which are males. The age and gender of bison recovered from Earthwatch sponsored investigations are still undergoing analysis.

▼ **What was the season of the kill?**

The season of the 800-year-old kill has not been determined.

▼ **Can we discern larger topics, such as the density of bison in Jackson Hole, from this single site?**

The density of bison in Jackson Hole, and the Greater Yellowstone Ecosystem, is an ongoing research topic. The field investigations over the past three summers indicate that bison have been a component of the local faunal community for thousands of years, and may have been more prevalent than previous researchers have suggested (cf. Wright 1984). This will be an ongoing topic of this field investigation.

▼ **What are the results from the geophysical survey?**

Data processing of the geophysical survey is currently being undertaken, but initial results indicate anomalies are present around the spring. These anomalies have signatures that meet our criteria for precontact deposits and will be ground truthed through excavation in 2004.

▼ Immunological Analysis.

The results of the immunological analysis can add to our knowledge of subsistence of precontact groups, as well as help in the interpretation of how stone tools functioned. The limited sample from the Goetz site is encouraging and suggests that immunological analysis is a viable research tool for understanding a number of issues at the Goetz site.

▼ Geochemical Analysis of Obsidian Artifacts.

Although obsidian artifacts are limited at the Goetz site understanding the location of the geologic source of the obsidian adds greatly to questions concerning precontact land use patterns. The analysis of obsidian artifacts will continue as part of this research.

PUBLICATIONS

In 2002, Deanna Darr and Mark Andrews from the *Jackson Hole Guide* visited the site and produced an article for the paper (21 August 2002). Ken also conducted a phone interview with the *Jackson Hole News*. The National Museum of Wildlife Art in Jackson invited Ken to give a talk on the research (9 August 2002). Following the talk we gave a site tour to members of the audience. A short video of the tour was made and shown on the morning news at the local NBC affiliate KJWY.

In 2003, we presented a poster entitled *Recent Investigations at the Goetz site, Jackson Hole, Wyoming* at the Sixty-eighth Annual Meeting of the Society for American Archaeology in Milwaukee, Wisconsin. Frank Meek of the local NBC affiliate KJWY spent the afternoon of 7 July with us videotaping the excavations and interviewing the volunteers. A short segment of the interviews was shown on the morning news. Frank has expressed interest in conducting a larger video project of the Goetz site research and Earthwatch. Bert Raynes in his *Jackson Hole New and Guide* column *Far Afield* (5 February 2003) reported on our work in Jackson Hole and at the Goetz site.

Although not directly based upon the results of the Goetz site investigations, Molly and I have three publications in press on the archeology of Jackson Hole and northwestern Wyoming that will be published in 2004:

Hunter-Gatherers in Jackson Hole, Wyoming: Testing Assumptions about Site Function, by Kenneth P. Cannon, Dawn R. Bringelson, and Molly Boeka Cannon. In *Hunters and Gatherers in Theory and Archaeology*, edited by George M. Crothers, Occasional Paper No. 31, Center for Archaeological Investigations, Southern Illinois University.

Applied Zooarchaeology, Because It Matters, by R. Lee Lyman and Kenneth P. Cannon. In *Adding Prehistory to Conservation Biology: Zooarchaeological Studies from North America*, edited by R. Lee Lyman and Kenneth P. Cannon. University of Utah Press, Salt Lake City.

2004 Zooarchaeology and Wildlife Management in the Greater Yellowstone Ecosystem, by Kenneth P. Cannon and Molly Boeka Cannon, In *Adding Prehistory to Conservation Biology: Zooarchaeological Studies from North America*, edited by R. Lee Lyman and Kenneth P. Cannon. University of Utah Press, Salt Lake City.

Other recent publications include:

2003 Quaternary Geology and Ecology of the Greater Yellowstone Area, by Kenneth L. Pierce, Don G. Despain, Cathy Whitlock, Kenneth P. Cannon, Grant Meyer, Lisa Morgan, and Joe M. Licciardi.. *INQUA 2003 Field Guide Volume*, edited by D.J. Easterbrook, pp. 313-344. Desert Research Institute, Reno, Nevada.

2002 Post-Glacial Inflation-Deflation Cycles, Tilting, and Faulting in the Yellowstone Caldera Based on Yellowstone lake Shorelines, by Kenneth L. Pierce, Kenneth P. Cannon, Grant A. Meyer, Matthew J. Trebesch, and Raymond D. Watts. US Geological Survey Open-File Report 02-0142.

OTHER ACCOMPLISHMENTS AND BENEFITS

Photographs from the last two field season are currently posted on the Midwest Archeological Center's website. We plan on providing updates on our research through this forum. The website URL is <http://www.cr.nps.gov/mwac/>.

Molly is also developing a web GIS (geographic information system) using data from the Goetz site investigations. Internet-based mapping allows viewers to query and create maps without the need for GIS software on their machines. This website will be up and running by the end of 2003.

An unexpected discovery by Danny Walker at the University of Wyoming provided us with additional bison bones from the 1971 excavations. Also in the box was the mandible of a bear.

REFERENCES CITED

- Anderson, D.C., J.A. Tiffany, and F. Nelson
1986 Recent Research on Obsidian from Iowa Archeological Sites. *American Antiquity* 51(4):837-852.
- Arquembourg, P.C.
1975 *Immunoelectrophoresis: Theory, Method, Identification, Interpretation*. S. Krager, Basel-Munshen.
- Ascenzi, A. M. Brunori, G.Citro, and R. Zito
1985 Immunological detection of hemoglobin in bones of ancient Roman times and of Iron and Neolithic Ages. *Proceedings National Academy of Sciences USA* 82:7170-7172.
- Baugh, T.G., and F.W. Nelson, Jr.
1988 Archaeological Obsidian Recovered from selected north Dakota Sites and Its Relationship to Changing Exchange Systems in the Plains. *Journal of North Dakota Archaeological Association* 3:74-94.
- Beck, C., and G.T. Jones
1990 Toolstone Selection and Lithic Technology in Early Great Basin Prehistory. *Journal of Field Archaeology* 17:283-299.
- Beta Analytic, Inc.
1999 Analytical Procedures and Final Report. Beta Analytic, Inc., Miami, Florida.
- Bevan, Bruce W.
2000 *An early Geophysical Survey at Williamsburg, USA*. *Archeological Prospection* 7(1):51-58.
- 1998 *Geophysical Exploration for Archeology: An Introduction to Geophysical Exploration*. Midwest Archeological Center Special Report No. 1, Midwest Archeological Center, Lincoln.
- Bjorklund, B.
1952 Serological Analysis of Components of Hemopoietic Tissue. *Proceedings of the Society for Experimental Biology and Medicine* 79(2):324-328.
- Broderick, M.
1979 Ascending Paper Chromatographic Technique in Archaeology. In *Lithic Use-Wear Analysis*, edited by B. Hajden, pp. 375-383. Academic Press, New York.
- Burgett, G.R.
1990 *The Bones of the Beast: Resolving Questions of Faunal Assemblage Formation Processes Through Actualistic Research*. Unpublished Ph.D. Dissertation, Department of Anthropology, University of New Mexico, Albuquerque.
- Cannon, K.P., D. Bringelson, W. Eckerle, J. Androy, M. Sittler, M. Boeka, and H. Roeker
2001 The Results of Archeological Investigations at Three Sites Along the Wilson-Fall Creek Road Corridor, Teton County, Wyoming. United States Department of Interior, National Park Service, Midwest Archeological Center, Lincoln.
- Cannon, K.P., and R.E. Hughes
1993 Obsidian Source Characterization of Paleoindian Projectile Points from Yellowstone National Park. *Current Research in the Pleistocene* 10:54-56.
- 1997 Provenance Analysis of Obsidian Paleoindian Projectile Points from Yellowstone National Park, Wyoming. *Current Research in the Pleistocene* 14:101-104.

- Cannon, K.P., and R.E. Hughes
1999 Geochemical Analysis of Geologic Obsidian in the Greater Yellowstone Area. Research proposal submitted to the National Center for Preservation and Technology Transfer, Natchitoches, Louisiana.
- Cannon, K.P., R.E. Hughes, K.L. Pierce, and L.A. Morgan
1999 Geochemical Analysis of Geologic Obsidian in the Greater Yellowstone Area. Proposal submitted to The National Center for Preservation Technology and Training, Department of the Interior, National Park Service, Natchitoches, Louisiana.
- Clark, Anthony
1996 *Seeing Beneath the Soil: Prospecting Methods in Archeology*. 2nd Edition. T. Batsford, London.
- Connor, M.A.
1986 An Archeological Inventory of the Grand Loop Road from Biscuit Basin to West Thumb. Manuscript on file, Midwest Archeological Center, Lincoln, Nebraska.
- Culliford, B.J.
1964 Precipitin Reactions in Forensic Problems. *Nature* 201:1092-1094.
- Davis, L.B.
1972 *The Prehistoric Use of Obsidian in the Northwestern Plains*. 2 volumes. Ph.D. dissertation, Department of Archeology, University of Calgary.
- Downs, E.F.
1985 An Approach to Selecting and identifying Blood Residues on Archeological Stone Artifacts: A Feasibility Study. Manuscript on file, Center for Materials Research in Archeology and Ethnology, Massachusetts Institute of Technology, Cambridge.
- Downs, E.F., and J.M. Lowenstein
1995 Identification of Archeological Blood Proteins: A Cautionary Note. *Journal of Archeological Science* 22(1):11-16.
- Fredericksen, C.
1988 Gas Chromatography and Prehistoric Tool Use Residues: A Preliminary Study. *Archaeology in New Zealand* 31(1):28-34.
- Frison, G.C.
1974 The Application of Volcanic and Non-Volcanic Natural Glass Studies to Archeology in Wyoming. In *Applied Geology and Archaeology: The Holocene History of Wyoming*, edited by M. Wilson, pp. 61-64. The Geological Survey of Wyoming, Laramie.
- 1991 *Prehistoric Hunters of the High Plains*. 2nd Edition. Academic Press, New York.
- Frison, G.C., G.A. Wright, J.B. Griffin, and A.A. Gordus
1968 Neutron Activation of Obsidian: An Example of Its Relevance to Northwestern Plains Archeology. *Plains Anthropologist* 13(41):209-217.
- Gaensslen, R.E.
1983 *Sourcebook in Forensic Serology Immunology, and Biochemistry*. United States Department of Justice, Washington, D.C.
- Geoscan Research
1999 *Fluxgate Gradiometer FM9 FM18 FM36 Instruction Manual version 3.00g*. Geoscan Research, Bradford, England.

- Gordus, A.A., J.B. Griffin, and G.A. Wright
1971 Activation Analysis Identification of the Geologic Origins of Prehistoric Obsidian Artifacts. In *Science and Archaeology*, edited by R.H. Brill, pp. 222-234. The MIT Press, Cambridge, Massachusetts.
- Griffin, J.B., A. Gordus, and G.A. Wright
1969 Identification of the Sources of Hopewellian Obsidian in the Middle West. *American Antiquity* 34(1):1-14.
- Haber, E.
1964 Recovery of Antigenic Specificity after Denaturation and Complete reduction of Disulfides in a Papin Fragment Antibody. *Proceedings of the National Academy of Sciences* 52:1099-1106.
- Hansen, H.E., and H. Gurtler
1983 HLA Types of Mummified Eskimo Bodies from the 15th Century. *American Journal of Physical Anthropology* 61:447-452.
- Hedges, R.E.M., and G.J. Van Klinken
1992 A Review of Current Approaches in the Pretreatment of Bone for Radiocarbon Dating by AMS. *Radiocarbon* 34(3):279-291.
- Heglar, R.
1972 Paleoserology techniques Applied to Skeletal Identification. *Journal of Forensic Sciences* 24:601-611.
- Heron, C.L., R.P. Evershed, L.J. Goad, and V. Denham
1991 New Approaches to the Analysis of Organic Residues from Archaeological Remains. In *Archaeological Sciences 1989*, edited by P. Budd, B. Chapman, R. Janaway and B. Ottaway, pp.332-339. Oxbow Monograph 9.
- Hill, H.E., J. Evans, and M. Card
1985 New Approaches to the Analysis of Organic Residues from Archeological Remains. In *Archeological Sciences 1989*, edited by P. Budd, B. Chapman, R. Janaway, and B. Ottaway, pp. 332-339. Oxford Monographs 9.
- Hood, D.
1999 Letter report on results of radiocarbon assay of MWAC specimen 455.1.49 from Beta Analytic, Inc., dated 17 September 1999.
2003 Letter report on the results of radiocarbon assay of MWAC specimen FS124.09.007 from Beta Analytic, Inc., dated 2 November 2003.
- Hughes, R.E. (editor)
1989 *New directions in California Obsidian Studies*. Contributions of the University of California Archaeological Research Facility No. 48.
- Hughes, R.E.
1982 Age and Exploitation of Obsidian from Medicine Lake Highland, California. *Journal of Archaeological Science* 9(2):173-185.
1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 1-19. *Contributions of the University of California Archeological Research Facility* No. 45.
1988 The Coso Volcanic Field Reexamined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geoarchaeology* 3:253-265.
1990 Obsidian Sources at James Creek Shelter, and Trace element Geochemistry of Some Northeastern Nevada Volcanic Glasses. In *The Archaeology of James Creek Rockshelter*, edited by R.G. Elston and E.E. Buddy, pp. 297-305. Anthropological Papers No. 115. University of Utah, Salt Lake, City.

Hughes, R.E.

1991 Letter report from Richard E. Hughes to Kenneth P. Cannon dated 10 December 1991 on the results of geochemical analysis of artifacts from Yellowstone National Park, Grand Teton National Park, Canyonlands National Park, and Bryce Canyon National Park. On file, Midwest Archeological Center, Lincoln, Nebraska.

1995a Results of Geochemical Analysis of Geologic Samples from Northwestern Wyoming. Letter Report 95-8. Geochemical Research Laboratory, Portola Valley, California.

1995b Results of Geochemical Analysis of Obsidian Artifacts from Yellowstone National Park and Geologic Samples from Teton County, Wyoming. Letter Report 95-28. Geochemical Research Laboratory, Portola Valley, California.

1997 Results of Geochemical Analysis of Geologic Samples from Northwestern Wyoming. Letter Report 96-111. Geochemical Research Laboratory, Portola Valley, California.

Hughes, R.E.

2002 Report on the Energy Dispersive X-Ray Fluorescence Analysis of Obsidian Artifacts from the Goetz site (48TE455), Jackson Hole, Wyoming. Letter Report 2002-36. Geochemical Research Laboratory, Portola Valley, California.

Hughes, R.E., and K.P. Cannon

1997 The Continuing Obsidian Studies in the Greater Yellowstone Area. Paper presented at the 62nd Annual Meeting of the Society for American Archaeology, Nashville, Tennessee.

Hughes, R.E., and W.B. Lees

1991 Provenance Analysis of Obsidian from Two Late Prehistoric Archaeological Sites in Kansas. *Transaction of the Kansas Academy of Science* 94:38-45.

Hughes, R.E., and F.W. Nelson, Jr.

1987 New Findings on Obsidian Source Utilization in Iowa. *Plains Anthropologist* 32:313-316.

Hyland, D.C., and T.R. Anderson

1990 Blood Residue Analysis of the Lithic Assemblage from the Mitchell Locality. In *Lithic Technology at the Mitchell Locality of Blackwater Draw: A Stratified Site in Eastern New Mexico*, edited by A.T. Boldurian, pp. 105-110. *Plains Anthropologist Memoir* 24.

Hyland, D.C., J.M. Tersak, J.M. Adovasio, and M.I. Siegel

1990 Identification of the Species of Origin or Residual Blood on Lithic Material.

Jack, R.N., and I.S.E. Carmichael

1969 The Chemical "Fingerprinting" of Acid Volcanic Rocks. *California Journal of Mines Geology Short Contributions to California Geology* S.R. 100:17-32.

Keckler, Doug

1994 *SURFER for Windows User's Guide: Contouring and 3D Surface Mapping*. Golden Software, Inc., Golden, Colorado.

Kooyman, B., M.E. Newman, and H. Ceri

1992 Verifying the Reliability of Blood Residue Analysis on Archaeological Tools. *Journal of Archaeological Science* 19(3):265-269.

Kunselman, R.

1991 Durable Paleoindian Artifacts: Variability of Some Selected Wyoming Source Materials. *Wyoming Archeologist* 34(1-2):15-26.

- Kunselman, R.
1994 Prehistoric Obsidian Utilization in the Central Rocky Mountains: The Lookingbill Site, 48FR308. *Wyoming Archeologist* 38(1-2):15-26.
- Kvamme, K.L.
2003 Geophysical Surveys as Landscape Archaeology. *American Antiquity* 68(3): 435-558.
- Lee, H.C., and P.R. DeForest
1976 A Precipitin-Inhibition Test on Denatured Bloodstains for the Determination of Human Origin. *Journal of Forensic Sciences* 21:804-809.
- Lee, H.C., R.E. Gaensslen, H.W. Carver, E.M. Pagliaro, and J. Carroll-Reho
1989 ABH Typing in Bone Tissue. *Journal of Forensic Sciences* 34(1):7-14.
- Love, C.
1972 *An Archeological Survey of the Jackson Hole Region, Wyoming*. Unpublished M.A. Thesis, Department of Anthropology, University of Wyoming, Laramie.
- Love, J.D., J.C. Reed, and A.C. Christiansen
1992 *Geologic Map of Grand Teton National Park, Teton County, Wyoming*. Miscellaneous Investigations Series No. I-2031. U.S. Geological Survey.
- Lowenstein, J.M.
1986 Molecular Approaches to the Identification of Species. *American Scientist* 73:541-547.
- Loy, T.H.
1983 Prehistoric Blood Residues: Detection on Tool Surfaces and Identification of Species of Origin. *Science* 220:1269-1271.
- Loy, T.H., and A.R. Wood
1989 Blood Residue Analysis at Canonu Tepesi, Turkey. *Journal of Field Archaeology* 16:451-460.
- Macey, H.L.
1979 The Identification of Human Blood in a 166-Year-Old Stain. *Canadian Journal of Forensic Sciences* 12(4):191-193.
- Migrom, F., and W.A. Campbell
1970 Identification of Species of Origin of Tissue Found in a Sewer. *Journal of Forensic Science* 15:78-85.
- Milgrom, F., Z.M. Tuggac, and E. Witebsky
1964 Studies on Species Specificity. *Journal of Immunology* 93:902-909.
- Nelson, F.W., Jr.
1984 X-Ray Fluorescence Analysis of Some Western North American Obsidian. In *Obsidian Studies in the Great Basin*, edited by R.E. Hughes, pp. 27-61. Contributions of the University of California Research Facility No. 45. Berkeley.
- Newman, M.E.
1990 The Hidden Evidence From Hidden Cave, Nevada. PhD dissertation on file, University of Toronto, Canada.
- Newman, M.E.
2001 Immunological Analysis of Artifacts from the Goetz Site (48TE455). Letter report dated 31 October 2001. Bioarch, Inc., Cochrane, Alberta.
- 2002 Immunological Analysis of Artifacts from the Goetz Site (48TE455). Letter report dated 24 March 2002. Bioarch, Inc., Cochrane, Alberta.

- Newman, M.E., and P. Julig
1989 Protein Residues on Lithic Artifacts from a Stratified Boreal Forest Site. *Canadian Journal of Archaeology* 13:119-132.
- Newman, M.E., R.M. Yohe II, H. Ceri, and M.Q. Sutton
1993 Immunological Protein Residue Analysis of Non-Lithic Archeological Materials. *Journal of Archaeological Science* 20(1):93-100.
- Nickel, Robert K.
1993 The KNRI Magnetometer Survey and Mapping Subprogram. In *The Phase I Archeological Research Program for the Knife River Indian Villages National Historic Site, Part I: Objectives, Methods, and Summaries of Baseline Studies*, edited by T. D. Thiessen, National Park Service, Midwest Archeological Center, Lincoln, Nebraska.
- Nuttall, G.H.F.
1901a The Recognition of Human Blood. *The British Medical Journal* 1:788.
1901b A Further Note on the Biological Test for Blood and Its Importance in Zoological Classification. *The British Medical Journal* 2:669.
1904 *Blood Immunity and Blood Relationship*. Cambridge University Press, Cambridge.
- Pääbo, S.
1985 Molecular cloning of Ancient Egyptian mummy DNA. *Nature* 314:644-645.
1986 Molecular Genetic Investigations of Ancient Human Remains. *Cold Spring Harbor Symposia on Quantitative Biology* 11:441-446.
1989 Ancient DNA: Extraction, characterization, Molecular cloning, and enzymatic amplification. *Proceedings National Academy of Science USA* 86:1939-1943.
- Pääbo, S., R.G. Higuchi, and A.C. Wilson
1989 Ancient DNA and the Polymerase Chain Reaction. *The Journal of Biological Chemistry* 254:269.
- Pierce, K.L., and Good, J. M.
1986 Quaternary Geologic Setting of Archeological Sites, Jackson Lake, Wyoming: An Interim Administrative Report Concerned Mostly with the Lawrence Site. In *Jackson Lake Archeological Project, 1985: An Interim Report*, by M.A. Connor, pp. 157-192. On file, National Park Service, Midwest Archeological Center, Lincoln, Nebraska.
- Reeve, S.A.
1989 Prehistoric Settlement at the Yellowstone Lake Outlet, Yellowstone National Park, Wyoming. Manuscript on file, National Park Service, Midwest Archeological Center, Lincoln, Nebraska.
- Royal Canadian Mounted Police
1983 *Methods Manual, Serology Section*. Ottawa, Ontario.
- Roitt, I., J. Brotsroff, and D.K. Male
1985 *Immunology*. Gower Medical Publishing, London.
- Schoen, J.R.
1997 As Clear As Opaque Obsidian: Source Locations in Jackson Hole, Wyoming. *Tebiwa* 26(2):216-224.
- Scollar, I. A., A. Hesse, and I. Herzog
1990 *Archeological Prospecting and Remote Sensing*. Cambridge University Press, New York.

- Sensabaugh, G.F., A.C. Wilson, and P.L. Kirk
 1971a Protein Stability in Preserved Biological Remains I: Survival of Biologically Active Proteins in an 8-Year-Old Sample of Dried Blood. *International Journal of Biochemistry* 2:545-557.
- 1971b Protein Stability in Preserved Biological Remains II: Modification and Aggregation of Proteins in an 8-Year-Old Sample of Dried Blood. *International Journal of Biochemistry* 2:558-568.
- Stuiver, M., P.J. Reimer, E. Bard, J.W. Beck, G.S. Burr, K.A. Hughen, B. Kromer, G. McCormac, J. Van Der Plicht, and M. Spurk
 1998 INTCAL98 Radiocarbon Age Calibration, 24,000-0 cal BP. *Radiocarbon* 40(3):1041-1083.
- Stuiver, M., and P.J. Reimer
 1993 Extended ¹⁴C Data Base and Revised CALIB 3.0 ¹⁴C Age Calibration Program. *Radiocarbon* 35(1):215-230.
- Talma, A.S., and J.C. Vogel
 1993 A Simplified Approach to Calibrating C14 Dates. *Radiocarbon* 35(2):317-322.
- Thomas, K.D.
 1993 Molecular Biology and Archeology: A Prospectus for Inter-Disciplinary Research. *World Archaeology* 25:1-17.
- Todd, L.C.
 1987 Taphonomy of the Horner II Bone Bed. In *The Horner Site: Type Site of the Cody Complex*, edited by G.C. Frison and L.C. Todd, pp. 107-198. Academic Press, New York.
- Todd, L.C., and D.J. Rapson
 1991 *1991 Excavations at the Hudson-Meng Bonebed: Aspects of the Formational*
- Wright, G.A.
 1968 *Obsidian Analyses and Early Trade in the Near East*. Ph.D. dissertation, Department of Anthropology, University of Michigan, Ann Arbor.
- 1975 A Preliminary Report on the Archeology of the Jackson Hole Country. On file, National Park Service, Midwest Archeological Center, Lincoln, Nebraska.
- 1984 *People of the High Country: Jackson Hole Before the Settlers*. Peter Lang, New York.
- Wright, G.A., and Marceau, T.E.
 1981 Report on Excavations at Blacktail Butte. Manuscript on file, National Park Service, Midwest Archeological Center, Lincoln, Nebraska.
- Wright, G.A., J.B. Griffin, and A.A. Gordus
 1969 Preliminary Report on Obsidian Samples from Veratic Rockshelter, Idaho. *Tebiwa* 12(1):27-30.
- Yohe, R., M.E. Newman, and J.S. Schneider
 1991 Immunological Identification of Small-Mammal Proteins on Aboriginal Milling Equipment. *American Antiquity*