THE WYOMING ARCHAEOLOGIST

PAPERS FOR GEORGE C. FRISON

WYOMING STATE ARCHAEOLOGIST

1967-1984

edited by
Danny N. Walker

Volume 29(1-2) *Spring 1986*

THE WYOMING ARCHAEOLOGIST

THE WYOMING ARCHAEOLOGICAL SOCIETY, INC.

Carolyn Buff, President
1671 Westridge Terrace
Casper, Wyoming 82604

Kerry Lippincott, Exec. Secretary
441 Kirk Avenue
Casper, Wyoming 82604

Milford Hanson, Treasurer
1631 26th St.
Cody, Wyoming 82414

George Brox, Editor
1128 11th Street
Rawlins, Wyoming 82301

Danny Walker, Associate Editor
Department of Anthropology
University of Wyoming
Laramie, Wyoming 82071

THE WYOMING ARCHAEOLOGIST is published quarterly by the Wyoming State Archaeological Society, with the financial assistance of the Wyoming Recreation Commission. Address manuscripts and news items for publication to: George Brox, Editor, The Wyoming Archaeologist, 1128 11th Street, Rawlins, Wyoming 82301. Please send a minimum of two (2) copies of each manuscript submitted. A third copy would speed the review process. Readers should consult the articles in this issue for style and format.

Membership period is from January through December. All subscriptions expire with the Winter Issue and renewals are due the first part of January each year. Continuing members whose dues are not paid by March 30 of the new year will receive back issues only upon payment of $5.00 per issue.

If you move or have a change of address, please notify the Executive Secretary. Your WYOMING ARCHAEOLOGIST will not be forwarded unless a payment of $1.00 is received for return and forwarding postage.

Checks for chapter subscriptions and renewals should be sent to the chapter secretary involved. All other checks, subscriptions, and renewals should be addressed to the Treasurer. Correspondence and orders for back issues should be addressed to the Executive Secretary.

State Society yearly subscription rates are as follows:

Individual Associate Member @ $10.00
Single Active Member @ $6.00
Family Active Member @ $7.50
Institutional Member @ $15.00
Other Memberships, including Supporting and Contributing are available. Contact the Treasurer for information. Local chapter dues are in addition to the state society dues listed above. The Wyoming Archaeological Society is a Non-Profit Organization.

THE WYOMING ARCHAEOLOGIST

WYOMING ARCHAEOLOGICAL SOCIETY, INC.

VOLUME 29(1-2)

SPRING 1986

PAPERS FOR GEORGE C. FRISON
WYOMING STATE ARCHAEOLOGIST, 1967-1984

EDITED BY

DANNY N. WALKER

PREFACE

MARK E. MILLER

George C. Frison was Wyoming's State Archaeologist from September 1967 through April 1984. During these 17 highly productive years in this position, Dr. Frison completed some of the most significant research now available on prehistoric hunters of the High Plains. Throughout this tenure, he never hesitated to share his vast knowledge of Wyoming archaeology with the interested public.

When the Wyoming Archaeological Society first learned of Dr. Frison's impending resignation, the membership immediately began planning an appropriate way to acknowledge his years of service to the field and to the state. They chose to publish research papers from former students in a commemorative issue of The Wyoming Archaeologist.

Danny N. Walker, Assistant State Archaeologist and Associate Editor of the journal, solicited articles from 46 departmental graduates. Each student attended the University of Wyoming during Dr. Frison's term as State Archaeologist. The eight articles printed here illustrate the wide range of research that these scientists are engaged in. The papers also are testimony to the intellectual stimulation Dr. Frison fostered during each author's early academic career.

I am proud to write this preface. Dr. Frison, who still serves as Head of the Anthropology Department, exemplifies total commitment to our discipline. He carried Wyoming archaeology beyond its formative years and laid the foundation for contemporary studies. Professionals and avocational archaeologists alike will refer to his research, and gain from his insights, for decades to come. I join my colleagues in the hope that the articles published here illustrate, in some small way, the enduring influence Dr. Frison has bestowed upon archaeology and the discipline of anthropology.

TABLE OF CONTENTS

ANNOUNCEMENTS

IN REMEMBRANCE

Members of the Wyoming Archaeological Society will be saddened to hear of the passing of Jim Adams on January 7, 1986, in Lander, Wyoming. He had been in failing health for several years.

Jim had been an active member of the Society for about 20 years, having first joined the group in its fledgling years in 1962. Jim served the Society as its state president in 1968, was a member of the Wyoming Archaeological Foundation for about 10 years and was always an interested participant in both the annual spring meetings and the summer meetings. He was the recipient of the Society's Golden Trowel Award in 1979.

As president of the Lander Chapter, he led the group in several digs and surveys, with the assistance of the Department of Anthropology at the University of Wyoming. In recent years, Jim's interest widened into studying and photographing of petroglyphs. The entire issue of "The Wyoming Archaeologist" for March 1974 concerned his study of the ancient figures at Trail Lake. Jim's enthusiasm for archaeology and his contributions to further it will be missed by the Society.

-- Lucille Adams

MINUTES OF THE WYOMING ARCHAEOLOGICAL SOCIETY SPRING MEETING, APRIL 3-6, 1986

Program

From 8:00 P.M., April 3rd through 3:00 P.M., April 5th, in cooperation with the Montana Archaeological Society, the Montana Archaeological Association and the Wyoming Association of Professional Archaeologists, the Wyoming Archaeological Society presented a series of papers as part of a symposium entitled "New Developments in Northwest Plains Prehistory." A copy of that program is appended.

Business Meeting

The 1986 business meeting of the Wyoming Archaeological Society was held Friday, April 4th, 1986 at the Holiday Inn, Cody, Wyoming. The meeting was called to order at 8:00 P.M. by President Carolyn Buff.

Certification of Delegates

Voting delegates and alternates presented their credentials to the Executive Secretary, Kerry Lippincott. a roll call of the delegates and alternates from represented chapters was taken.

Secretary's Report

A motion was made by Grover Phelan and seconded by Patt Brown that the minutes of the previous business meeting be approved as published in the last Wyoming Archaeologist. Imogine Hanson asked that the dues published in that issue be corrected to reflect the current dues structure of Single Membership: $10.00; Family Membership: $15.00. The minutes were approved as corrected.

Presidents Note: Further inquiry into this discussion was undertaken following the conclusion of this meeting. Original minutes as taken by the secretary at the 1985 meeting and notes taken by myself during the meeting were examined, and Mr. Belz was consulted. All available information that could be drawn together indicates the figures as published in the Spring 1985 Wyoming Archaeologist were correct. The higher figures apparently reflect the addition of local chapter dues to the state society dues. Further inquiry into this problem will be undertaken and presented at the next annual meeting for clarification.

Editor's Report

In the absence of the editor, George Brox, Associate Editor Danny Walker gave the editor's report. He said the Fall issue for 1985 had been delayed by technical problems at the printers, but should be mailed soon. The spring issue for 1986 will go to a different printer next week. there is almost enough material for the Fall 1986 issue on hand, which would put the society's publication on schedule for 1986.

Treasurer's Report

The treasurer's report for the Wyoming Archaeological Society and the Wyoming Archaeological Foundation were presented by Milford Hanson. A motion to accept the report as audited was made by Mary Helen Hendry and seconded by John gilman. The motion was approved unanimously. Copies of both financial statements are appended.

Librarian's Report

The society's librarian, Danny Walker, reported that the library has been recently reorganized at the Department of Anthropology at the University of Wyoming. All of the materials are marked as the property of the Society and are available for use. there appears to have been a drastic reduction in the number of exchange publications. All but the most current of the society's correspondence is also stored at the Anthropology Department.

Committee Reports

The Scholarship Committee will meet on Saturday to discuss the applicants for the Mulloy and Frison Scholarships.

Chapter Reports

The Fremont County Chapter had a formal, annual report (see below) and the Cherokee Trails, North Big Horn, High Plains and Casper Chapters presented informal reports from the floor. It was moved and seconded that a reminder be sent to each chapter to prepare an annual report for presentation at the state meeting. The motion carried.

Annual Report, Fremont County Chapter, WAS

The Fremont County Chapter held nine regular meetings during 1985, with an average attendance for the meetings of 18 members. The meetings were held alternately in Riverton and Lander. The club had 12 family and 13 individual memberships. Officers for the year were: Bill Porter, President; Gail Gossett, Vice President; Lucille Adams, Secretary; and Ray Gossett, Treasurer.

The club initiated a new concept for presenting programs that we felt worked very well. this plan was to give each member the responsibility for one program during the year. We felt that this would give each member a sense of involvement with club activities.

In January, Nick Miller presented a program at which he displayed artifacts from southeastern United States. Pit houses in Hanna and Split Rock was the subject of the February meeting given by Mark Miller. Don Higgins of Central Wyoming College gave a TV documentary titled "Seeking the First Americans" for our March meeting. In April, Patt Brown displayed her tremendous collection of Indian beadwork, with demonstrations of various types of this craft. A

WYOMING
ARCHAEOLOGICAL SOCIETY, INC.

FINANCIAL STATEMENT
1985-86

BALANCE IN CHECKING ACCOUNT 3-14-85		$ 1,462.12
INCOME		2,144.00
		3,606.12
EXPENDITURES:		
Scholarships	700.00	
Secy of State	3.00	
Editors	215.08	
Meeting (1985 Torrington)	292.20	
Treasurer	50.42	
City of Cody Dep.	65.00	
Safety Deposit Box	10.00	
Secretary	256.32	
	$1,592.02	- 1,592.02
BALANCE IN CHECKING ACCOUNT		2,014.10
Certificate of Deposit #6015536		9,381.69
Net Worth 3-14-86		$11,395.79

This report respectfully submitted by,

Milford F. Hanson, Treasurer

Audit Committee:

Wyoming Archaeological Foundation

FINANCIAL STATEMENT
3-18-86

Balance Checking 3-14-85		$ 450.96
Income		759.83
		$1,210.79
EXPENDITURES		
Secy of State	3.00	
Postmaster Cody	22.00	
SFNB	400.00	
	425.00	
Balance Checking 3-18-86		785.79
C.D. 6015537		15,414.78
Int: due 5-5-86 approx. 539.51		
		16,200.57

This report respectfully submitted by,

Milford F. Hanson, Treasurer

Aduit Committee:

contract geologist, Jim Welch, told us of the trials and methods used by contract geologist for our May meeting. After a three month recess during which time several field trips were taken, we resumed formal meetings in September. The Gossetts showed us slides of a trip to Pompeii at this fall meeting. Slides and an interesting talk on working the Custer battlefield was the last meeting of 1985.

We felt that our chapter had an interesting and successful year.

Old Business

There was no old business to discuss.

New Business

Carolyn Buff reviewed the legislative activities that affected the Archaeological Survey section of the Wyoming Recreation Commission. She presented ideas for a possible future need for a political action legislative committee to assist the Survey section to continue its duties. She asked for at least one dedicated and committed volunteer from each chapter to serve on such a committee. David Eckles of the Survey section thanked all the members who had supported that agency in the past and asked to continue our support in the future. He outlined the past activities of the Survey section and summarized the current position with the legislature. George Frison presented his position on the necessity of a state agency with the ability to conduct high quality archaeological work as a yardstick with which to measure private contractor's work and as a training ground for students. He noted that the value of archaeological resources cannot be measured as if they were an item in the open market and that the Survey section had been good to the resource and had made contributions to research. An extensive discussion followed concerning the proposed legislative action committee. It was eventually moved and seconded that each chapter ask one member to serve on such a committee. They will meet before the summer meeting to develop a plan to promote the stabilization of funding and personnel of the Archaeological Survey section. The motion passed unanimously.

Election of Officers

Mary Helen Hendry made and John Gilman seconded a motion to retain the existing elected officers for another year. The officers were asked if they were willing and they said they were. They are:

- President -- Carolyn Buff
- 1st Vice President -- Alan Korell
- 2nd Vice President -- Susan Hughes

The motion to reelect was passed.

Summer Meeting

David Eckles presented a plan to hold the summer meeting at Edness Kimball Wilkins State Park in Casper in conjunction with a festival for all state parks. Other locations and sites were discussed. Grover Phelan made and Ray Parman seconded a motion to hold the summer meeting at Edness Kimball Wilkins Park, June 13th through 15th. The motion carried and the information will be distributed to individual members.

Spring Meeting 1987

Mary Helen Hendry made and John Gilman seconded a motion to hold the Spring Meeting for 1987 in Casper. After some discussion of facilities, the motion passed.

Adjournment

At 9:45, a motion was made and seconded to adjourn the meeting. The motion passed.

Scholarship Committee

At noon, April 6th, the Scholarship Committee and the Executive Officers met with Dr. George Frison and Dr. Charles Reher to select recipients of the Mulloy and Frison Scholarships. After a review of the applicants, their records, and references, it was decided to grant the Mulloy Scholarship to Jennifer Woodcock and the Frison Scholarship to Elizabeth Cartwright.

Golden Trowel Award

Carolyn Buff presented the Golden Trowel Award to Mimi Gilman in recognition of her service to the society as former Executive Secretary. The award was accepted in her absence by John Gilman.

Banquet and Guest Speaker

The annual banquet was held at the Cody Auditorium. The banquet speaker, Dr. Olga Soffer, University of Illinois, Urbana, gave a lecture and slide presentation entitled "Mammoth Hunters and Houses on the Russian Plain.

Respectfully Submitted,

(signed)
Kerry Lippincott
Executive Secretary

PROGRAM AGENDA

(Abbreviations defined below)

Thursday, April 3

1:00-5:00 p.m.	Registration at *BBHC Lobby*
2:00-5:00 p.m.	Montana Archaeological Association meeting at *BBHC classroom*
8:00 p.m.	Program by Richard Fox entitled: "Recent Developments in the Custer Battlefield Excavations" *ET 70, NWCC, Powell, Wyoming*

Friday, April 4

8:00 a.m.	Registration at *BBHC Lobby*
8:10 a.m.	Opening Remarks at *BBHC Auditorium*
8:20 a.m.	"Medicine Wheels in the Northern Plains: A Summary and Appraisal" *J. Brumley*
8:40 a.m.	"Rock Art Studies in Carbon County, Montana" *L. Loendorf*
9:00 a.m.	"Shields and Shield Bearers" *S. Conner*
9:20 a.m.	"Historical Archaeology at Fort Bridger 48UT29" *J. Hauff*
9:40 a.m.	**Break**
10:00 a.m.	"Settlement Patterns and Processes at Bannack, Montana (1862-1930)" *K. Karsmizki*
10:20 a.m.	"Frontier Settlement: Prehistoric and Early Historic Occupation of Southeastern Wyoming" *C. Reher*
10:40 a.m.	"Cultural Resource overview of the Cow Island Area, North-Central Montana" *D. Davidson*
11:00 a.m.	"Excavations at Three Sites in the Pine Breaks of Southeastern Montana: Lookout Point (24RB1007), Pyramid Mountain (24RB1008), and Timi's Shelter (24RB253)" *G. Munson*
11:20 a.m.	**Lunch Break**
11:45 a.m.	Wives' Luncheon at the *Country Club*
12:55 p.m.	Announcements

1:00 p.m.	"A New Ceramic Style for Avonlea in West-Central, Montana;; *J. Quigg*
1:20 p.m.	"The Lost Terrace Site (24CH68): A Decade Later" *L. B. Davis*
1:40 p.m.	"Avonlea Projectile Point Manufacture: A Testable Model" *A. Stanfill*
2:00 p.m.	"Continuing Investigations at the Scoggin Bison Kill-Butchery Site in Southcentral Wyoming" *M. Miller*
2:20 p.m.	**Break**
2:40 p.m.	"The Split Rock Ranch Pithouse Site near Jeffrey City, Wyoming" *D. Eakin*
3:00 p.m.	"Housepits and Hunter-Gatherer Adapation in Southwest Wyoming" *S. Creasman*
3:20 p.m.	"The 1985 Jackson Lake Archaeological Project" *M. Connor*
3:40 p.m.	"Bush Shelter (48WA324): A Study of Long Term Utilization of a Rock Shelter Site in North-Central Wyoming" *K. Miller*
4:30 p.m.	**Beer and Wine Party** *sponsored by BBHC and WAS in BBHC Lounge*
7:30 p.m.	Business Meetings of the Wyoming Archaeological Society, Montana Archaeological Society, and Wyoming Association of Professional Archaeologists at the *Holiday Inn*
8:00 p.m.	Program by Olga Soffer entitled: "Mammoth Hunters and Houses on the Russian Plain" *ET 70, NWCC, Powell, Wyoming*

Saturday, April 5

8:30 a.m.	Announcements at *BBHC Auditorium*
8:40 a.m.	"The Metzal Site (24Ma171): A Stratified Multicomponent early Holocene Site in Southwestern Montana *W. Eckerle*
9:00 a.m.	"Investigation of Site Structure at a Late Prehistoric Occupation Site: 1985 Excavations at the Bugas-Holding Site, Northwestern Wyoming" *D. Rapson*
9:20 a.m.	"Salvage Archaeology of the Timbered Lodges at Thirty Mile Area after the Hawk Creek Fire of 1984" *K. Feyle*
9:40 a.m.	"New Evidence for the Goshen Complex on the Northwestern Plains" *G. Frison*
10:00 a.m.	**Break**
10:20 a.m.	"Lithic Reduction Sequence and Spatial Analysis of a Folsom Site: the Hanson Site (48BH329)" *E. Ingbar*
10:40 a.m.	"Preliminary Investigations of Bison Populations from the Hawken Site" *H. Haspel*
11:00 a.m.	"The Horner Site Bone Beds: Documentation, Pattern Recognition, and Interpretation" *L. Todd*
11:20 a.m.	"A Comparison of Attrition Rates of Prehistoric and Historic Populations of Plains Indians" *C. Zimpel*
11:40 a.m.	**Lunch Break**
1:30 p.m.	Panel Discussion: **New Developments In Northern Plains Prehistory.** *Moderator:* Dr. Les Davis, Montana State University. *Discussants:* Dr. Tom Roll, Montana State University, Dr. Ken Deaver, Ethnoscience, Dr. Brian O.K. Reeves, University of Calgary, Dr. George Frison, University of Wyoming, Dr. Bob Alex, South Dakota State Archaeologist, and Dr. Michael Metcalf, Eagle, Colorado.

3:30 p.m.	Atlatl Demonstration with Rod Laird, Saratoga, Wyoming. Public participation invited at *BBHC front lawn, weather permitting*
6:00 p.m.	No host cocktail party at the *Cody Club Room*
7:00 p.m.	Banquet at the *Cody Club Room*. Speaker: Dr. Olga Soffer, "Mammoth Hunters and Houses on the Russian Plain"
Sunday, April 6	
8:00 a.m.	WAS Foundation Breakfast at the *Holiday Inn, no host*
9:00 a.m.	Fieldtrip to Hanson Site led by Milford Hanson and George Frison. Optional trip to Legend Rock Petroglyphs.

Abbreviations:
BBHC - Buffalo Bill Historical Center, Cody, Wyoming
NWCC - Northwest Community College, Powell, Wyoming
ET - Engineering and Technology Building, NWCC

GEORGE C. FRISON
WYOMING STATE ARCHAEOLOGIST, 1967-1984

DANNY N. WALKER

The Wyoming Archaeological Society first asked me to edit a volume of papers to commemorate George C. Frison's tenure as Wyoming State Archaeologist at their spring meeting in 1983. The society wished to honor George's commitment to Wyoming archaeology and the Wyoming Archaeological Society by collecting papers from former anthropology and archaeology graduate students at the University of Wyoming.

However, at first I felt some small degree of trepidation about being able to adequately prepare a volume of papers worthy of this commemoration. After working with the project for these past three years, I hope that I have done so.

At the same time, there was also a degree of pride in that the society chose me to prepare the volume. I have always looked up to and admired George and his many accomplishments over the years. I have worked both for and with him for 13 years and have never ceased to be amazed at what can be accomplished with little more than a couple of shovels, a screen, a few hand tools, a small amount of money for food, and a large amount of incentive. George is the type of person that makes people feel proud of being able to work with him, often getting nothing in return but a pat on the back and a good feeling of accomplishment and being involved in excellent archaeological research. I have known many students who had guilty consciences when they were unable to get away from their studies and drive hundreds of miles on the spur of a moment to help on one of his sites. I include myself among these students with such a guilty conscience.

The quality and quantity of his research on all aspects of archaeology has been nothing short of amazing. His interests range from classic site descriptions, to detailed lithic analysis, innovative faunal studies, and interdisciplinary fields such as geology, pedology, botany, and paleoecology. I have had the opportunity to learn about more about archaeology with George than I ever dreamed possible and have never regretted it for a minute.

Forty-three students graduated from the University of Wyoming with a Master of Arts degree in Anthropology during the period George Frison was Wyoming State Archaeologist. In addition, at least three undergraduates from the Department entered graduate school at other institutions, and placed George on their graduate committees or continued work on research projects initiated at the University of Wyoming. All forty-six of these former students (some of whom were not archaeologists) were invited to participate in this volume. Nineteen initially responded and expressed an interest in participating in the volume. Eight papers were finally accepted for the volume.

There is a wide range of archaeologically related studies represented in these eight papers by George's former students. They represent the multidisciplinary interests that are reflected in George's own research and the directions archaeology at the University of Wyoming and the Wyoming State Archaeologist's Office has taken under George's leadership.

Three of the papers present either summary or innovative information on techniques for analyzing faunal remains, particularly Bison. Fawcett reviews data on site aspects, tool types and percentages and numbers of animals in the site. Todd continues his earlier work on refitting of bison remains with this study on sexual dimorphism in the humerus and radius. Hughes reports on an excellent, semi-controlled situation for examining bone breakage after animals jumped from a 70 foot cliff. Related to these studies is Peterson's paper. While primarily concerned with lithic analysis of shellworking tools, the paper contains data relative to cultural modification of shell which can also be extended to cultural modification of bone by stone tools.

Francis, Kornfeld and Larson and Miller present three papers on lithic analyses. Francis' paper examines the inferences concerning site structure that can be made from detailed investigation of surface distribution of artifacts from the Powder River Basin. Kornfeld and Larson look at the vertical distribution of artifacts to establish living floors in a site where the stratigraphy does not allow easy separation of cultural occupation. Miller reports on a Hell Gap Paleoindian site in central Wyoming and reviews the depositional history of the Ferris-Seminoe dune field and how it relates to the cultural occupation of the area.

The last paper in the volume reviews the cultural sequence of an area in southeastern Colorado. Wood has been involved in the archaeology of this area even before her graduate work at U.W. in 1976.

BIOGRAPHY OF GEORGE C. FRISON[1]

George C. Frison was born November 11, 1924, in Worland, Wyoming. He first attended the University of Wyoming in 1942. Early in 1943 he joined the U.S. Navy, served with the amphibious forces in the South Pacific and was discharged in 1946. He operated a ranch in the Ten Sleep area until 1962 when he re-entered U.W. to complete a B.S. degree in 1964.

As a Woodrow Wilson Fellow, he then enrolled at the University of Michigan to receive an M.A. degree in one year and a doctorate in but two, both in anthropology. Frison was appointed head of the U.W. Anthropology Department the same month he received his Ph.D. degree -- May 1967 -- and became Wyoming State Archaeologist later that same year.

His teaching performance is colored by the rich insights derived from meticulous field work conducted over more than two decades. He is considered demanding in the classroom, yet is soft-spoken and gentle in demeanor. Students quickly recognize and appreciate

[1]revised from an article by Carl Harper, U.W. News Service, The Wyoming Archaeologist, Volume 28(1-2), 1985.

his encyclopedic knowledge. They praise his unfailing willingness to lavish time assisting them with individual academic problems.

As a researcher, a generator of new knowledge, Frison has achieved an eminence attained only by a dedicated few in any given century, a position confirmed by the acclaim of fellow professionals. His work has expanded by whole chapters the book of North American prehistory, replete with details of the primitive tool kits and the subsistence strategies that spelled survival for early man in an environment that remains harsh even by modern standards.

He has written and edited five major books, more than 50 other professional publications (with several additional now in press) and has presented scientific papers before more than 40 regional and national meetings. He has held more than a dozen research grants from the National Science Foundation and other agencies.

Frison was elected to the Board of Directors (1970), then president, Plains Anthropological Association (1970-1972); Fellow, American Academy for the Advancement of Science (1972); executive board, Society for American Archeology (1973); and president-elect (1981-1983) and president (1983-1985), Society for American Archeology. He received the Nebraska Historical Society's Asa Hill Award for "outstanding archeological research and interpretation on the Plains" (1975); the first Smithsonian Institution Regents' Award for archaeological research (1979); and the University of Wyoming George Duke Humphrey Distinguished Faculty Award (1985). He is also counselor and member of the Editorial Board, American Quaternary Association; a member of the Washington State University Radiocarbon Dating Advisory Committee (1982); and a Research Associate in the Department of Anthropology at the Smithsonian Institution (1984-1987).

BIBLIOGRAPHY OF GEORGE C. FRISON

1962 Wedding of the Waters Cave, 48HO301: A stratified site in the Big Horn Basin of northern Wyoming. Plains Anthropologist 7(18):246-265.

1965 Spring Creek Cave, Wyoming. American Antiquity 31(1):81-94.

1965 A preliminary report on two sites at Piney Creek, Wyoming: 48JO311 and 48JO312. Plains Anthropologist 10(30):240-249.

1967 The Piney Creek sites, Wyoming. University of Wyoming, Publications in Science 33(1):1-92.

1968 Site 48SH312: An Early Middle Period bison kill in the Powder River Basin of Wyoming. Plains Anthropologist 13(39):31-39.

1968 A functional analysis of certain chipped stone tools. American Antiquity 33(2):149-155.

1968 Neutron activation analysis of obsidian: An example of its relevance to Northwestern Plains Anthropology. Plains Anthropologist 13(41):209-217.

1968 Daughtery Cave, Wyoming. Plains Anthropologist 13(41):253-295.

1968 Leigh Cave, Wyoming. The

Wyoming Archaeologist 11(3): 20-33. (George C. Frison and Marion Huseaus).

1970 The Kobold site, 24BH406: A post-Altithermal record of buffalo jumping for the Northwestern Plains. Plains Anthropologist 15(47):1-35.

1970 The Glenrock Buffalo Jump 48CO304: Late Prehistoric buffalo procurement and butchering. Plains Anthropologist Memoir 7:1-66.

1971 The Buffalo pound in Northwestern Plains prehistory. American Antiquity 36(1):77-91.

1971 Shoshonean antelope procurement in the Upper Green River Basin, Wyoming. Plains Anthropologist 16(54):258-284.

1972 The role of buffalo procurement in post-Altithermal populations on the Northwestern Plains. Pp. 11-19., in Social Exchange and Interaction (E.N. Wilmsen, ed.). Anthropological Papers, University of Michigan 46.

1973 The Wardell Buffalo trap 48SU301: Communal procurement in the Upper Green River Basin, Wyoming. Anthropological Papers, University of Michigan 48.

1973 The Plains. Pp. 151-184, in The Development of North American Archeology (J. E. Fitting, ed.). Anchor Books.

1973 Early Period marginal cultural groups in northern Wyoming. Plains Anthropologist 18(62):300-312.

1974 The application of volcanic and non-volcanic glass studies to archeology in Wyoming. Pp. 61-64, in Applied geology and archaeology: the Holocene history of Wyoming (M. Wilson, ed.). Wyoming Geological Survey, Reports of Investigation 10.

1974 The Holocene stratigraphic archaeology of Wyoming: An introduction. Pp. 108-127, in Applied geology and archaeology: the Holocene history of Wyoming (M. Wilson, ed.). Wyoming Geological Survey, Reports of Investigation 10. (George C. Frison, Michael Wilson, and Diane Wilson).

1974 The Casper site: A Hell Gap bison kill on the High Plains. Academic Press, New York.

1975 Man's interaction with Holocene environments on the Plains. Quaternary Research 5:289-300.

1975 An introduction to Big Horn Basin Archaeology. Wyoming Geological Association Guidebook 27:19-35. (George C. Frison and Michael Wilson).

1975 Archeological reconnaissance survey of the Bridger-Teton National Forest. USDA Forest Service, Intermountain Region, Report 1.

1976 The cultural chronology of Paleo-Indian and Altithermal period groups in the Big Horn Basin, Wyoming. Pp. 147-173. in Cultural change and Continuity: Essays in Honor of James Bennet Griffin (C. E.

Cleland, ed.). Academic Press, New York.

1976 Fossil Bison and artifacts from an early Altithermal period arroyo trap in Wyoming. American Antiquity 41(1):28-57. (George C. Frison, Michael Wilson, and Diane Wilson).

1976 Crow pottery in northern Wyoming. Plains Anthropologist 21(71):29-44.

1976 Paleo-Indian research of intermontane basins adjacent to the North American High Plains. Actas del XLI Congreso Internacional de Americanistas 3:462-467.

1976 Cultural activity associated with prehistoric mammoth butchering and processing. Science 194:728-730.

1977 Paleo-Indian sites and economic orientations in the Big Horn Basin. The Museum Journal 17:97-116.

1978 Prehistoric Hunters of the High Plains. Academic Press, New York.

1978 Paleo-Indian procurement of Camelops on the Northwestern Plains. Quaternary Research 10(3):385-400. (George C. Frison, Danny N. Walker, S. David Webb, and George M. Zeimens).

1978 Animal population studies and cultural inference. Pp. 44-52, in Bison procurement and utilization: A symposium (L. B. Davis and M. Wilson, eds.). Plains Anthropologist Memoir 14.

1978 The Big Goose Creek site: Bison procurement and faunal analysis. Occasional Papers on Wyoming Archeology 1:1-50. (George C. Frison, Michael Wilson and Danny N. Walker).

1978 The archaeology of the Wind River Basin. Wyoming Geological Association Guidebook 30:25-37.

1978 Prehistoric man and bison relations on the High Plains [Abstract]. AMQUA Abstracts and Program, Fifth Biennial Meeting, pp. 88.

1978 The archeology of Little Canyon Creek Cave and its associated late Pleistocene fauna [Abstract]. AMQUA Abstracts and Program, Fifth Biennial Meeting, pp. 200. (George C. Frison and Danny N. Walker).

1979 Observation on the use of stone tools: Dulling of working edges of some chipped stone tools in bison butchering. Pp. 259-268, in Lithic Use-Wear Analysis (B. Hayden, ed.). Academic Press, New York.

1980 Bone projectile points: An addition to the Folsom cultural complex. American Antiquity 45(2): 231-237. (George C. Frison and George M. Zeimens).

1980 Pryor Stemmed: A specialized paleo-indian ecological adaptation. Plains Anthropologist 25(87):27-46. (George C. Frison and Donald C. Grey).

1980 Folsom Tools and Technology at the Hanson Site, Wyoming. University of New Mexico

Press, Albuquerque. (George C. Frison and Bruce A. Bradley).

1980 The Vore site, 48CK302: A stratified buffalo jump in the Wyoming Black Hills. Plains Anthropologist Memoir 16. (Charles A. Reher and George C. Frison, eds.).

1980 A composite, reflexed, mountain sheep horn bow from western Wyoming. Plains Anthropologist 25(88):173-175.

1980 Man and bison relationships in North America. Canadian Journal of Anthropology 1(1): 75-76.

1980 The late Pleistocene mammalian fauna from the Colby mammoth kill site, Wyoming. University of Wyoming, Contributions to Geology 19(1):69-79. (Danny N. Walker and George C. Frison).

1980 The early Holocene vertebrate fauna from the Agate Basin site, Niobrara county, Wyoming. AMQUA Abstracts and Program, Sixth Biennial Meeting, pp. 194-195. (Danny N. Walker and George C. Frison).

1981 Fluting Folsom projectile points: Archeological evidence. Lithic Technology 10(1):13-16. (George C. Frison and Bruce A. Bradley).

1981 Linear arrangements of cairns in Wyoming and Montana. Pp. 133-147, in Megaliths to Medicine Wheels: Boulder structures in archaeology (M. Wilson, K. L. Road and K. J. Hardy, eds.). Chacmool Conference, Proceedings 11:133-148.

1982 Paleo-Indian winter subsistence strategies on the High Plains. Smithsonian Contributions to Anthropology 30:193-201.

1982 A probable Paleoindian flintknapping kit from the Medicine Lodge Creek site, 48BH499, Wyoming. Lithic Technology 11(1):3-5.

1982 Sources of steatite and methods of prehistoric procurement and use in Wyoming. Plains Anthropologist 27(98): 273-286.

1982 Bone butchering tools in archaeological sites. Canadian Journal of Anthropology 2(2):159-167.

1982 Studies on Amerindian Dogs, 3: Prehistoric wolf/dog hybrids from the Northwestern Plains. Journal of Archaeological Science 9:125-172. (Danny N. Walker and George C. Frison).

1982 The Agate Basin Site: A Record of Paleoindian Occupation of the Northwestern High Plains. Academic Press, New York. (George C. Frison and Dennis J. Stanford, eds.).

1983 The Lookingbill site: 48FR308. Tebiwa 20:1-16.

1983 The western plains and mountain region. Pp. 109-124, in Early Man in the New World (R. Shutler, Jr., ed.). Sage Publications, Beverly Hills.

1983 Stone circles, stone-filled fire pits, grinding stones and High Plains archaeology. Plains Anthropologist Memoir 19:81-91.

1984 Avocational archaeology: Its past, present and future. Pp. 184-193, In Ethics and Values in Archaeology (E. L. Green, ed.). The Free Press, New York.

1984 The Carter/Kerr-McGee paleoindian site: Cultural resource management and archaeological research. American Antiquity 49(2):288-314.

1984 The Dead Indian Creek site: An archaic occupation in the Absaroka Mountains of Northwestern Wyoming. The Wyoming Archaeologist 27(1-2):11-122. (George C. Frison and Danny N. Walker, eds.).

1986 The Colby Mammoth Site: Taphonomy and Archaeology of a Clovis Kill in Northern Wyoming. University of New Mexico Press, Albuquerque. (George C. Frison and Lawrence C. Todd, eds.).

1986 The Wind River Canyon burial and cache: 48HO10. Archaeology in Montana 26(2):43-52.

1986 A late paleoindian animal trapping net from northern Wyoming. American Antiquity 51(2). (George C. Frison, R. L. Andrews, J. M. Adovasio, R. C. Carlisle, and Robert Edgar).

THESES SUPERVISED BY GEORGE C. FRISON

1971 Joanne M. Mack: Archaeological investigations in the Bighorn Basin, Wyoming.

1971 Charles A. Reher: A survey of ceramic sites in southeastern Wyoming.

1972 Charles M. Love: An archeological survey of the Jackson Hole region, Wyoming.

1973 John E. Lobdell: The Scoggin site: An Early Middle Period bison kill.

1974 Jean Newman Bedord: Morphological variation in bison metacarpals and metatarsals from six archeological sites.

1975 Danny N. Walker: A cultural and ecological analysis of the vertebrate fauna from the Medicine Lodge Creek site (48BH499).

1975 George M. Zeimens: 48AB301: A Late Prehistoric Period site in the Shirley Basin of Wyoming.

1975 Charles R. Swaim: A survey of the Trail Lake petroglyphs.

1975 James R. Durkee, Jr.: An archeological data bank at the University of Wyoming.

1976 Caryl Wood Simpson: Trinchera Cave: A rock shelter in southeastern Colorado.

1976 Mark E. Miller: Communal bison procurement during the Middle Plains Archaic: A comparative study.

1976 Mary Elizabeth Galvan: The vegetative ecology of the Medicine Lodge Creek site: An approach to Archaic subsistence problems.

1976 Thomas K. Larson: The Archeology of 32SH7: A bison kill in central North Dakota.

1977 Robert Peterson, Jr.: Sexual

and morphological characteristics of bison populations from communal kill sites in and near Wyoming: Radiographic analysis of the metacarpals.

1977 John Jameson: Archeological investigations in the area of the proposed Middle Fork Dam and Reservoir, Johnson County, Wyoming.

1979 Francis E. Smiley: An analysis of the cursorial aspects of the biomechanics of the forelimb in Wyoming Holocene bison.

1980 Leslie C. Shaw: Early Plains Archaic procurement systems during the Altithermal: The Wyoming evidence.

1980 Rhoda Owen Lewis: Use of opal phytoliths in paleoenvironmental reconstructions.

1980 William L. Tibesar: An intrasite discussion of the Greyrocks archeological site: 48PL65.

1982 Marcel Kornfeld: Stockraising settlement strategies.

1982 Gregory Newberry: A multivariate analysis of end scrapers from the Northwestern High Plains.

1982 Paul H. Sanders: A Lithic Analysis of the Windust Phase Component, Hatwai site (10PL43), Nes Perce County, Idaho.

Danny N. Walker
Office of the Wyoming State Archaeologist
Department of Anthropology
University of Wyoming
Laramie, Wyoming 82071

VARIATION IN CHIPPED-STONE TOOL ASSEMBLAGES FROM BISON KILLS AND ASSOCIATED PROCESSING AND CAMP SITES

WILLIAM B. FAWCETT JR.

ABSTRACT

Chipped-stone tools from ninety-eight excavated assemblages are analyzed to determine if significant differences exist in tool frequencies and densities between bison kill, processing and camp sites. When the assemblages from various kinds of bison kills are compared, the only major distinction is in the number of projectile points per bison. Pounds and jumps have three times more points per bison than arroyo or other forms of bison traps. This counter-intuitive finding may be explained if animal processing at pounds and jumps is more intensive, thus reducing the number of bison remains. This observation may also be explained by tec hnological changes, such as bows and arrows replacing thrusting or throwing spears. Most pounds and jumps date to the Late Prehistoric period when arrowpoints were in use. Bison kill, processing, and camp sites differ most sig nificantly in the proportions of projectile points, end scrapers, retouched flakes, gravers, and den ticulates. Questions about site function, the rarity of bison kill sites, and the organization of food storage are considered using these results.

INTRODUCTION

A fundamental procedure in archaeological research is the comparison of artifact frequencies, both relative and absolute, between sites and between excavation levels. Various tools types are assumed to have specific functions. Humans use specific tools to accomplish activities and then eventually discard them. Also, many tools are not always discarded at the place of use; sometimes tools are reused or altered later.

Chipped-stone tool frequencies are compared to examine whether significant differences exist between assemblages from Plains bison kill, processing, and camp sites. Some archaeologists have previously stated that tool types and frequencies vary between different kinds of sites (Frison 1971:86; Keyser 1979a:144) and are uniform within each kind of site (Roll and Deaver 1980:95). Few comparative studies are available.

This paper contributes to the resolution of several problems affecting our understanding of prehistory. Prehistoric inhabitants of the Plains are believed to have relied on bison for much of their subsistence. Bison were often obtained through communal hunts. It is, therefore, surprising to learn that communal bison kill sites account for only one to three percent of the Great Plains archaeological sites (Fawcett 1984). The infrequency of bison kill sites may be due to the natural destruction and deterioration of bonebeds. When bone is not preserved, many bison kills might go undetected in archaeological site surveys. The ability to distinguish the stone tool assemblages of bison kills from other types of sites would permit an assessment of the underreporting of bison kill sites, due to poor bone preservation.

Each type of bison kill site (pounds, jumps, arroyo traps, bogs, sand dunes, etc.) might have a distinct stone tool assemblage. Questions concerning the means of bison trapping might be resolved through an examination of the stone tool assemblages associated with these sites.

Issues raised in this paper are not limited to bison hunting in the American Plains, but are also relevant to a discussion of the organization, recognition, and relative importance of hunting activities and home bases in the African and European Paleolithic. This topic will be elaborated on in a later section. Predications about variation in stone tool assemblages will be developed from the existing literature. These predictions are then evaluated with actual chipped-stone tool assemblage data from bison kill, processing and camp sites. Finally, the research results are used to resolve some specific questions about site function, methods of bison procurement, and meat storage.

EXPECTATIONS AND PREDICTIONS

Prehistoric bison hunters utilized at least three types of sites. Kill sites are locations where animals were procured and partially butchered (Frison 1978: 77; Reher and Frison 1980:19). Processing sites were frequently situated nearby to minimize the difficulty in transporting bones, hides, and meat before bulk was reduced and preservation was accomplished. At processing sites, meat was cut into strips for drying, bones were broken and boiled to extract marrow and grease, and hides were scraped, cut, and sewn (Frison 1973:48; 1978:148; Frison et al. 1978:11; Keyser 1979a:135; Wheat 1979:148). These products were then used and consumed in camps where more permanent habitation occurred, along with various everyday activities (Frison and Bradley 1980; Keyser 1979a:137; Parry and Speth 1984:60-64).

Projectile points are the most common artifacts at bison kill sites (79% of chipped-stone tools, Judge 1974:125; Agenbroad 1978:91; Judge 1973; Kehoe 1967:90; Roll and Deaver 1980:Table 5; Wheat 1979: 148). Where bison were driven over lethal jumps (> 12 m), fewer projectile points are found (1/bison). Projectile points are much more abundant in arroyo traps and pounds (4-5/bison) than at jumps (Frison 1970a:42, 1970b:29, 1973:6, 12; 1978:202; Judge 1974:71; Kehoe 1967:90; Reher and Frison 1980: 19).

Initial butchering was accomplished at kill sites with a few heavy chopping and cutting tools, including large flakes, choppers, and hammerstones. Some flakes were retouched and are commonly called side scrapers (Frison 1973:85; 1978:77,313; Frison and Bradley 1980:127-129). Bifaces (knives) rarely occur in butchering assemblages (Frison 1978:311). As cutting implements became dull they were resharpened or replaced. Processing activities were accomplished with end scrapers, retouched/utilized flakes, gravers, drills, hammerstones, grinding stones, and ceramics (Roll and Deaver 1980:Table 5). The few projectile points found in processing areas might result from those transported from the bison kill site in larger cuts of meat.

Camps are locations of longer occupations and more diverse activities. Tool use for more varied activities produces an assemblage with greater diversity and higher proportions of multi-functional and complex use-edges (Frison and Bradley 1980, Parry and Speth 1984: 60). Tools are frequently recycled for other purposes. Gravers, drills, and denticulates are more numerous in camps than in other sites (Judge 1973:199; Stanford and Albanese 1971:24-25), as are pottery and grinding stones (Keyser 1979a:137). In comparison, few projectile points occur within camps sites (13-16% of tools; Judge 1973, 1974:125; Wheat 1978: 88-89).

In summary, high proportions of projectile points and heavy butchering implements (choppers, side scrapers, retouched flakes) are expected to occur in chipped-stone assemblages from bison kill sites. Processing site assemblages are expected to include lower proportions of points and higher percentages of end scrapers, retouched flakes, and pounding tools. Camps would differ by having more diverse tool forms, many of which are absent or rare at other types of sites (gravers, denticulates, and drills). More multifunctional and recycled tools (multiple scrapers) and fewer projectile points are expected in assemblages from camps. These predictions represent empirical generalizations that have been rarely examined with samples of stone tool assemblages from more than one time period or sub-area of the Great Plains.

ASSUMPTIONS AND QUALIFICATIONS

Some assumptions are necessary before assemblages can be compared. Although most archaeologists sort their tools into similar tool types, their definitions of these types vary. Some tools are reclassified on the basis of written tool descriptions and illustrations in an attempt at standardization.

The actual number of tools excavated from an archaeological site is not the same as the number of tools used at a site, since many of the tools were taken to other locations following their initial use (Frison 1967:47, 1970a:37, 1971:89). The proportion of tools that were removed or curated is probably related to the availability, hardness, or texture of raw materials, anticipated future use, the condition of a tool, and the bulk or weight of a tool. Site reuse for different purposes would also alter tool frequencies. For present purposes, I assume that the values for these variables are constant across space, through time, and between classes of tools. I also assume that a particular assemblage was produced by people doing the same things, even when the site was reused. Ultimately these simplifying assumptions will have to be relaxed to examine more interesting research questions.

The condition of the animals being butchered also alters rates of tool use. Tools used to butcher leaner animals and to scrape grimier hides would wear out more quickly as a result of more frequent resharpening (Brose 1975; Frison 1973:12). Animal condition varies seasonally as the amount and quality of forage changes and various biological events occur (pregnancy, breeding, etc.). Comparisons of stone tool assemblages should, therefore, be restricted to sites with identical seasonalities. Because the exact seasonality of most of the sites in the sample is unknown, this solution is not attempted.

THE SITE SAMPLE

A total of ninety-eight archaeological sites have been selected for comparison (Table 1). Almost half (n=48) of these sites are bison kills. The rest are split almost evenly between processing (n=22) and camp (n=19) sites. The kill sites include arroyo traps (n=16), pounds (n=16), jumps (n=11), and other forms (bogs, dune, drifts, or unknown; n=5). The sites are scattered throughout the Plains. Bonfire shelter (41VV218) is the only rockshelter included in the analysis.

Several data quality criteria have been employed in selecting the sites. At least 10 tools have been reported from the excavations at each site. Archaeological sediments usually were screened for artifacts. Debitage (cores and flakes), groundstone, and pottery are excluded from the analysis because their frequencies are inconsistently reported. Bone tools are not considered, due to differential recognition, reporting, and preservation.

Tool frequencies are tabulated from site or component for the following categories: projectile points, bifaces (knives), end scrapers, side scrapers, multiple scrapers, gravers, drills, retouched flakes (utilized flakes), choppers, and denticulates (notches, spokeshaves). Tools with multiple functions or use-edges are included with multiple scrapers. Data are also coded on the volume and number (MNI) of bison recovered from the excavation. The height of the drop-off above the kill or bonebed is recorded from jump sites.

ANALYSIS

The research question is not simply one of classification (i.e., how sites can be sorted into pigeon holes), that could be addressed through discriminant analysis. Instead, the question is to determine if chipped stone tool assemblages from different types of sites are distinguishable in the ways indicated by prior archaeological research.

One-way analysis of variance (ANOVA) is a statistical technique well-suited for examining this type of question (Blalock 1972:317-329). Separate means and standard deviations are computed for the relative frequencies of each tool type from each type of site (Table 2). The null hypothesis is that the means for each tool type are equal for each type of site. The hypothesis is evaluated with the F-test.

Two ANOVAs were calculated for each tool type (Table 2). The first (all kills) compares different varieties of bison kills, and the second (all sites) compares kills to processing and camp sites.

ANOVA requires the assumption of normality, independent random samples, and equal population standard deviations (Blalock 1972: 317). Some tool types exhibit

Case no.	Site	Site number	State/ Province	Reference	Comments
1	Old Women's	Ec Pl-1	Alberta	Forbis 1962	All levels
2	Fish Creek	Ec Pm-27	Alberta	Smith et al. 1977	Level 1, no posts
3	Fish Creek	Ec Pm-27	Alberta	Smith et al. 1977	Level 1
4	Muhlbach	---	Alberta	Gruhn 1969	
5	Kremlin	24HL401	Montana	Keyser 1979a	Process
6	Ayers-Frazier	24PE30	Montana	Clark & Wilson 1981	
7	Boarding Schl	24GL302	Montana	Kehoe 1967	Level 7,15,18
8	Avocet	24HL8	Montana	Keyser 1979a	
9	Krelmin	24HL401	Montana	Keyser 1979a	Kill
10	Wardell	48SU301	Wyoming	Frison 1973	Pound
11	Wardell	48SU301	Wyoming	Frison 1973	Process
12	Hawken	48CK303	Wyoming	Frison et al. 1976	
13	Fresno	24HL103	Montana	Keyser 1979a	Pound
14	Glenrock	48CO304	Wyoming	Frison 1970a	
15	Casper	---	Wyoming	Frison 1974	
16	Bootlegger	24TL1237	Montana	Roll & Deaver 1980	Kill, no posts
17	Bootlegger	24TL1237	Montana	Roll & Deaver 1980	Process
18	Big Goose Cr.	48SH313	Wyoming	Frison et al. 1978	Jump
19	Big Goose Cr.	48SH313	Wyoming	Frison et al. 1978	Camp
20	Bonfire	41VV218	Texas	Dibble et al. 1968	All levels
21	Hudson-Meng	25SX115	Nebraska	Agenbroad 1978	
22	Olsen-Chubbuck	5CH3	Colorado	Wheat 1972	
23	Twilla	A73	Texas	Hughes 1977	
24	Doc Bell	A696	Texas	Hughes 1977	
25	Fresno	24HL103	Montana	Keyser 1979a	Process
26	Rex Rodgers	41BI42	Texas	Speer 1978, Willey et al. 1978	
28	Itasca	---	Minnesota	Shay 1971	Kill
29	Itasca	---	Minnesota	Shay 1971	Process
30	Gull Lake	---	Sask.	Kehoe 1973	Zones 2,4,5; No posts
31	Bakken-Wright	---	Sask.	Adams 1975	
32	Kobold	24BH406	Montana	Frison 1970b	Jump, all levels
34	Piney Creek	48JO312	Wyoming	Frison 1967, 1978	Jump
35	Piney Creek	48JO312	Wyoming	Frison 1967, 1978	Process
36	Piney Creek	48JO311	Wyoming	Frison 1967, 1978	Camp
37	Vore	48CK302	Wyoming	Reher & Frison 1980	All levels
38	Scoggin	---	Wyoming	Lobdell 1973	
39	Estuary	---	Sask.	Adams 1977	
40	Ruby	48CA302	Wyoming	Frison 1971, 1978	Pound
41	Jones-Miller	---	Colorado	Stanford 1974, 1975, 1978	
42	Powers-Yonkee	24PR5	Montana	Bentzen 1962,1966a	
43	Buffalo Creek	48SH311	Wyoming	Bentzen 1966b	
44	Powder River	48SH312	Wyoming	Frison 1968, 1978	
45	Lamb Springs	5DA201	Colorado	Rancier et al. 1982 Stanford et al. 1981	Cody
46	Frasca	5LG19	Colorado	Fulgham et al. 1982	
47	Tschetter	---	Sask.	Prentice 1983	
48	Cherokee	13CK405	Iowa	Anderson & Semken 1980	Ib,IIb,IIIa
49	Garnsey Spring	LA18400	N.M.	Parry & Speth 1984	Camp
50	Garnsey	LA17399	N.M.	Speth 1983	No posts
51	Lightning Spr.	39HN204	S. D.	Keyser 1982	McKean levels
53	Hanson	---	Wyoming	Frison and Bradley 1980	

TABLE 1: Bison kill, processing, and camp sites in the sample.

54	Anderson	Fd Ct-1	Alberta	Quigg 1984	
55	Teton Ridge	24TT1002	Montana	Keyser 1979b	
57	Garza	41GA40	Texas	Ruckels 1964	
58	Montgomery	---	Texas	Word 1965	
59	Jurgens	5WL53	Colorado	Wheat 1978,1979	Area 1-2
60	Jurgens	5WL53	Colorado	Wheat 1979,1979	Area 3
61	Highwalker	24PR627	Montana	Keyser & Davis 1981	
63	W. Rosebud	24ST651	Montana	Greiser & Plochman 1981	
65	Pete Creek	X41CB1	Texas	Parsons 1967	
66	Anderson	32ML111	N. D.	Good and Hauff 1979	
67	Stark-Lewis	24GV401	Montana	Feyhl 1972	
68	Abraxas	32MZ333	N. D.	Floodman et al. 1982	
69	Stott	Dl Ma-1	Manitoba	Hamilton et al. 1981	
70	BLM	24RB1021	Montana	Eckland 1974	
71	Roberts	5LR100	Colorado	Witkind 1971	Jump Process
72	Roberts	5LR100	Colorado	Witkind 1971	
73	Cordero	48CA75	Wyoming	Reher et al. 1978	
74	Castle Gardens	48FR1398	Wyoming	Walker & Todd 1984	
75	Dead Indians	48PK551	Wyoming	Frison & Walker 1984	
76	Foss-Thomas	---	Montana	Fry 1971, Frison 1978	
77	Ramilles	---	Alberta	Brumley 1976	Pound Process
78	Ramilles	---	Alberta	Brumley 1976	
79	Ft. McLeod	Dk Pi-2	Alberta	Reeves et al. 1981	Occup. 3-4
80	Willow Springs	48AB130	Wyoming	Bupp 1981, Frison 1978	
81	Wagensen	48CA89	Wyoming	Reher 1982	Area 1 & 3
82	Wagensen	48CA89	Wyoming	Reher 1982	Area 2
84	Garratt	Ec Nj-7	Sask.	Morgan 1979	Level 6
85	Belly River	Dh Pj-11	Alberta	Quigg 1974	Level 2-4
87	Carter/Kerr	48CA12	Wyoming	Frison 1984	Alberta-Cody
88	Canning	21NR9	Minnesota	Michlovic 1983	
89	J. Allen	---	Wyoming	Mulloy 1959	
90	Melhagen	---	Sask.	Phenix 1969	
91	Lipscomb	41LP1	Texas	Schultz 1943	
92	Plainview	41HA1	Texas	Sellards et al. 1947	
93	Milnesand	---	N.M.	Sellards 1955	
94	---	32SH7	N.D.	Larson 1976	
95	Gowen	---	Sask.	Walker 1980	
97	Fresno	24HL103	Montana	Keyser 1979a	Besant process
98	Agate Basin	---	Wyoming	Frison et al. 1982	Folsom/A2

TABLE 1: (continued).

considerable skewing, violating this assumption. These include the relative frequencies of choppers, end scrapers, side scrapers, retouched flakes, and gravers, and the densities of projectile points and total tools. Generally, these items are present at low frequencies. I have not attempted to normalize the data through transformations, but have eliminated some outliers.

Relative frequencies (percentages) may create problems with autocorrelation between tool types and obscure the effects of variation in assemblage size (Speth and Johnson 1976). Relative frequencies are also exceedingly difficult to normalize or transform. Artifact densities might be preferable to relative frequencies. To examine this possibility, ANOVAs were computed with densities and then

TOOL PROPORTIONS

A. Projectile points (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	66.4	74.5	29.6	11.6	100.0	16	
jump	77.8	78.9	16.4	48.6	100.0	11	
arroyo	68.0	72.7	21.4	25.0	96.0	16	
other	70.6	83.3	26.8	27.8	94.2	5	
all kills	70.0	76.0	23.8	11.6	100.0	48	0.5
process	32.2	25.2	21.0	3.1	76.5	22	
camp	27.0	19.4	21.5	3.6	72.7	19	
all sites	51.5	52.1	30.2	3.1	100.0	89	35.0 ***

B. Bifaces (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	8.8	5.8	8.6	0.0	27.6	16	
jump	6.1	4.8	6.7	0.0	22.2	11	
arroyo	5.4	2.9	6.0	0.0	16.7	16	
other	3.5	5.1	3.3	0.0	7.0	5	
all kills	6.5	4.5	7.0	0.0	27.6	48	1.1
process	13.4	12.8	9.2	0.0	34.1	22	
camp	12.9	9.3	9.7	0.5	35.7	19	
all sites	9.6	6.8	8.8	0.0	35.7	89	7.3 **

C. Choppers (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	2.4	0.1	5.5	0.0	22.2	16	
jump	1.9	0.0	3.3	0.0	10.9	11	
arroyo	3.1	0.0	8.6	0.0	33.3	16	
other	4.1	1.5	7.1	0.0	16.7	5	
all kills	2.7	0.0	6.3	0.0	33.3	48	0.2
process	1.6	0.0	2.8	0.0	9.1	22	
camp	3.0	0.9	6.0	0.0	25.0	19	
all sites	2.5	0.0	5.6	0.0	33.3	89	0.4

D. End scrapers (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	3.0	1.9	3.2	0.0	9.7	16	
jump	2.4	1.2	4.3	0.0	14.3	11	
arroyo	3.0	0.0	4.6	0.0	15.8	16	
other	3.6	4.2	2.2	0.0	5.6	5	
all kills	2.9	1.2	3.8	0.0	15.8	48	0.1
process	12.0	11.1	7.5	0.0	29.3	22	
camp	9.3	9.1	6.0	0.0	22.9	19	
all sites	6.5	4.8	6.7	0.0	29.3	89	24.3 ***

E. Side scrapers (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	1.7	0.0	4.3	0.0	15.7	16	
jump	2.8	2.3	3.1	0.0	8.8	11	
arroyo	5.4	1.5	7.6	0.0	21.4	16	
other	4.5	0.0	6.2	0.0	12.1	5	
all kills	3.5	0.0	5.7	0.0	21.4	48	1.3
process	3.8	2.2	4.5	0.0	15.8	22	
camp	5.1	3.7	6.3	0.0	20.7	19	
all sites	3.9	1.0	5.5	0.0	21.4	89	0.6

F. Multiple-edge scrapers/tools (%)

	mean	median	s.d.	min.	max.	n	F-test
pound	0.2	0.0	0.9	0.0	3.4	16	
jump	0.1	0.0	0.4	0.0	1.2	11	
arroyo	0.0	0.0	0.0	0.0	0.0	16	
other	0.0	0.0	0.0	0.0	0.0	5	
all kills	0.1	0.0	5.2	0.0	3.4	48	0.5
process	1.1	0.0	2.1	0.0	8.3	22	
camp	2.1	0.0	4.9	0.0	18.8	19	
all sites	0.8	0.0	2.6	0.0	18.8	89	4.7 **

TABLE 2: Descriptive statistics and ANOVA results from chipped stone tools from bison kills, processing, and camp sites.

G. Retouched/utilized flakes (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	17.2	6.2	23.2	0.0	68.6	16	
jump	8.7	7.2	9.0	0.0	31.4	11	
arroyo	14.4	8.4	18.2	0.0	63.5	16	
other	12.6	5.8	15.8	0.0	38.9	5	
all kills	13.8	7.5	18.1	0.0	68.6	48	0.5
process	33.4	34.0	20.3	0.7	66.5	22	
camp	34.2	35.9	19.9	8.2	83.1	19	
all sites	23.0	15.6	21.3	0.0	83.1	89	12.1 ***

H. Gravers (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	0.1	0.0	0.2	0.0	1.0	16	
jump	0.0	0.0	0.0	0.0	0.0	11	
arroyo	0.5	0.0	1.4	0.0	4.2	16	
other	0.0	0.0	0.0	0.0	0.0	5	
all kills	0.1	0.0	0.8	0.0	4.2	48	1.2
process	1.5	0.5	2.0	0.0	6.8	22	
camp	2.3	1.1	3.5	0.0	14.3	19	
all sites	1.0	0.0	2.2	0.0	14.3	89	8.6 ***

I. Drills (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	0.0	0.0	0.1	0.0	1.0	16	
jump	0.0	0.0	0.0	0.0	0.2	11	
arroyo	0.0	0.0	1.0	0.0	4.1	16	
other	1.1	0.0	2.5	0.0	5.6	5	
all kills	0.3	0.0	0.1	0.0	5.6	48	1.5
process	0.9	0.2	1.2	0.0	3.8	22	
camp	1.5	0.6	1.9	0.0	5.9	19	
all sites	0.7	0.0	1.3	0.0	5.9	89	6.6 **

J. Denticulates, Notches, and Spokeshaves (%).

	mean	median	s.d.	min.	max.	n	F-test
pound	0.0	0.0	0.2	0.0	0.6	16	
jump	0.0	0.0	0.0	0.0	0.0	11	
arroyo	0.0	0.0	0.0	0.0	0.0	16	
other	0.0	0.0	0.0	0.0	0.0	5	
all kills	0.0	0.0	0.1	0.0	0.6	48	0.6
process	0.2	0.0	0.8	0.0	3.5	22	
camp	2.5	0.4	4.5	0.0	14.6	19	
all sites	0.6	0.0	2.3	0.0	14.6	89	10.4 ***

RATIOS

Points per bison.

	mean	median	s.d	min.	max.	n	F-test
pound	2.7	2.2	2.3	0.3	8.3	13	
jump	1.3	0.9	0.9	0.3	2.9	8	
arroyo	0.7	0.4	0.6	0.1	2.1	15	
other	0.5	0.4	0.3	0.2	0.8	4	
all kills	1.4	0.8	1.7	0.1	8.3	40	5.3 **
process	1.9	1.3	1.6	0.1	5.3	17	
camp	12.1	2.3	19.4	0.3	62.0	10	
all sites	3.1	1.0	8.2	0.1	62.0	89	8.6 ***

TABLE 2: (continued).

DENSITY (per cubic meter)

A. Bison (MNI).

	mean	median	s.d.	min.	max.	n	F-test
pound	2.8	2.7	1.8	0.1	6.0	13	
jump	2.4	1.6	2.5	0.6	8.3	8	
arroyo	5.8	4.3	6.4	0.7	23.5	15	
other	2.1	1.8	2.0	0.1	4.8	4	
all kills	3.8	2.6	4.5	0.1	23.5	40	1.8
process	1.9	0.9	2.3	0.1	6.7	16	
camp	0.7	0.1	1.3	0.0	4.0	11	
all sites	2.8	1.5	3.8	0.1	23.5	89	3.6 *

B. Projectile points.

	mean	median	s.d.	min.	max.	n	F-test
pound	6.0	2.5	8.2	0.0	30.7	16	
jump	6.0	2.5	10.3	0.5	34.6	10	
arroyo	3.8	1.4	5.4	0.3	20.3	16	
other	1.8	0.9	2.1	0.0	5.1	5	
all kills	4.8	2.3	7.4	0.0	34.6	47	0.6
process	2.8	0.8	4.3	0.1	17.3	21	
camp	2.5	1.4	3.0	0.0	12.0	18	
all sites	3.8	1.8	6.1	0.0	34.6	89	1.2

C. Total tools.

	mean	median	s.d.	min.	max.	n	F-test
pound	8.1	4.1	9.1	0.2	31.1	16	
jump	8.4	3.7	15.9	0.7	53.2	10	
arroyo	5.2	3.1	5.8	0.3	21.5	16	
other	2.4	0.9	2.6	0.1	5.9	5	
all kills	6.6	3.3	9.6	0.1	53.2	47	0.7
process	10.5	4.5	16.0	0.7	68.2	21	
camp	19.4	5.3	41.2	0.9	180.0	19	
all sites							2.3

Note: ANOVA for all sites compares the values for all kills, processing, and camp sites. ANOVA for all kills compares the values for pounds, jumps, arroyo traps, and other types of kill sites. F-test: * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

TABLE 2: (continued).

with relative percentages. The results are similar.

RESULTS

The number of projectile points per bison is the only variable that differs significantly between distinct kinds of bison kill sites. On the average, arroyo traps have the fewest (0.7), jumps have intermediate (1.3), and pounds have the highest (2.7) number of points per bison. The low ratios at arroyo traps runs counter to the earlier predictions and may be due to less intensive bison processing (Wheat 1972:104) or a greater reliance on thrusting and throwing spears. All sixteen of the arroyo traps pre-date the advent of the bow and arrow early in the Late Prehistoric period (ca. A.D. 500, Frison 1978:62). The lower ratios at jumps was probably due to animals dying as a result of the lethal fall. This explanation is substantiated by the strong negative correlation between jump height and the point to bison ratio ($r=-.711$, $n=7$, $p=0.06$).

When kill sites are considered as an aggregate, the tool assemblages from them differ significantly from processing and camp sites (Table 2). The greatest differences ($p < 0.001$) are in the relative proportions of projectile points ($F=35$), end scrapers ($F=24$), retouched flakes ($F=12$), denticulates ($F=10$), and gravers ($F=9$). Also, bison density (MNI/m^3) and the number of points per bison varies significantly between each site type.

Camps are most distinguishable from processing areas by the percentage of denticulates in the assemblage. Camps also have much higher ratios of projectile points per bison than processing areas (Table 2:Ratios).

Assemblages from bison kills tend to be characterized by high proportions of projectile points (mean=70%) and low proportions of every other tool category (Table 2). Retouched flakes tend to be the second most abundant tool type (mean=14%).

Processing sites have assemblages with equal proportions of retouched flakes and projectile points (mean about 33%). The highest relative proportions of bifaces (mean=13%) and end scrapers (mean=12%) also occur in processing areas.

Camp assemblages have the highest diversity of tools. About a third of the tools are retouched flakes. Somewhat less than a third of the tools are projectile points (mean=27%). Bifaces account for about 10-12% of the assemblage in camps. The following tool types are present more often in camps than in any other form of site: side scrapers, gravers, drills, denticulates, and multiple scrapers (total about 28%). It appears that more multiple function and highly specialized tools were used in camps. Contrary to the predictions, choppers are present at higher percentages in camps than other sites. The high projectile point to bison ratio is an indication of the relative scarcity of bison remains in camp sites (Table 2).

Tool densities may be primarily determined by the size of the human group, duration of occupation, frequency of reoccupation, rates of natural deposition, and discard rates. Variation in these variables probably cross-cut the site types and so contribute to the absence of significant differences in tool densities between the site types.

In summary, except for the low projectile point to bison ratios at arroyo traps and most frequent association of choppers with camp sites, the results conform close to the initial predictions.

IMPLICATIONS AND APPLICATIONS

Several questions of interpretation can be addressed with the results from this study, including: (a) the rarity of bison kill sites in archaeological site surveys (i.e., is there a problem of not recognizing bison kills where bone is not preserved?), (b) the functional claims for certain sites (e.g., Sinnock, Buchner 1984), (c) the uncertainty about the method of bison procurement at some sites (e.g., Jones-Miller), and (d) the evidence for changes in storage technology. Beyond questions of Plains prehistory, this research has some implications for archaeologists investigating the Paleolithic.

One explanation for the rarity of bison kill sites (1-3% of known Plains sites) is that kill sites go unrecognized in site surveys when the bone is either not preserved or poorly exposed. Archaeological surveys of large areas of the Powder River Basin in Wyoming and

Montana have discovered few bison kill or processing sites. I will not attempt the task of reviewing all the reports produced from these surveys, but instead examine a frequently cited, and perhaps representative, report about an archaeological survey around Pumpkin Buttes (Eckles and Welty 1980). Based on my analysis, when projectile points comprise over 50% of the chipped-stone tool assemblage, the site is considered a probable kill site. Projectile points account for less than 50% of the tools at every site reported by Eckles and Welty where more than ten tools were collected off the surface. It is possible that projectile points percentages were lowered by "arrowhead" collecting before the survey. At the Pumpkin Buttes survey, bison kills are probably not going unrecognized due to the poor preservation of bone, because tool assemblages from none of the sites resemble the assemblages from bison-kill sites.

The Sinnock site (Buchner 1984) provides another, similar, example. Buchner bases the claim that Sinnock is a bison kill on a concentration of bifaces and projectile points in one area of the site. This conclusion can be questioned since we have already seen that tool densities are not significantly different between kill, processing, and camp areas. In addition, projectile points account for only 5.3% of the assemblage, a proportion far below the average (70%) present at most kill sites. Sinnock is probably a camp, judging from the high proportions of bifaces (52.8%), scrapers (35.5%), and denticulates (0.9%).

The research results may also provide useful insights into some ongoing debates about the Paleolithic. For example, Isaac (1971, 1978) has suggested that kill and camp sites can be distinguished on the basis of tool and bone densities. Kill sites are predicted to have a low stone artifact density and a high bone density. Camps are believed to have high densities of both bones and stone artifacts. If we can assume some similarities in human behavior between the prehistoric Plains inhabitants and early hominids, it appears that Isaac is only partially correct. Although the differences in stone tool and bone densities are not significant between kill, processing, and camp sites (Table 2), kills do tend to have the highest densities of bone and lowest densities of stone tools.

Unfortunately, the study results do not provide as much help in resolving questions about the method of bison procurement at a particular kill site. Tool proportions and densities are not significantly different between different varieties of bison kills. However, the number of points per bison differs significantly between varieties of kills, probably for technological reasons. Pounds have a much higher number of points per bison (mean or median=2-3) than jumps (mean or median=1). Arroyo and other types of kills have less than 1 point per bison.

The method of bison procurement at the Jones-Miller site in Colorado has been variously described as a pound, a snowdrift trap, or a non-procurement (processing) site (Stanford 1974, 1975, 1978). Given the low point to bison ratio at the Jones-Miller site (0.3 to 1), the site was not a pound or processing site, but was the scene of either an arroyo, sand dune, or snowdrift trap.

The analysis of chipped-stone tool assemblages can provide insights into food storage. During the Paleoindian and Early Plains

Archaic most bison kills took place in the winter. Partially articulated bison remains have been found in the archaeological excavations at many of these early kill sites. Frison (1980, 1982; Frison and Stanford 1982:363) suggest that these remains are remnants of frozen meat caches around which Paleoindian and Early Archaic people camped in the winter. According to Frison little evidence exists for the extraction of bone grease or the manufacture of pemmican within Paleoindian and Early Plains Archaic sites. Separate processing sites/areas would be unexpected for pre-Middle Plains Archaic times.

Bison processing areas are reported at two Paleoindian (Jurgens, Hudson-Meng) and three Early Plains Archaic sites (Itasca, Cherokee, Gowen). At the Early Plains Archaic sites, several features were found that may be analogous to bone grease extraction features in later sites (i.e., hearths, stone boiling pits, abundant fire-cracked rock, smashed and charred bone). The high proportions of projectile points present in the assemblages from Jurgens and Hudson-Meng indicates that these sites are actually kill sites. In contrast, all three Early Archaic sites were probably processing sites, based on the high proportions of end scrapers and retouched flakes, and low proportion, compared to bison kills, of projectile points. The absence of denticulates from these sites probably indicates their not being camps.

The three Early Plains Archaic sites are all on the periphery of the Plains. The more intensive processing during this period may be in response to Altithermal drought conditions and the necessity of preserving meat in a more storable or transportable form, so that it is usable at times other than the winter.

These examples should suffice to illustrate some of the ways in which the results of the comparative study of stone tool assemblages can contribute solutions to some of the problems faced by archaeologists.

SUMMARY

Chipped stone tools from a sample of ninety-eight excavated assemblages were analyzed to determine if significant differences exist between tool frequencies and densities at bison kill, processing, and camp sites. Comparisons were made between the assemblages from various types of bison kills. The only major distinction between types of kills is in the number of projectile points per bison. Pounds and jumps have more points than arroyo traps. Kills, processing, and camp sites differ most significantly in proportions of projectile points, end scrapers, retouched flakes, gravers, and denticulates in their assemblages. The results are applicable to the resolution of several particular questions about site function, the rarity of bison kill sites on the Plains, and the organization of food storage.

ACKNOWLEDGMENTS

I thank Danny Walker for inviting me to contribute a paper and for his patience. A conversation with Dena Dincauze stimulated me to write this paper by making me realize that what I assumed to be common knowledge, based on my experiences in the West, is not generally accepted in the Northeast. Brenda Baker, Eric Ingbar, Marcel Kornfeld, Mary Lou Larson, and

Patricia Mangan provided some highly critical, but insightful comments. I alone must accept responsibility for not always acting on their wise advice. A copy of the data set is available on request.

REFERENCES CITED

Adams, Gary F.

1975 The Bakken-Wright site: A multi-component bison kill in southwestern Saskatchewan. National Museum of Man, Mercury Series 33:133-199.

1977 The Estuary bison pound site in southwestern Saskatchewan. National Museum of Man, Mercury Series 68.

Agenbroad, Larry D.

1978 The Hudson-Meng site: An Alberta bison kill in the Nebraska High Plains. University Press of America, Washington.

Anderson, Duane C. and Holmes A. Semken, Jr., editors

1980 The Cherokee excavations: Holocene ecology and human adaptations in northwestern Iowa. Academic Press, New York.

Bentzen, R.C.

1962 The Mavrakis-Bentzen-Roberts bison trap, 48SH311. Sheridan Chapter, Wyoming Archaeological Society, Sheridan.

1966a The Powers-Yonkee bison trap. The Wyoming Archaeologist 9(1):7-20.

1966b The Mavrakis-Bentzen-Roberts bison trap 48SH311. The Wyoming Archaeologist 9(1):7-20.

Blalock, Hubert M., Jr.

1972 Social statistics. Second edition. McGraw-Hill, New York.

Brose, David S.

1975 Functional analysis of stone tools: A cautionary note on the role of animal fats. American Antiquity 40:86-94.

Brumley, John H.

1976 Ramilles: A Late Prehistoric bison kill and campsite located in southeastern Alberta, Canada. National Museum of Man, Mercury Series 55.

Buchner, Anthony P.

1984 Investigations at the Sinnock site 1980 and 1982. Department of Culture, Heritage and Recreation, Papers in Manitoba Archaeology, Final Report 17.

Bupp, Susan L.

1981 The Willow Springs bison pound: 48AB130. Unpublished M.A. thesis, Department of Anthropology, University of Wyoming, Laramie.

Clark, Gerald R. and Michael Clayton Wilson

1981 The Ayers-Frazier bison trap (24PE30): A Late Middle Period bison kill on the Lower Yellowstone River. Archaeology in Montana 22(1):23-77.

Dibble, David S. and Dessamae Lorraine
1968 Bonfire Shelter: A stratified bison kill site, Val Verde County, Texas. Texas Memorial Museum Miscellaneous Papers 1.

Eckland, C.
1974 Salvage excavations at the BLM bison trap (24RB1021). Cultural Resource Management Report, on file, Cultural Resource Division, Mineral Research Center, Butte, Montana.

Eckles, David and Larry Welty
1980 Archaeology of the Pumpkin Buttes. Cultural Resource Managment Report, on file, Office of the Wyoming State Archaeologist, Department of Anthropology, University of Wyoming, Laramie.

Fawcett, William B., Jr.
1984 Communal bison hunting among hunter-gatherers on the High Plains. Unpublished dissertation prospectus, Department of Anthropology, University of Massachusetts, Amherst.

Feyhl, Ken J.
1972 The Stark-Lewis site, 24GV401. Archaeology in Montana 13(2):1-55.

Floodman, Mervin C., M.J. Tate, and R.A. Williams
1982 Archaeological mitigation at 32MZ333 and 32MZ334. USDA Forest Service, Northern Region, Cultural Resource Report 9.

Forbis, Richard. G.
1962 The Old Women's buffalo jump, Alberta. National Museums of Canada Bulletin 180:56-123.

Frison, George C.
1967 The Piney Creek sites, Wyoming. University of Wyoming Publication 33:1-92.

1968 Site 48SH312: An Early Middle Period bison kill in the Powder River Basin of Wyoming. Plains Anthropologist 13:31-39.

1970a The Glenrock buffalo jump, 48CO304: Late Prehistoric period buffalo procurement and butchering. Plains Anthropologist Memoir 7.

1970b The Kobold site, 24BH406: A post-Altithermal record of buffalo jumping for the Northwestern Plains. Plains Anthropologist 15:1-35.

1971 The buffalo pound in Northwestern Plains prehistory: Site 48CA302, Wyoming. American Antiquity 36:77-91.

1973 The Wardell buffalo trap 48SU301: Communal procurement in the Upper Green River Basin, Wyoming. Anthropological Papers, Museum of Anthropology, University of Michigan 48.

1974 The Casper site: A Hell Gap bison kill on the High Plains. Academic Press, New York.

1978 Prehistoric hunters of the High Plains. Academic Press, New York.

1980 Man and bison relationships in North America. Canadian Journal of Anthropology 1(1):75-76.

1982 Paleo-Indian winter subsistence strategies on the High Plains. Smithsonian Contributions to Anthropology 10:193-201.

1984 The Carter/Kerr-McGee Paleoindian site: Cultural resource management and archaeological research. American Antiquity 49:288-314.

Frison, George C. and Bruce Bradley
1980 Folsom tools and technology at the Hanson site, Wyoming. University of New Mexico Press, Albuquerque.

Frison, George C. and Dennis J. Stanford, editors
1982 The Agate Basin site: A record of Paleoindian occupation of the Northwestern Plains. Academic Press, New York.

Frison, George C. and Danny N. Walker, editors
1984 The Dead Indian site: An Archaic occupation in the Absaroka Mountains of Northwestern Wyoming. The Wyoming Archaeologist 27(1-2).

Frison, George C., Michael C. Wilson, and Danny N. Walker
1978 The Big Goose Creek site: Bison procurement and faunal analysis. Occasional Papers on Wyoming Archeology 1:1-50.

Frison, George C., Michael C. Wilson, and Diane J. Wilson
1976 Fossil bison and artifacts from an early Altithermal period arroyo trap in Wyoming. American Antiquity 41: 28-57.

Fry, Gary R.
1971 Preliminary report on Foss-Thomas site. The Wyoming Archaeologist 14(1):15-22.

Fulgham, Tommy and Dennis Stanford
1982 The Frasca site, A preliminary report. Southwestern Lore 48:1-9.

Good, Kent N. and Jeffrey L. Hauff
1979 Archaeological test excavation at the Anderson tipi ring site (32ML111), McLean County, North Dakota: A cultural resource study in central North Dakota. Cultural Resource Management Report, on file, Department of Anthropology and Archaeology, University of North Dakota, Grand Forks.

Greiser, Sally T. and Heidi Plochman
1981 Archaeological investigations at the West Rosebud archaeological site - 24ST651. USDA Forest Service, Northern Region, Cultural Resources Report 2.

Gruhn, Ruth
1969 Preliminary report on the Muhlbach site: A Besant bison trap in Central Alberta. Na-

tional *Museums of Canada Bulletin* 232(4):128-156.

Hamilton, Scott, W. Ferris, S. Hallgrimson, G. McNeely, K. Sammons, E. Simonds, and K. Topinka
1981 1979 excavations at the Stott site (Dl Ma-1): With interpretations of cultural stratigraphy. *Department of Cultural Affairs and Historical Resources, Historic Resources Branch, Papers in Manitoba Archaeology, Miscellaneous Paper* 12.

Hughes, David T.
1977 *Analysis of certain prehistoric bison kills in the Texas Panhandle and adjacent areas*. Unpublished M.A. thesis, Department of Anthropology, University of Arkansas, Fayetteville.

Isaac, Glynn
1971 The diet of early man: Aspects of archaeological evidence from Lower and Middle Pleistocene sites in Africa. *World Archaeology* 2:278-299.

1978 The food-sharing behavior of protohuman hominids. *Scientific American* 238:90-108.

Judge, W. James
1973 *Paleoindian occupation of the Central Rio Grande Valley in New Mexico*. University of New Mexico Press, Albuquerque.

1974 Projectile point form and function in Late Paleo-Indian period assemblages. *The Museum Journal* 15:123-182.

Kehoe, Thomas F.
1967 The Boarding School bison drive site. *Plains Anthropologist Memoir* 4.

1973 The Gull Lake site: A prehistoric bison drive in southwestern Saskatchewan. *Milwaukee Public Museum Publications in Anthropology and History* 1.

Keyser, James D.
1979a Late Prehistoric period bison procurement on the Milk River in north-central Montana. *Archaeology in Montana* 20(1).

1979b Variations in stone ring use at two sites in central Montana. *Plains Anthropologist* 24(84): 133-144.

1982 A comparative analysis of two McKean phase occupations in the Grand River drainage. *Journal of the North Dakota Archaeological Association* 1:31-41.

Keyser, James D. and Carl M. Davis
1981 Highwalker/One Bear: 1979 archeological excavations on the Ashland division, Custer National Forest. *USDA Forest Service, Northern Region, Cultural Resource Report* 3.

Larson, Thomas K.
1976 The archaeology of 32SH7: A bison kill in central North Dakota. *University of North Da-*

kota, Department of Anthropology and Archaeology, Contribution 46.

Lobdell, John E.
1973 The Scoggin site: An early Middle Period bison kill. The Wyoming Archaeologist 16(3-4):1-71.

Michlovic, Michael G.
1983 The Canning site (21NR9) and cultural stability on the prehistoric Plains. Paper presented at the Society for American Archaeology 48th annual meeting, Pittsburgh.

Morgan, R. Grace
1979 An ecological study of the Northern Plains as seen through the Garratt site. University of Regina, Occasional Papers in Anthropology 1.

Mulloy, William T.
1959 The James Allen site, near Laramie, Wyoming. American Antiquity 25: 112-116.

Parsons, Mark L.
1967 Archeological investigations in Crosby and Dickens Counties, Texas during the winter, 1966-1967. Texas State Building Commission, Archeological Program Report 7.

Parry, William J. and John D. Speth
1984 The Garnsey spring campsite: Late Prehistoric occupation in southeastern New Mexico. Museum of Anthropology, University of Michigan, Technical Reports 15.

Phenix, Tom S.
1969 Melhagen site preliminary report. Saskatchewan Archeology Newsletter 24:13-15.

Prentice, J.
1983 The Tschetter site: A study of a Late Prehistoric bison kill. Unpublished M.A. thesis, Department of Anthropology and Archaeology, University of Saskatchewan, Saskatoon.

Quigg, J. Michael
1974 The Belly River: Prehistoric population dynamics in a Northwestern Plains transition area. National Museum of Man, Mercury series 23.

1984 A 4700-year old tool assemblage from east-central Alberta. Plains Anthropologist 29(104): 151-159.

Rancier, J., G. Haynes, and D. Stanford
1982 1981 investigations of Lamb Spring. Southwestern Lore 48(2):1-17.

Reeves, B.O.K., B. Loveseth, and V. Maltin
1981 Final report 1980 field investigations Dk Pi-2 Fort MacLeod. Archaeological Survey of Alberta Permit Report 80-53, Edmonton.

Reher, Charles A.
1982 The Wagensen site, 48CA89: A large Plains Indian village in the

central Powder River basin. Unpublished manuscript, on file, Department of Anthropology, University of Wyoming, Laramie.

Reher, Charles A. and George C. Frison
1980 The Vore site, 48CK302, A stratified buffalo jump in the Wyoming Black Hills. Plains Anthropologist Memoir 16.

Reher, Charles A., George M. Zeimens, and George C. Frison
1978 Continued archeological investigations for the Cordero mine, Sun Oil Company, 48CA75. Cultural Resource Management Report, on file, Office of the Wyoming State Archeologist, University of Wyoming, Laramie.

Roll, Tom E. and Ken Deaver
1980 The Bootlegger Trail site, A Late Prehistoric spring bison kill. USDI Heritage Conservation and Recreation Service, Interagency Archeological Service, Investigative Report no 1.

Ruckels, Frank A.
1964 The Garza site: A Neoamerican campsite near Post, Texas. Bulletin of the Texas Archaeological Society 35:101-126.

Schultz, C. Bernard
1943 Some artifacts and sites of early man in the Great Plains and adjacent areas. American Antiquity 8(3):242-249.

Sellards, E.H.
1955 Fossil bison and associated artifacts from Milnesand, New Mexico. American Antiquity 20: 336-344.

Sellards, E.H., G.L. Evans, G.E. Meade, A. Kreiger
1947 Fossil bison and associated artifacts from Plainview, Texas. Bulletin of the Geological Society of America 58: 927-954.

Shay, C. Thomas
1971 The Itasca bison kill site: An ecological analysis. Minnesota Historical Society, St. Paul.

Smith, T., E.M. Calder, and B.O.K. Reeves
1977 Archaeological investigations Ef Pm-27 Fish Creek Provincial Park. Archaeological Survey of Alberta Permit Report 76-26, Edmonton.

Speer, Roberta D.
1978 Fossil bison remains from the Rex Rodgers site. In Archeology at MacKenzie reservoir, edited by J.T. Hughes and P.S. Willey, pp. 68-107. Texas Historical Commission, Office of the State Archeologist, Archeological Survey Report 24.

Speth, John D.
1983 Bison kills and bone counts: Decision making by ancient hunters. University of Chicago Press, Chicago.

Speth, John D. and Gregory A. Johnson
1976 Problems in the use of correlation for the investigation of tool kits and activity areas. In Cultural Change and Continuity, edited by C. E. Cleland, pp. 35-57. Academic Press, New York.

Stanford, Dennis J.
1974 Preliminary report of the excavation of the Jones-Miller Hell Gap site, Yuma County, Colorado. Southwestern Lore 40(3-4):29-36.

1975 The 1975 excavations at the Jones-Miller site Yuma County, Colorado. Southwestern Lore 41:34-38.

1978 The Jones-Miller site: An example of Hell Gap bison procurement strategy. Plains Anthropologist Memoir 14:90-97.

Stanford, Dennis J. and John Albanese
1971 Preliminary results of the Smithsonian Institution excavation at the Claypool site, Washington County, Colorado. Southwestern Lore 41(4): 22-28.

Stanford, D., W.R. Wedel, and G.R. Scott
1981 Archaeological investigations of the Lamb Spring site. Southwestern Lore 47:14-27.

Walker, Danny N. and Larry C. Todd, editors
1984 Archaeological salvage at 48FR1398: The Castle Gardens access road site, Fremont County, Wyoming. Occasional Papers on Wyoming Archaeology 2.

Walker, Ernest G.
1980 The Gowen site: An Early Archaic site on the Northern Plains. Unpublished PhD. dissertation, Department of Anthropology, University of Texas, Austin.

Wheat, Joe Ben
1972 The Olsen-Chubbuck site: A Paleo-Indian bison kill. Memoirs of the Society for American Archaeology. 26.

1978 Olsen-Chubbuck and Jurgens sites: Four aspects of Paleo-Indian bison economy. Plains Anthropologist Memoir 14:84-89.

1979 The Jurgens site. Plains Anthropologist Memoir 15.

Willey, Patrick S., Billy R. Harrison, and Jack T. Hughes
1978 The Rex Rodgers site. In Archeology at Mackenzie reservoir, edited by J.T. Hughes and P.S. Willey, pp. 51-67. Texas Historical Commission, Office of the State Archeologist, Archeological Survey Report 24.

Witkind, Max
1971 An archaeological interpretation of the Roberts buffalo jump site, Larimer County, Colorado. Unpublished M.A. thesis,

Department of Anthropology, Colorado State University, Fort Collins.

Word, James H.
1965 The Montgomery site. _Bulletin of the South Plains Archaeological Society_ 2:55-102.

William B. Fawcett, Jr.
Department of Anthropology
University of Massachusetts
Amherst, Massachusetts

ASSEMBLAGE VARIATION OF OPEN LITHIC SCATTERS

JULIE E. FRANCIS

ABSTRACT

Plains archaeologists have used the terms "lithic scatter," "occupation site," "open campsite," etc. to describe surface artifact scatters. Occasionally such sites can have features such as firehearths or a few stone circles. Nevertheless, these sites have often been lumped into one category and there have been few attempts at either systematic description or examination of variation in this broad class of sites. This paper examines assemblage variation in open artifact scatters from the eastern Powder River Basin of Wyoming. It is argued that relatively simple measures of assemblage diversity, in conjunction other analyses of artifactual assemblages, can be used to make inferences regarding site use. It is also argued that information about both debitage and modified items found on a site are critical to understanding activities which may have occurred at that locality. This has implications for current federal non-collection policies, where only diagnostic items are collected for analysis, and little attention is paid to unmodified lithic debris.

STUDY AREA

The study area covers 3866 ha, 40 km southeast of Gillette, Wyoming in the eastern Powder River Basin (Figure 1). The Powder River Basin is one of a series of structural basins found in the unglaciated section of the Missouri Plateau (Thornbury 1965). The basin itself is bounded by the Casper Arch to the south and west, the Laramie Range to the south, the Bighorn Mountains to the west, the Missouri Breaks to the north and the Black Hills and Hartville Uplift to the east (Reher et al. 1977:15).

Topography within the study area is typical of the Powder River Basin (Department of Interior 1979:II-1), and consists of gently rolling hills dissected by ephemeral drainages. The principal drainage of the study area is the East Fork of Coal Creek. This is a deeply dissected ephemeral drainage which runs northwest into the Belle Fourche River. Elevations range from approximately 1478 m to 1415 m above sea level.

Climate within the study area is extremely variable. Generally, the area is considered semi-arid. Precipitation and temperature fluctuations are highly variable daily

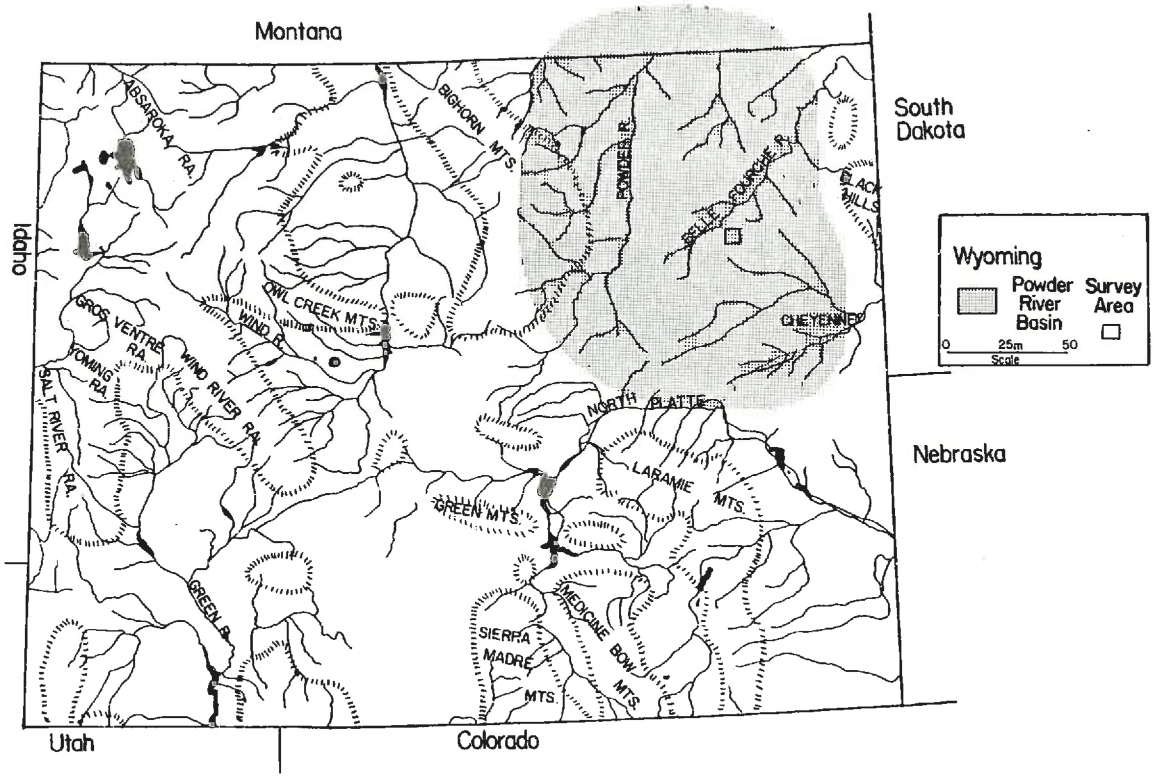


FIGURE 1: The Powder River Basin.

and seasonally. Rainfall typically increases through spring and drops off sharply during the summer months. Violent thunderstorms can occur during the summer, and blizzards occur in the winter. Annual precipitation currently ranges between 30.48 cm and 38.1 cm per year and snowfall averages between 101.6 cm and 127 cm per year (Reher et al. 1977:25-26). Temperatures can range between 43°C to -40°C throughout the year (Reher et al. 1977:26).

The Coal Creek study area can be considered part of the shortgrass plains biome. The modern vegetation of the area has been divided into eight plant communities (Department of Interior 1979: II-19-21). At least two of these communities (seeded meadows and annual weeds on disturbed sites)are the result of modern occupation of the study area. Within each of the undisturbed communities, a variety of plants which may have been utilized prehistorically occur. A detailed ethnobotany can be found in Reher et al. (1977:48-56).

Natural vegetative communities found in the study area include (from major to minor): 1) big sagebrush/shrub-lands; 2) bunchgrass-cushion plant; 3) riparian; 4) mixed grass prairie; 5) playa grasslands and 6) shrub community on clay slopes. Native mammals adapted to the shortgrass plains can be found throughout the Coal Creek study area. Detailed lists of these species can be found in Department of Interior (1979:II-21-23), with species important prehistorically discussed by Reher et al. (1977:56-61).

METHODOLOGY

The data base for this paper consists of the artifactual assemblages from 31 prehistoric sites (Francis 1981). When these sites were originally discovered, field recording methodologies were far less complex than those currently employed. The sites were plotted on maps and general notes taken regarding the site and features. However, site size was not routinely recorded, and only estimated if it was recorded at all. Site sketch maps were not always made, and the locations of individual artifacts within the site were not plotted. For many surveys during this time period, only diagnostic artifacts were collected. However, fairly large quantities of debitage were present in the Coal Creek collections. It was presumed that fairly complete surface collections had been made at most sites.

Lithic assemblages provided the basic source of information by which to interpret the archaeological record of the area, and the analysis was structured to examine stages of core reduction, reduction or manufacture of tools, the maintenance of tools and generalized tool function. The lithic classification system is presented in Table 1. Primary flakes are considered the initial flake or flakes detached from the core to remove the cortex. Secondary flakes are also produced during the early stages of core reduction. Tertiary flakes are produced during core preparation and tool manufacture.

Utilized flakes were identified on the basis of the presence of extremely small flake scars on a working edge, while retouched flakes tend to have larger, regularly shaped flake scars on the worked edge and use retouch. Only four formal tool categories were observed in the collections. These included projectile points, end-scrapers, large bifaces, and several small, apparently unfinished bifacially flaked preforms.

Use edges of modified items were examined. Cutting versus scraping functions edges were differentiated on the basis of wear and edge angle. A scraping edge shows a series of extremely small step fractures intruding into the retouch flake scars or unmodified edge of the tool. Use retouch tends to be unifacial. The working edge may have an edge angle of 60° or greater (Wilmsen 1970). An edge which has been used for cutting may have more acute edge angles (Wilmsen 1970) and may have a line of flake scars which run parallel to the working edge. Use retouch may be bifacial.

Artifactual materials were also cross-classified by raw material type or source area. This was done to identify which materials were available locally and which were brought into the study area. Eight raw material types or sources were observed in the collections. These are porcellanite, non-volcanic glass, Morrison formation quartzite, Hartville Uplift chert, petrified wood, miscellaneous chert, miscellaneous quartzite and obsidian. Lithic counts are summarized in Table 2.

The vast majority of porcellanite observed in the Coal Creek collections occurs locally in scoria outcrops. It consists of small fractured nodules ranging from a dull grey to purple in color. Occasional pieces of higher quality maroon porcellanite were observed. These occur in the Fort Union formation of northern Wyoming and southern Montana, some 136 km from the study area. The non-volcanic glass, a highly lustrous grey, red or black glass (Frison 1974) also

CATEGORY	DEFINITION
DEBITAGE	
Primary flake	unmodified flake with between 100% and 75% cortex on dorsal surface.
Secondary flake	unmodified flake with between 75% and 1% cortex on dorsal surface; one to two dorsal flake scars.
Tertiary flake	unmodified flake with 0% cortex on dorsal surface; three or more dorsal flake scars.
TOOLS	
Utilized flake	flake showing modification due only to use; subdivided into cutting and scraping tools.
Retouched flake	flake on which only a working edge has been intentionally modified; subdivided into cutting and scraping tools.
Preform	unfinished biface which does not appear to have been used; presumed to have been a projectile point blank.
Biface/knife	bifacially flaked tool which shows evidence of having been used for cutting.
Endscraper	unifacially flaked artifact which exhibits one end that has been steeply retouched. This working edge is usually convex in outline, exhibits a steep edge angle, and often small step-fracture edge wear.
Projectile point	subdivided into complete specimens and fragmentary specimens (tip, midsection, base).
Core	nucleus of raw material from which flakes have been removed.

TABLE 1: Lithic descriptions and classification system, Coal Creek Permit Area.

comes from this general area.

Morrison Formation quartzite is an extremely fine-grained grey, yellow or rust colored quartzite. The nearest exposures of this formation occur in the Black Hills, approximately 88 km northeast of the study area.

Primary sources of cherts identified as Hartville Uplift occur about 160 km south of the study area. These cherts are typically opaque or translucent, show a wide color range, and have small dendritic inclusions. Cherts very similar to these occur in the Black Hills. At this point, it is impossible to determine from which source the dendritic cherts were obtained.

Petrified wood is locally available throughout the Powder River Basin, often as small nodules or pebbles. This material is commonly a translucent brown banded chert.

The miscellaneous quartzites are commonly white, brown, pink, red and yellow, and have a fine-grained sugary appearance. They closely resemble quartzite from the Flint Hills area of South Dakota, some 160 km southeast. However, their high frequency in the collections suggests a local, much closer source, possibly Pleistocene cobbles. The miscellaneous cherts are a variable class. They are most likely derived from Pleistocene cobble deposits in the area.

THE COAL CREEK SITES AND ARTIFACT ASSEMBLAGE

Of the 31 sites in the sample analyzed, the vast majority are small surface artifact scatters. For 11 of the sites, size was only reported as covering a few square meters. For the remainder of the sites, estimates of size range from

Site #	Total Arti-facts	Total Flakes	Total Tools	Tool %	Raw Material	Core	PP			UT		RET		PRE	BF	SCR	P	S	T	TOTAL
							TP	B	C	CU	SC	CU	SC							
48CA50	20	8	11	0.58	Porcellanite	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
					Misc. chert	1	-	-	-	-	1	-	-	-	-	1	1	1	1	6
					Hartville chert	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
					Quartzite	-	-	-	-	-	-	-	-	-	-	1	1	2	1	5
					Morrison	-	-	-	-	-	2	-	-	-	-	-	-	-	2	4
					Glass	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
					Wood	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2
48CA51	4	2	2	0.50	Porcellanite	-	-	-	-	-	-	-	-	-	-	1	-	-	1	2
					Quartzite	-	-	-	-	-	-	-	1	-	-	-	-	1	-	2
48CA53	9	5	4	0.44	Misc. chert	1	-	-	-	-	-	-	-	-	-	-	1	-	1	3
					Hartville chert	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
					Quartzite	-	-	-	-	-	1	-	1	-	-	-	-	1	2	5
48CA54	4	2	2	0.50	Porcellanite	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
					Misc. chert	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2
					Quartzite	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
48CA105	7	3	5	0.62	Porcellanite	-	-	-	-	-	-	-	1	-	-	-	-	-	2	3
					Misc. chert	-	-	-	-	-	-	-	1	-	-	-	1	-	-	2
					Wood	-	-	-	-	1	-	-	-	-	-	1	-	-	-	2
48CA106	5	0	5	1.00	Porcellanite	3	-	-	-	-	-	-	-	-	-	-	-	-	-	3
					Quartzite	-	-	-	-	-	1	1	-	-	-	-	-	-	-	2
48CA107	100	74	27	0.27	Porcellanite	1	-	-	-	-	4	-	-	-	1	-	6	15	25	52
					Misc. chert	-	-	-	-	2	1	-	-	-	-	-	1	1	1	6
					Hartville chert	-	-	1	-	2	1	-	-	-	-	-	1	1	2	8
					Quartzite	2	-	-	-	-	-	-	-	-	1	2	5	4	2	16
					Morrison	-	-	1	-	1	-	-	-	1	1	-	-	3	2	9
					Glass	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
					Obsidian	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
					Wood	-	-	-	-	2	1	1	-	-	-	-	-	1	2	7
48CA108	3	2	1	0.33	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
					Morrison	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2
48CA109	10	1	9	0.90	Porcellanite	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2
					Misc. chert	-	-	1	-	-	2	-	1	-	-	-	-	-	-	4
					Quartzite	-	-	-	-	-	-	1	1	-	1	-	-	-	1	4
48CA110	7	5	2	0.28	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
					Misc. chert	1	-	-	-	-	-	-	-	-	-	-	-	-	2	3
					Quartzite	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
					Wood	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1

TABLE 2: (continued).

Site #	Total Arti-facts	Total Flakes	Total Tools	Tool %	Raw Material	Core	PP			UT		RET		PRE	BF	SCR	P	S	T	TOTAL
							TP	B	C	CU	SC	CU	SC							
48CA40	46	29	17	0.40	Porcellanite	1	-	-	-	1	-	-	-	1	-	2	1	1	6	13
					Misc. chert	-	1	1	-	-	3	-	-	1	-	-	2	-	3	11
					Hartville chert	-	-	-	-	-	-	-	-	-	-	-	-	2	2	4
					Quartzite	-	-	-	-	-	-	1	-	-	-	1	-	3	5	10
					Morrison	-	-	1	-	-	-	-	-	-	-	-	-	-	1	2
					Glass	-	-	1	-	-	-	-	1	-	-	-	-	-	1	3
					Wood	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3
48CA41	69	54	16	0.23	Porcellanite	-	-	-	2	1	-	-	1	-	-	-	1	9	6	20
					Misc. chert	1	-	-	-	1	-	1	2	-	-	2	3	3	6	19
					Hartville chert	-	-	-	-	-	-	-	1	-	-	-	-	-	4	5
					Quartzite	-	-	-	1	-	1	-	1	-	-	-	1	5	10	19
					Morrison	-	-	-	-	-	-	-	1	-	-	-	-	1	2	[illegible]
					Glass	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
48CA42	20	12	8	0.40	Porcellanite	-	-	-	-	-	1	-	-	-	-	-	1	1	4	7
					Misc. chert	1	-	1	1	-	-	-	-	-	-	-	-	-	2	5
					Quartzite	1	-	-	-	-	1	-	-	-	2	-	-	1	2	7
					Wood	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
48CA43	59	50	9	0.15	Porcellanite	-	-	-	-	-	-	1	-	-	-	-	-	-	6	7
					Misc. chert	-	-	-	-	-	-	-	-	-	-	1	1	3	20	25
					Hartville chert	-	-	-	-	-	-	-	-	-	-	3	1	1	7	12
					Quartzite	-	-	-	-	-	1	-	-	-	-	-	1	5	5	12
					Glass	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
					Obsidian	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
					Unknown	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
48CA44	6	6	0	0.00	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
					Misc. chert	-	-	-	-	-	-	-	-	-	-	-	1	1	1	3
48CA45	6	2	4	0.67	Misc. chert	-	-	-	-	-	-	-	-	1	-	1	1	-	-	3
					Quartzite	-	-	-	-	-	-	-	-	-	1	-	-	-	1	2
					Morrison	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
48CA46	4	3	1	0.25	Misc. chert	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2
					Quartzite	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2
48CA47	7	5	2	0.29	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	1	2	3
					Misc. chert	-	-	-	-	-	-	-	-	-	1	-	1	-	1	3
					Morrison	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
48CA48	5	5	0	0.00	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	2	1	3
					Misc. chert	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2
48CA49	7	2	5	0.75	Misc. chert	-	1	-	-	-	-	-	1	-	-	-	-	-	-	2
					Hartville chert	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
					Quartzite	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2
					Morrison	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
					Wood	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1

TABLE 2: (continued).

Site #	Total Arti-facts	Total Flakes	Total Tools	Tool %	Raw Material	Core	PP			UT		RET		PRE	BF	SCR	P	S	T	TOTAL
							TP	B	C	CU	SC	CU	SC							
48CA28	5	0	5	1.00	Porcellanite	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2
					Misc. chert	-	-	-	-	-	-	1	1	-	-	-	-	-	-	2
					Wood	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
48CA29	1	0	1	1.00	Porcellanite	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
48CA31	4	1	3	0.75	Misc. chert	-	-	1	-	-	-	-	1	-	-	-	-	-	-	2
					Quartzite	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
					Wood	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
48CA33	19	11	9	0.45	Porcellanite	1	-	-	-	-	-	-	-	-	-	-	2	-	-	3
					Misc. chert	-	-	-	-	-	-	1	1	-	-	-	1	-	-	3
					Hartville chert	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
					Quartzite	1	-	-	-	-	-	-	3	-	1	-	1	-	6	12
48CA34	12	6	6	0.50	Misc. chert	1	-	-	-	1	-	-	1	-	-	1	-	2	1	7
					Hartville chert	-	-	-	-	-	-	1	-	-	-	1	-	-	1	3
					Morrison	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
					Wood	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
48CA35	5	2	3	0.60	Porcellanite	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
					Quartzite	-	-	-	-	-	1	-	-	-	-	-	-	1	-	2
					Morrison	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
					Glass	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
48CA36	3	1	2	0.67	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
					Misc. chert	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
					Morrison	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
48CA37	2	2	0	0.00	Porcellanite	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
					Quartzite	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
48CA38	5	1	4	0.80	Porcellanite	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
					Misc. chert	-	-	-	-	1	-	1	1	-	-	-	-	-	-	3
					Quartzite	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
48CA39	6	2	4	0.67	Porcellanite	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2
					Misc. chert	-	-	-	-	-	1	-	-	-	-	-	-	1	1	3
					Hartville chert	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1

TABLE 2: Lithic counts, ARCO Coal Creek Mine project area. PP = Projectile Point; UT = Utilized Flake; RET = Retouched Flakes; PRE = Preform; BF = Biface knife; SC = Scraper; P = Primary; S = Secondary; T = Tertiary; TP = Tip; B = Base; C = Complete; CU = Cutting; SC = Scraping.

six to 30,000 m^2. If these estimates can be considered accurate, 13 sites cover an area of 1000 m^2 or less. This translates to an area slightly over 30x30 m. The largest sites appear to be 48CA33 (ca. 8000 m^2), 48CA35 (ca. 1050 m^2), 48CA42 (ca. 30,000 m^2), 48CA50 (ca. 4500 m^2), and 48CA107 (ca 17800 m^2). No estimates, except that it was a large site, were made for 48CA43. 48CA52 was a small buried charcoal level. Cultural materials were associated with the level, however it was thought that the majority of the site had eroded away. Thus it is impossible to estimate original site size. Hearths and stone circles were reported from 48CA33, 48CA40, and 48CA41. A possible hearth was noted at 48CA52. Firecracked rock was reported at 48CA107.

Table 3 presents summary data for the Coal Creek lithic assemblage. Four raw material types can be considered local sources. These are porcellanite, quartzite, miscellaneous chert, and petrified wood. They comprise 82% of the lithic assemblage. The remaining source areas account for the rest of the assemblage and are considered non-local. Morrison quartzite was most likely obtained from the Black Hills. It should be noted that Hartville or dendritic chert occurs in identical frequencies as the Morrison materials. This suggests that the dendritic chert may be from the Black Hills, rather than from the Hartville Uplift south of the study area. With the exception of obsidian, the majority of the non-local raw materials are derived from sources to the north, northeast, and possibly south of the study area. This indicates the regional settlement system may have encompased the Black Hills and possibly the Hartville Uplift.

Table 3 also presents summary counts of the artifact types present in the Coal Creek assemblages. The high frequency of cores and the debitage assemblage suggest that all stages of core reduction and tool manufacture took place within the study area. The tool types present suggest that the assemblage can be characterized as somewhat expedient. Utilized and retouched flakes, requiring little to no modification for use, account for over one-half of all modified items. Only four formal tool types (points, preforms, biface knives, and endscrapers) were found in the assemblage. The projectile points are diagnostic of the Middle and Late Archaic periods and the Late Prehistoric period. In general, the Coal Creek assemblage is notable for its lack of other stylized artifact types. This indicates that the Coal Creek area was utilized for a limited range of activities throughout prehistory.

The artifact types seem to reflect a strong, although not necessarily exclusive, orientation toward hunting activities. There is little direct evidence to suggest plant resources in the area were heavily utilized. Only one site report mentions the occurrence of ground stone. The occurrence of broken projectile points, particularly finished bases, suggests these items may have been broken during use. The presence of a few small, unfinished point preforms indicates that the prehistoric inhabitants repaired and maintained broken weaponry. The remainder of the tools could have been used in the context of butchering and game processing activities.

ASSEMBLAGE VARIATION

Reher (1979) has argued that measures of assemblage diversity

Artifact Type	Subtotal		Total
Projectile points	Tip	1	
	Midsection	2	
	Base	9	
	Complete	5	
	Unknown	2	19
Preforms			4
Biface/knives			10
Endscrapers			21
Utilized flakes	Cutting	19	
	Scraping	35	54
Retouched flakes	Cutting	10	
	Scraping	28	38
Cores			17
Drill			1
Primary flakes			41
Secondary flakes			84
Tertiary flakes			171
		Total	460
Raw materials	Porcellanite		135
	Quartzite		107
	Miscellaneous chert		122
	Hartville chert		37
	Morrison quartzite		27
	Petrified wood		20
	Non-volcanic glass		9
	Obsidian		2
	Unknown		1
		Total	460

TABLE 3: Composite tool assemblage, ARCO Coal Creek sites.

can be used to discriminate between residential locations and limited activity sites. His argument can be summarized as follows. Habitations or residential locations are presumed to have been occupied by a small local group or segment of the band. It is presumed that a wide variety of daily tasks would take place at such sites. This could include core reduction, tool manufacture and repair, and processing and preparation of foods. In other words, a variety of activities would be reflected by a high diversity of artifactual remains.

Limited activity sites are presumed to have been utilized by a specific task group or segment of the residential group. Specific tools could be brought to such sites for specific purposes and would not necessarily have been manufactured at the location of use. Thus lower diversity indices would be expected. Specific limited activity locations could correspond to small hunting stands, areas where initial field butchering of animals occurred, lithic procurement areas, and areas utilized by task groups for plant gathering purposes. It should be noted that this model is probably most applicable to collectors as defined by Binford (1980:10).

Reher (1979:247) utilized the Shannon-Wiener Index to examine assemblage diversity for a series of open lithic scatters in the western Powder River Basin. A bimodal distribution of diversity indices was found. Reher inferred that sites in the upper mode represented habitation or residential locations. Sites in the lower mode represented limited activity locales. It is recognized here that diversity is not necessarily the perfect or most accurate measure of assemblage variation. There are many factors, both cultural and methodological, other than differences in site use which can produce variation in diversity indices. For example, reoccupation of the same locality over long periods of time can result in extremely diverse tool assemblages. It has been shown that diversity is also a function of both site size and sample size (Jones et al. 1982).

Jones et al. (1982:8) argue that sample size must be taken into account when examining artifact diversity. This could be done by utilizing site size data and examining variation in artifact densities across space. Unfortunately, given the lack of reliable site size data from the Coal Creek area, this is impossible. It might also be possible to examine re-occupation through a detailed analysis of horizontal spatial distributions of artifacts across a site. Again, this is impossible with the Coal Creek data because artifacts were not individually mapped. However, given the limitations of the Coal Creek data, it is argued that relatively simple measures of diversity in conjunction with other aspects of assemblage variation can be used to make some inferences about site use.

The number of raw material types, based on the total assemblage, and the number of tool types per site were used as crude measures of assemblage diversity. The percentage of the assemblage composed of tools was also calculated in order to examine variation in relative frequencies of tools. Figure 2 shows a bimodal frequency distribution of both raw material types and tool types per site. Raw materials range from one to nine types per site with peaks at three and seven sources. Tools range between zero and eight types per site, with a broad peak between one and four types. A second peak is seen at eight types per site. These patterns seem to replicate results obtained by Reher (1979), they seem to support the model that residential locations would exhibit high assemblage diversities and limited activity areas would exhibit low assemblage diversities.

Tool percentages range from less than 9% to 100% (Figure 3). The frequency distribution of tool percentages is more complex and exhibits several peaks, as compared to both raw material and tool type

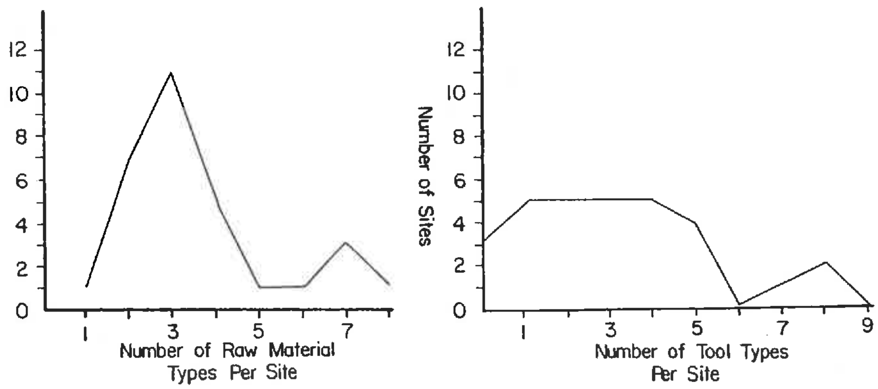


FIGURE 2: Frequency distributions of number of raw material and tool types present.

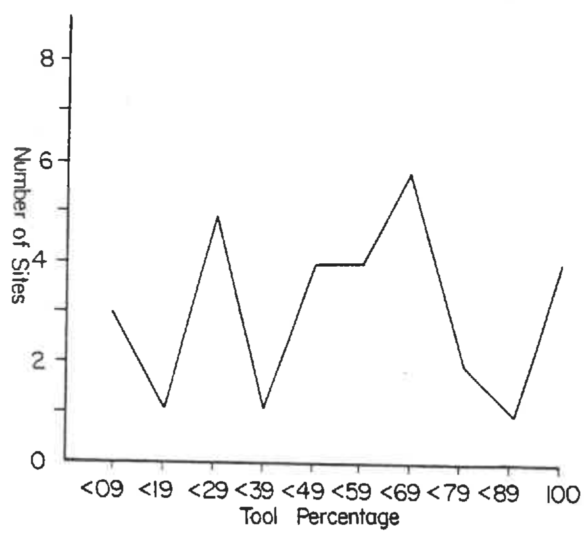


FIGURE 3: Frequency distribution of tool percentages.

distributions. At least in part, the structure of this frequency distribution is related to collection strategies rather than differences in site use. Four sites (48CA28, CA29, CA106, and CA109) exhibit tool percentages of 90% or greater. There are very few sites which do not contain some debitage, and it is likely that incomplete collections were made at these sites. These four sites were deleted from the following regression analysis.

To examine the relationships between raw material types, tool types, and assemblage size, regression coefficients were calculated. The first examined the interrelationships between the number of raw material types and the number of tool types on the site. In terms of statistical models, linear regression and correlation coefficients can be used to examine how changes in an independent variable (number of raw material types) can be used to predict the value of a dependent variable (number of tool types) (Blalock 1979:381-340). Figure 4 presents a scatter plot comparing the number of raw material types against the number of tool types. Site numbers are denoted on the plot. In this case, r, the correlation coefficient, was 0.8249, indicating a strong linear relationship between the two variables. In other words, as the number of raw material types increases, so does the number of tool types.

Two additional correlation coefficients were computed. The first examined the relationships between total number of artifacts and number of raw material types. Here, r was 0.8253, again indicating a strong linear relationship. The value of r^2 can be used as a

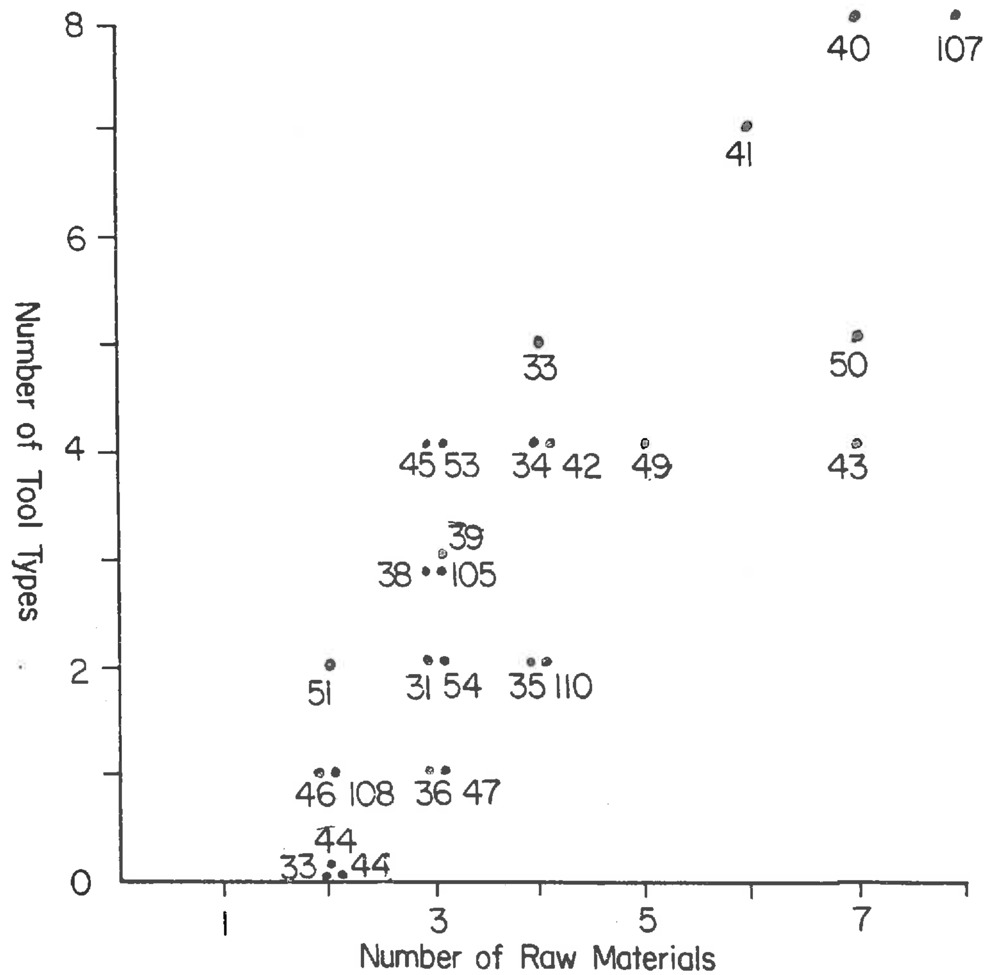


FIGURE 4: Scatterplot of tool types and raw material types.

measure of the percentage of variability in the second variable that is explained by the first. Here $r^2 = 0.6812$, or 68% of the variability in the number of raw material types can be explained by total number of artifacts. For the number of tool types and the total number of artifacts, r was 0.7606 ($r^2 = 0.5786$), indicating that nearly 58% of the variation in tool types can be explained by assemblage size.

Given there are reasonably strong relationships between number of raw material types, number of tool types, and total artifacts, the question of why do some localities contain lots of artifacts with lots of raw material and tool types, as opposed to other localities which contain far fewer and less diverse artifacts, still remains to be answered. Reoccupation of certain areas over long periods of time is certainly one possible answer. This question is difficult to evaluate given available data and methodologies. Projectile points from different time periods were found in two sites (48CA40 and 48CA107), and the reoccupation of some areas cannot be ruled out. However, other aspects of assemblage variation suggest alternative explanations for differences in assemblage diversity.

Sites 48CA33, CA34, CA40, CA41, CA50, and CA107 exhibited the highest number of raw material and tool types of all the Coal Creek sites. Of these sites, hearths, firecracked rock or stone circles were present on sites 48CA33, CA40, CA41, and CA107. These are the only prehistoric sites in the study area which were originally reported to contain features. This may indicate that the duration of occupation of these sites was longer, possibly requiring some food preparation, than at other locales.

Sites 48CA33, CA34, CA40, CA41, CA50, and CA107 also show the largest assemblages of any of the sites. However, there appears to be a somewhat uneven distribution of different artifact types between these six sites and the rest of the sites. On the whole, about 58% of all artifacts were found in these six sites (Table 4). However, there are some notable departures from this generalized figure. First approximately 70% of all primary and secondary flaking debris occurs in these six sites. It should also be noted that three of four preforms occur in these same six sites. This may indicate that sites 48CA33, CA34, CA40, CA41, CA50, and CA107 were the locations of a greater amount of core reduction and tool manufacture than the remainder of the sites in the study area.

The relative frequencies of tertiary flakes are close to the overall artifact distributions. This may indicate that final stages of tool manufacture or maintenance occurred at nearly all sites on the study area. The relative frequencies of nearly all tool types are slightly, but not significantly lower, in sites 48CA33, CA34, CA40, CA41, CA50, and CA107 than the remainder of sites in the study. The overall impression is that these six sites with the highest assemblage diversities were the locations of all stages of core reduction and tool manufacture, as well as tool use. The remainder of the sites seem to place a heavier emphasis on tool usage and maintenance, i.e., they may have served as extractive locations.

Nearly 90% of all cores and flaking debris is comprised of local raw materials (Table 5). The remainder of the tool types exhibit slightly lower relative frequencies

	Counts from sites 48CA33, CA34, CA40, CA41, CA50, and CA107	Total Count	Percentage of Total
All artifacts	266	460	57.8
Primary flakes	29	41	70.7
Secondary flakes	58	84	69.0
Tertiary flakes	94	171	54.9
Cores	9	17	52.9
Projectile points	10	19	52.6
Bifaces	5	10	50.0
Preforms	3	4	75.0
Endscrapers	12	21	57.1
Utilized flakes	29	54	53.7
Retouched flakes	17	38	44.7

TABLE 4: Distribution of artifact types between sites in Coal Creek project area.

Artifact Type	% Local	% Non-local
Primary flakes	90.0	10.0
Secondary flakes	86.9	13.1
Tertiary flakes	87.1	12.9
Cores	88.3	11.7
Projectile points	63.1	36.9
Bifaces	80.0	20.0
Preforms	75.0	25.0
Endscrapers	76.1	23.1
Utilized flakes	68.5	31.5
Retouched flakes	81.5	18.5

TABLE 5: Relative frequencies of artifact types and raw material types.

on local raw materials, and higher percentages of non-local materials. This suggests that small groups came into the Coal Creek area already equipped with some tools, but also relied heavily on locally available raw materials for the remainder of their tool inventory. Given the occurrence of features and the higher relative frequencies of flaking debris at sites 48CA33, CA34, CA40, CA41, CA50, and CA107, these sites may have served as the foci for lithic and food procurement activities. These sites could have served as field camps or temporary operational centers (Binford 1980:10). Most of the other sites served as extractive locations, primarily oriented towards hunting activities.

There is no evidence to suggest the occurrence of communal game procurement techniques within the study area. Rather it appears that animals, both small and large game, were hunted as individuals or as small groups by individual hunters or by small hunting parties. The majority of the evidence suggests temporary occupation of the area by small groups of hunter-gatherers. The apparently small size and low artifact density of many sites may also indicate that some localities were occupied only once. The apparently restricted nature of activities and the lack of heavy occupational debris indicate that the Coal Creek area is only one small segment of the regional settlement system. It is also suggested that the archaeological record of the Coal Creek area is reflective of utilization of the area by logistically oriented task-groups as defined by Binford (1980).

DISCUSSION

Overall, the Coal Creek area seems to have been used for a limited set of activities and does not appear to have ever been heavily occupied. However, despite these factors, it is hoped that the previous section has demonstrated there is significant assemblage variation on sites throughout the study area and that this variation can be used to interpret the archaeological record. It is a central point of this paper that we cannot hope to increase our understanding of hunter-gatherer adaptations without addressing the question of assemblage variation of surface sites. It is entirely possible that, if one considers the Coal Creek sites as a small segment of the regional settlement system and compares this data with other assemblages, variation in artifactual assemblages, site structure, and site use will become much more apparent. It is at the larger level of the region, rather than one small coal mine permit area, that we will gain better insights into hunter-gatherer settlement systems and changes in those systems across time and space.

This paper has also shown that, in a very general sense, diversity can be used to make some inferences about site use. However, diversity alone is not sufficient. Such measures must be used in conjunction with other assemblage data, site maps, and any other data which can be gathered. In the case of the Coal Creek sites, the debitage showed the most marked variation as opposed to tool types. Without debitage collections, very little, if any, interpretation could have been made about the prehistory of the area. This highlights questions of field methodology for recording surface sites. At present, federal guidelines emphasize collection and analysis of diagnostic artifacts and tools. Current site report forms call only for estimates of amount of debitage. Without formal analyses of the debitage, or at least some kind of designed sample, current information on surface lithic scatters is not particularly useful. For the most part, the archaeological record of hunter-gatherers is very fragile. If we ever hope to increase our understanding of these ephemeral, yet complex, cultural systems, we must take advantage of all types of information contained in a site.

ACKNOWLEDGEMENTS

I would first like to thank Dr. George C. Frison for instilling in me a great interest in hunter-gatherers. Data for this paper were originally collected by Office of the Wyoming State Archaeologist field crews in 1975 and 1977. Preliminary analyses were first done by the author in 1979 for preparation of the final Coal Creek cultural resource report. I would especially like to thank Marcel Kornfeld and Eric Ingbar for their helpful suggestions and Brad Humphrey for drafting the figures.

REFERENCES CITED

Binford, Lewis R.
1980 Willow smoke and dogs' tails: Hunter-gatherer settlement systems and archaeological site formation. American Antiquity 45:4-20.

Blalock, Hubert M.
1979 Social Statistics. Revised 2nd ed. McGraw Hill, New York.

Department of Interior
1979 Proposed mining and reclamation plan, Coal Creek Mine, Campbell County, Wyoming. Federal Coal Lease W-3446. On file, Bureau of Land Management, Casper, Wyoming.

Francis, Julie E.
1981 Final report on cultural resource investigations (1975-1979), ARCO Coal Creek Mine, Campbell County, Wyoming. Cultural Resource Management Report submitted to the ARCO Coal Company by the Office of the Wyoming State Archaeologist. On file, Office of the Wyoming State

Archaeologist, Department of Anthropology, University of Wyoming, Laramie.

Frison, George C.
1974 The application of volcanic and non-volcanic glass studies to archaeology in Wyoming. <u>Geological Survey of Wyoming, Reports of Investigations</u> 10:61-65.

1978 <u>Prehistoric Hunters of the High Plains</u>. Academic Press, New York.

Jones, George T., Donald Grayson, and Charlotte Beck
1982 The surface archaeology of the Steens Mountain Region, southeastern Oregon. Paper presented at the 1982 Great Basin Anthropological Conference, Reno Nevada.

Reher, Charles A.
1979 The Western Powder River Basin Survey, Volume 1. Cultural Resource Management Report submitted to the Casper District, Bureau of Land Management. On file, Office of the Wyoming State Archaeologist, University of Wyoming, Laramie.

Reher, Charles A., Danny N. Walker and Sandra Todd
1977 Natural environment and cultural ecology. In Archaeology of the Eastern Powder River Basin, Wyoming, pp.; 15-86. Cultural Resource Management Report submitted to the Casper District, Bureau of Land Management. On file, Office of the Wyoming State Archaeologist, University of Wyoming, Laramie.

Thornbury, W.D.
1965 <u>Regional Geomorphology of the United States</u>. Wiley and Sons, New York.

Wilmsen, Edwin N.
1970 Lithic analysis and cultural inference: A paleoindian case. <u>University of Arizona Anthropological Papers</u> 16.

Julie Francis
Wyoming State Archaeologist's Office
Department of Anthropology
University of Wyoming
Laramie, Wyoming 82071

A MODERN ANALOG TO A BISON JUMP

SUSAN S. HUGHES

ABSTRACT

On November 14, 1982, hunters inadvertently drove 19 elk (Cervus elaphus) over a 70 foot cliff in Park County, Wyoming. This event provided an unique opportunity to study the types of fractures incurred by large ungulates under a "controlled" jump situation. Four of the carcasses were examined for injuries. These are compared to bison (Bison bison ssp.) injuries in prehistoric jump situations. The injury patterns seen in the elk are used to provide possible explanations for certain phenomena observed at prehistoric jump sites.

THE JUMP INCIDENT

A herd of 50 plus elk were grazing in the pastures of Valley Ranch on the South Fork of the Shoshone River early on the morning of November 14, 1982. Several parties of hunters on the road north of the fields startled the elk into moving north toward a draw which is a major elk migration trail into the Absaroka Mountains. The mountains in this area are extremely rugged, characterized by steep cliffs and talus slopes, and rocky pinnacles. Access to the mountaintops from the valley can only be easily accomplished by a few game trails used by migrating Yellowstone Park elk to descent to their winter range on the South Fork. As this particular herd of elk headed toward the trail, the hunters diverted part of the herd westward onto a ridge divide between two drainages. The elk began climbing the ridge to escape the hunters following on foot. One thousand feet up the ridge, the elk were halted by cliffs and found themselves trapped. The hunters following the elk began shooting at this point. Witnesses are unsure of the precise timing, but it appears the elk panicked, and leaped over the cliff face on the western side of the ridge (Figures 1 and 2). Nineteen elk jumped and landed on a steep talus slope and rolled further downslope. None of the hunters following the herd were aware of the jump until they arrived at the cliff edge. One witness on the road below (Wayne Becker, Powell, Wyoming) observed three go over the cliff, land on the front legs which buckled under them and began to roll. Becker felt the elk had probably leaped off several locations along the ridge at different times (Wayne Becker, personal communication 1982).

Within an hour, Warden Tim Fagan of the Cody District Game and Fish office was on the scene. All the animals but one cow were dead at the base of the cliff. This cow had survived the jump and fled down the ravine, but was soon apprehended by other waiting hunters. The

FIGURE 1: View toward elk jump. Jump occurred at head of left ravine with elk coming over right side. Actual location hidden by large rock outcrop in front.

FIGURE 2: Closeup of cliff face. Elk jumped off ledge halfway up cliff and from several locations to left of barren tree.

remaining 18 elk (one yearling spike, seven cows, and ten calves) had slid or rolled 200 feet down the talus slope to the center of the ravine. No bullet wounds were found in any of the carcasses during an examination by Game and Fish personnel. The elk were immediately eviscerated and over the next 48 hours were distributed to any hunter with a valid elk license.

EXAMINATION METHODOLOGY

Four of the elk carcasses (two cows and two calves) were examined for bone fracture patterns. While it is acknowledged this is not a statistically valid sample, these animals were all that were available. The remaining carcasses had already been processed before the owners could be contacted about this study.

X-rays were used to determine the fracture patterns on the four elk carcasses. The film and X-ray machine were donated by West Park County Hospital of Cody, Wyoming, with Mr. Pete Kure, X-ray Technician, taking the pictures. Dr. M. J. Smith, Radiologist, and Dr. Malcom Blessing, Veterinarian, separately examined the X-rays. Both provided descriptions and probable causes of the fractures. Information on internal injuries were provided by Game Wardens Tim Fagan and Dave Bragonier based on observations during evisceration of the carcasses.

RESULTS

The X-rays revealed some consistent patterning in the injuries resulting from the 70 foot jump (Table 1). The two cows (labelled A and C throughout this report) received a dislocation of the spine between the fifth and sixth lumbar vertebrae (Figures 4 and 5) just above the pelvis. Nearly complete separation occurred at this point. Both cows also suffered smashing of the front mandible. The head of Cow C was left at the kill site, but suffered damage to the nose, was missing incisors and had a swollen and bloodshot tongue with the only bruised meat found in the lumbar region (Mary Asvig, personal communication, 1982). Drs. Smith and Blessing felt this cow probably landed on her forelegs, which then buckled, resulting in the face smashing on the ground. The tremendous impact caused the hindquarters to jacknife forward, snapping the back at its weakest location (Drs. M. J. Smith and Malcolm Blessing, personal communication, 1982).

The X-rays revealed bone damage below the incisors of Cow A, and a possible compressional fracture of the frontal sinus (Figure 3). Considerable bruising was seen in the shoulder region, and it is possible the cow had landed on that area (Jim Hamilton, personal communication, 1982). Cow A may have landed in a similar position as Cow C, or because of the shoulder bruising and head fracture, she may have impacted on her shoulders and head, then flipped back into the ground producing a whiplash fracture identical to Cow C. Both individuals had damage to the transverse processes of the lumbar vertebrae; also consistent with a whiplash fracture (Dr. Malcolm Blessing, personal communication 1982). The tensions created by the muscles during such a whiplash would cause the processes to snap.

The fracture patterns shown by the two calves (Calf B and Calf D) were not consistent with those seen on the two cows, nor with each other. Calf D had a fracture of the inferior and superior borders of the right pelvis and the tip of the sacrum. This was caused by a stick which was driven through the pelvis on impact with the ground (Figure 6, right). A metatarsal was dislocated dorsally from the tibia on this same calf (figure 6, right). This calf probably landed on its pelvis and a front blow to the proximal metatarsal caused the leg dislocation on impact (Drs. M.

INJURY - seen on X-rays	INDIVIDUALS A (cow)	B (calf)	C (cow)	D (calf)	TOTALS
Dislocation of 5th and 6th lumbar vertebrae	X		X		2
Dislocation of lumbar transverse process	X	X	X		3
Compressional fracture of 5th lumbar vertebra		X			1
Dislocation of 1st and 2nd cervical vertebrae		X			1
Dislocation of proximal metatarsal				X	1
Pelvis and sacral fractures				X	1
Sternum compression with rib fractures		X(4)			1
Compression fracture, frontal sinus of cranium	X				1
Fracture of zygomatic arch on cranium		X			1
INJURY -- observed on animals, not seen on X-ray					
Thoracic rib fractures near spine (removed by carnivores prior to X-ray)	X		X(3)	X(5)	3
Anterior mandible damage	X		X	?	3
Tongue swollen and bloodshot			X		1
Bloodshot meat locations	X shoulders		X lumbar spine	X hind quarter	3

TABLE 1: Elk bone fractures incurred after a 70 foot jump.

J. Smith and Malcolm Blessing, personal communication, 1982). The entire hindquarters of the calf were badly bruised and not butchered (Steve Bates, personal communication, 1982). The head of Calf D was left on the site, and thus no information on head injuries is available.

Calf B had considerable injuries. Eight different fractures occurred in the ribs and their cartilaginous connections to the sternum. Ribs seven and eight were each fractured once. Ribs nine and ten had three fractures each (Figure 7). Damage to the temporal area of the cranium was also observed, as well as a dislocation of the first and second cervical vertebrae (Figure 9). The teeth and anterior portion of the face was undamaged. These injuries suggest this calf received initial impact on its sternum with the head tucked under the body. Damage to the cervical vertebrae should have been more severe if initial impact had

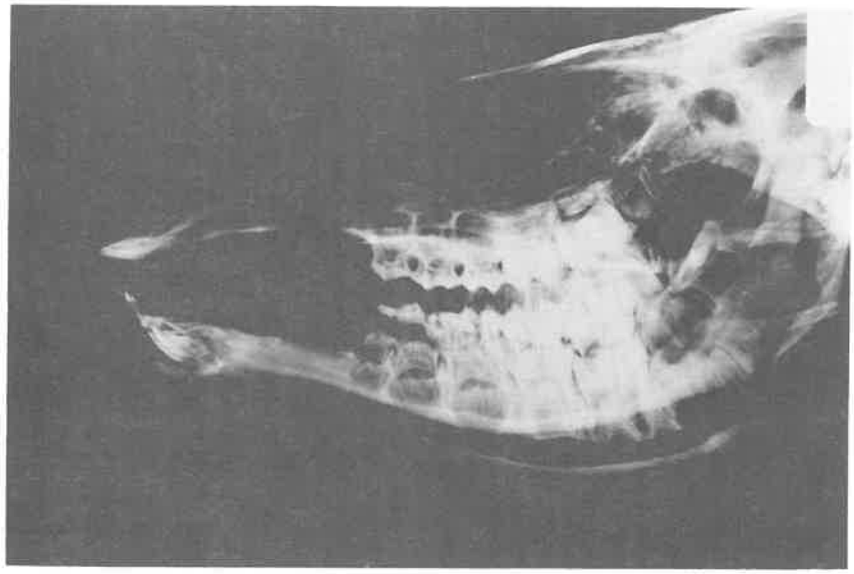


FIGURE 3: X-ray of Cow A cranium with compression fracture on top.

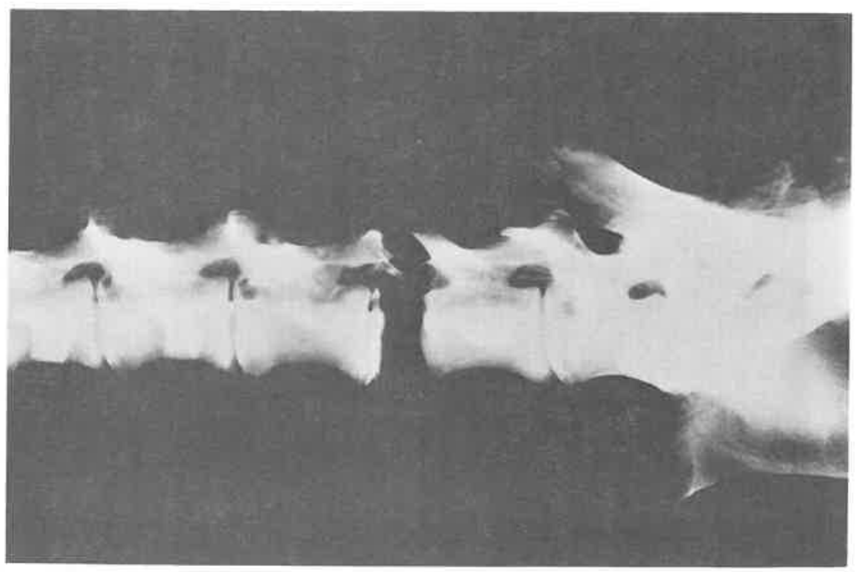


FIGURE 4: X-ray of Cow A with dislocation of fifth and sixth lumbar vertebrae.

occurred on the head (Dr. Malcolm Blessing, personal communication, 1982). A large circular hole appears in the fifth lumbar vertebra (Figure 8), originally though to have been a gunshot wound. This could have been caused by an explosive compressional fracture, as bullet fragments were not observed surrounding the wound (Dr. Malcolm Blessing, personal communication, 1982). A compressional fracture can be distinguished from a whiplash fracture in that it is caused by compaction of the bone elements rather than a whipping motion. The bone shatters against itself, or other bones, creating splitting and

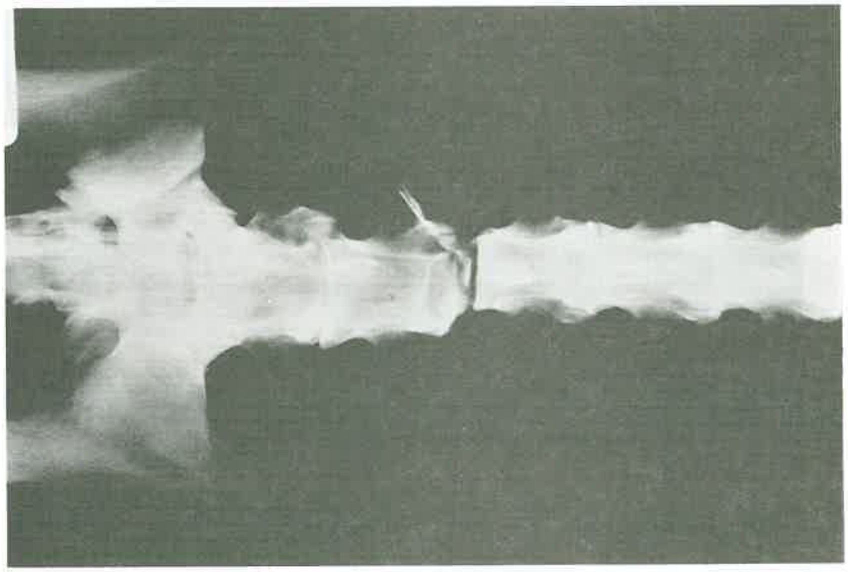


FIGURE 5: X-ray of Cow C with dislocation of fifth and sixth lumbar vertebrae.

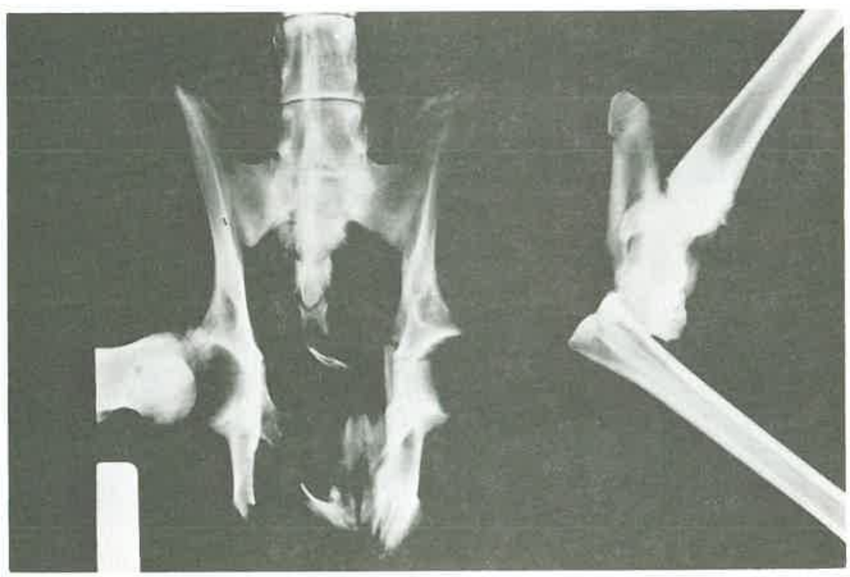


FIGURE 6: Left, X-ray of Calf D metatarsal dislocation. Right, X-ray of Calf D fractured pelvis. A stick was rammed through, removing portions of right pubic rami and bending the coccyx.

chipping (Dr. Malcolm Blessing, personal communication, 1982). Two possibilities are present for an injury of this type: a pelvic impact, although no pelvic damage or bruising was apparent (Dr. Malcolm Blessing, personal communication, 1982) or the result of the back caving in upon a four leg or chest impact (Dr. M. J. Smith, personal communication, 1982).

Rib fractures occurred consis-

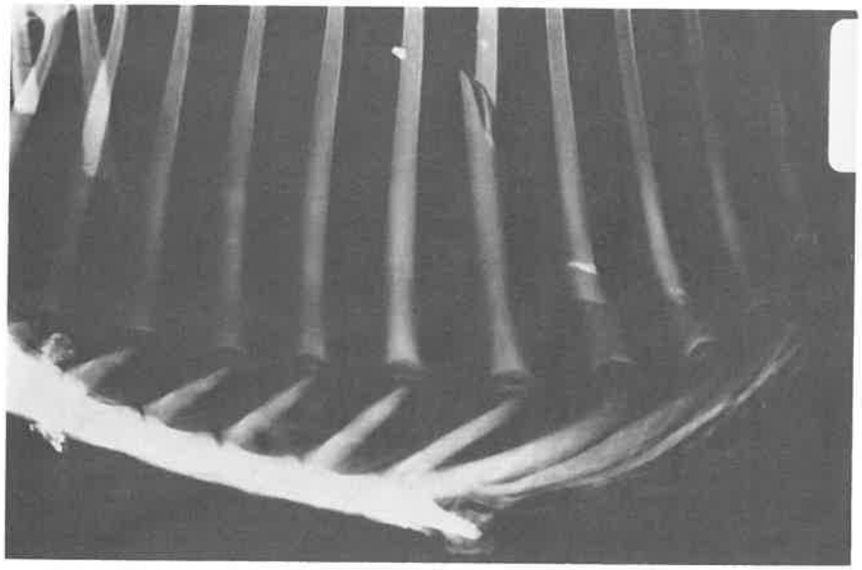


FIGURE 7: X-ray of Calf B rib fractures caused by compression of sternum.

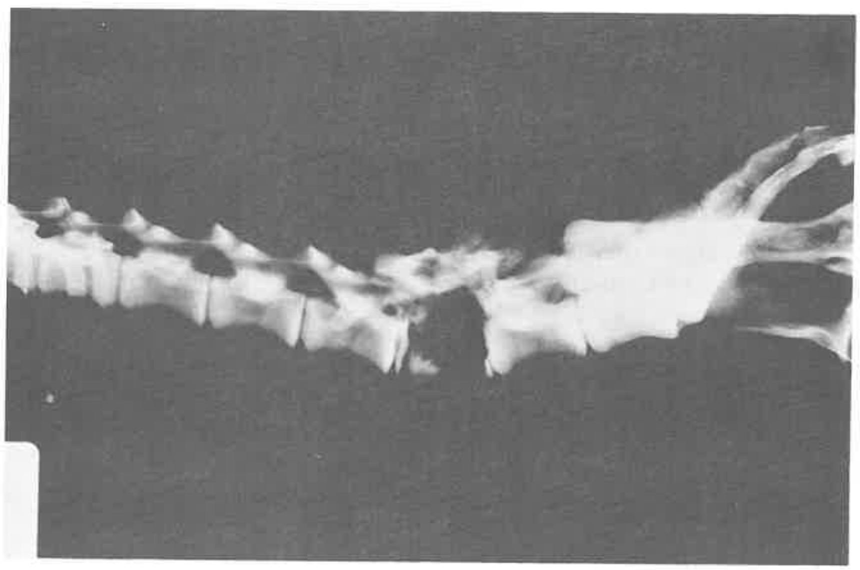


FIGURE 8: X-ray of Calf B lumbar vertebrae showing compressional "explosive" type fracture of fifth lumbar vaertebra.

tently in all four carcasses. This would be expected due to the fragility of these bones (Dr. Malcolm Blessing, personal communication, 1982). With the exception of Calf B, all rib breakage was near the lumbar region, and were probably associated with the lumbar dislocations and pelvis injuries. Unfortunately, many of the rib fractures were obliterated by carnivore gnawing prior to X-ray.

Most of the above documented injuries were consistent with the

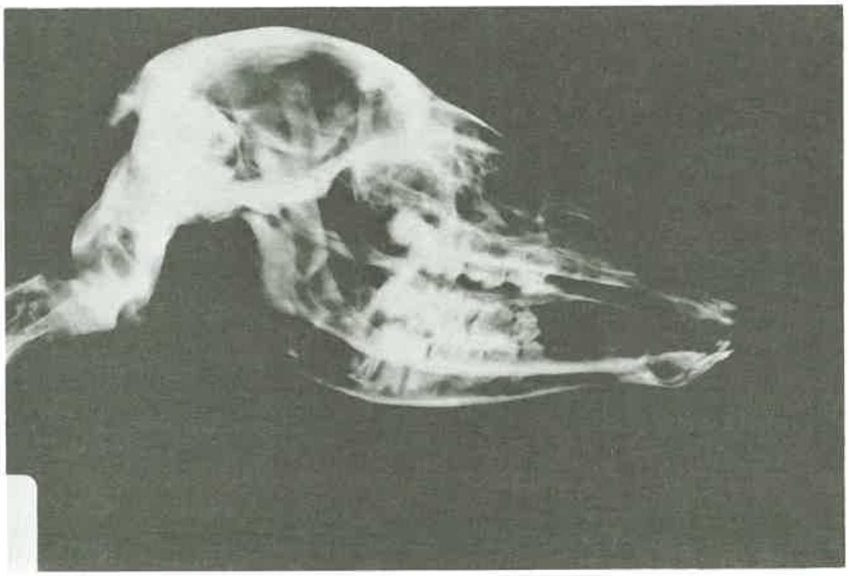


FIGURE 9: X-ray of Calf B neck and cranium, showing dislocation between first and second cervical vertebrae and damage around eye orbit.

fractures observed on other elk involved in the jump. Vertebral columns were also broken on three other cows and several calves examined, most often in the lumbar region. Crushed pelves, broken ribs and facial damage, but no lower limb fractures were also observed on other elk (Bob Hamilton, personal communication, 1982).

Observations on internal injuries of the elk were provided by Tim Fagan and Dave Bragonier of the Cody District Game and Fish Office. Ruptured livers and rectal prolapses were common. A ruptured liver causes internal bleeding with death occurring within a very short time. The concussion of the fall can also cause a sudden increase in pressure of the intestines, producing a rectal prolapse or pouching out of the intestines through the anus. Other internal injuries observed were ruptured stomachs and intestines. In one instance, a ruptured diaphram caused the intestines to move into the lung cavity. The intense pressure causing these injuries occurred at impact. Based on these observations, the immediate cause of death for most individuals was internal hemorrhage.

To summarize, it appears Cow C landed on her forelegs, which buckled causing the face to smash into the ground. This is seen in the broken teeth and swollen tongue. Cow A either landed in the same manner or on the top of the head and shoulders. A whiplash action of the hindquarters caused the vertebral column to snap between the fifth and sixth lumbar vertebrae.

The two calves showed a less consistent pattern. Calf B appears to have landed on its chest with its head tucked under the body, breaking the ribs and dislocating the neck. A caving-in of the back upon impact may have caused the compressional fracture of the fifth lumbar vertebra. Calf D appears to have landed on its hindquarters crushing the pelvis and dislocating a leg, with some damage to the chin as well. The force of impact to all four animals could have caused any of the internal injuries seen.

From this limited data, it appears that elk might tend to land on their forequarters and less frequently on the pelvis in such a 70 foot jump or fall. The most consistent injury was snapping or compression of the lumbar region, with additional damage to the immediate areas of impact.

ELK VS BISON

Communal bison procurement has been a major economic activity on the Northwestern Plains for over 10,000 years (Frison 1978). A number of trapping methods have been employed, with the most common being jumps nd pounds. Jumps were usually "rimrocks" or cliffs over which the bison were driven. The height of the rimrock is considered lethal enough to disable or kill the animals (Kehoe 1973:3). Pounds were wooden corral structures of varying size built to entrap the bison. The animals were subsequently killed by atlatl, spear, arrow, or club. Both types utilize some type of natural or man-made fence or "driveline" which allows the hunters to funnel the animals toward the kill location (Arthur 1975:78-87). Other types of communal kills mentioned in archaeological and ethnographic literature include: horse surrounds in the post-horse period (Verbicky-Todd 1984:33), arroyo traps (Frison 1978:150), snow drifts (Reeves 1978a:71), hydrothermal traps utilizing bogs, ponds, rivers, or other water forms (Reeves 1978a:71), and sand traps (Frison 1978:169).

Ethnographic accounts and some archaeological data reveal that communal bison hunts required extensive ritualistic preparations to ensure the success of the hunt (Arthur 1975:78-79; Verbicky-Todd 1984:11; Kehoe 1973:178; Frison 1971). Occasionally natural trapping situations were used spontaneously when hunters found bison in a propitious location (Medicine Crow 1978:252).

The South Fork elk jump bears some similarity to a spontaneous bison jump. A small band of elk cornered above a 70 foot cliff were unintentionally driven off by hunters. This accident provides archaeologists with a rare opportunity to study the structural and internal injury incured by large ungulates from a high jump. If one can assume that bison might incur similar injury as elk in a 70 foot jump, it may aid archaeologists in interpreting the archaeological record. These injurys may be reflected in the faunal and lithic assemblages found at jump sites, and may help to influence prehistoric hunters in their choice of kill situations.

To this author's knowledge, there is no incidence of a modern bison jump, nor any published information available which would allow a comparison of injuries that bison and elk would receive in a 70 foot jump. For this reason, caution should be used in applying the elk data to bison, however, certain factors suggest similar injuries may occur.

There are two aspects that should be addressed in comparing injuries of elk and bison from a 70 foot jump. These are, first the size and physical structure of the animals in question and second, innate landing behavior. Both animals are large, four-legged herbivores. The primary difference between the two is that bison are larger and heavier.

Size data for the two animals are listed on Table 2. There is some weight overlap between the largest elk bulls and the smallest bison cows. Elk are only slightly shorter in length than bison. Both animals are nearly equal in height with bison a little taller. The final measurement (Table 2) is the average of the combined anterior-posterior and transverse diameters of the radius diaphysis. The elk and bison measurements presented here were taken at slightly different locations which prevents exact comparison, however they do give a general idea of the comparative robustness of their long bones. There is almost complete separation in radius widths between the two animals with only the largest elk overlapping in the lower bison cow range.

This data shows that bison are a much heavier animal with most of its weight located in the fore-quarters. It has significantly thicker limb bones to support that weight. Elk are nearly as tall as bison, but have long, slender limbs. Their weight appears to be more evenly distributed throughout the body.

Based on Physical Laws of Motion, heavier bodies fall harder than light bodies (Elliot and Wilcox 1957:1-3, 144-162). Using the weight data presented above, the forces which a bison and elk would hit in a 70 foot jump was computed. The simplest method to do this is the Formula for Potential Energy. Potential energy is the ability of a body to do work because of its position, such as height. An animal on top of a cliff has potential energy. When the animal falls or jumps, it is in motion and thus has kinetic energy or the ability to exert a force when it impacts through the distance it falls (Elliot and Wilcox 1957:197). Potential energy at the top of the jump is equal to the kinetic energy at impact. This formula (Elliot and

	Weight (lbs)	Length (cm)	Height (cm)	Radius Width* (mm)
ADULT MALES				
B. b. bison	1800-2000	270	152-183	38.5-48.5
Cervus elaphus	657-822	216-262	144-168	33.5-35.5
ADULT FEMALES				
B. b. bison	700-800	---	137-152	30.0-40.0
C. elaphus	519-643	198-248	---	28.0-33.5
CALVES - 6 to 8 months, sexes combined				
B. b. bison	300-400	---	---	---
C. elaphus	251.5	165-192	122-126	22.0-26.5

*Elk radius measurement is an average of combined anterior-posterior and transverse diamters of diaphysis, five cm above the epiphysial attachment (Knight 1966:370). Bison radius measurement is also average of same two measurements, but taken at minimum transverse width of diaphysis (McDonald 1981:97).

Data compiled from: Anthony 1937:39, 41; Blood and Lovaas 1966:139; Knight 1966:370; McDonald 1981:97; Quimby and Johnson 1951:58.

TABLE 2: Bison and elk comparative sizes and weights.

Wilcox 1957: 199) for calculating potential energy is:

Kinetic Energy = Potential Energy = Weight * Height

In computing the force, 600 pounds was used as the average elk weight, and 1000 pounds as the average bison weight. This latter is a high average for female bison and used because females occur more frequently in prehistoric kill sites (Peterson and Hughes 1980: 175).

Elk = 600 pounds
K.E. = P.E. = W * H
= 600 * 70
= 42,000 foot pounds

Bison = 1000 pounds
K.E. = P.E. = W. * H
= 1000 * 70
= 70,000 foot pounds

These figures assume no reduction in velocity due to friction. The effects of friction in this example would be minimal given the short fall distance (Dr. Bruce Watne, personal communication 1983).

The figures reveal that female bison fall with nearly twice the foot pounds of force than elk. Foot pounds are the amount of work done when a force of one pound acts through a distance of one foot (Elliot and Wilcox 1957:194), or the total force created if the weight was concentrated on a nailhead. In the case of a bison or elk jump, this force would be dissipated across the part of the body that impacted. These figures reveal that, theoretically, bison injury may be considerably more severe in a 70 foot jump. The robustness of the bison may in part compensate for this.

The second factor discussed here is landing behavior. There is a difference between a "jump" and a "fall." A jump is an intentional leaping action which culminates in an attempted innate and predictable landing position. A fall is a descent with a random impact position. The size and shape of the animal may not be as important in determining jump injury as the innate landing behavior of the animals involved (Dr. Malcolm Blessing, personal communication, 1982). Both bison and elk are more likely to attempt to land on their front legs because this is an instinctive landing position, much like humans attempt to land on their feet when they jump (Dr. M. J. Smith, personal communication, 1982). The question here is, do elk and bison "jump" or "fall" in a rimrock kill?

Jumping, as a part of locomotion, is a conditioned reflex. It is a complex series of flexions and extensions of the muscles organized throughout the spinal cord and influenced by the brain (Dethier 1970:96). The specific response to a stimulus is often innate (instinctive) with environmental conditioning (learning from experience) (Heiligenberg 1972:261; Dethier 1970). When faced with a sudden dropoff, the information registers within the animal and he instinctively forms a conditioned response, i.e., prepare for impact in the learned manner it recovers from all "jump" situations. The jumping stance of an ungulate is the same as their position in a "jumping gallop."

> ". . . the animal begins with his front legs, stretches the body, and comes down again with the front legs, one after the other. Meanwhile, the hind legs leave the ground and almost simultaneously reach forward, sometimes passing

> the outside of its front legs. The hind legs then return to the ground and the animal begins the next leap with the front legs. While the body is stretching and contracting, all four legs are off the ground. This is called the "floating phase." The floating phase in stretching may . . . change over into a long jump, where the animals keep the front legs stretched forward almost horizontally and the hind legs angled closely toward the body." (Thenius and Walther 1972: 295).

A descending jump shouldn't be much different than the above described horizontal jump. In a prehistoric jump situation, the severe impact of landing could cause the animal to stumble, fall forward, and begin tumbling down a steep talus slope unless stopped by obstacles. In "high" jumps, the momentum of the animal in floating phase may cause it to begin rotating before impact, similar to a diver who flips backward or belly flops.

This suggests that animals when faced with a dropoff may attempt to land in a consistent manner. In higher vertebrates however, environmental conditioning (learning) may create variable responses. According to Heiligenberg:

> "The presentation of a particular stimulus pattern does not always release a corresponding behavior pattern: 'readiness' to respond depends on the environmental conditions and the animal's overall physiological state." (Heiligenberg 1972:258).

Heiligenberg goes on to state that while the response is not rigidly determined, it is statistical, and the way animals behave is as typical of their species as the physical traits they share. Not all animals will respond with their conditioned response. Circumstances related to the jump may also prevent some consistency. Animals who are not facing forward and are pushed from behind, may receive the jump stimulus, but may be unable to adjust their position. Extremely high jumps may cause the animal to begin a front or back rotation which will affect landing position. Assuming that most animals were attempting to land in a "jump" position, and achieved that position, it would be expected that the injuries incured would be similar and predictable.

The elk jump data suggest that the elk were attempting to land in "jump" positions. Becker's eyewitness account of the three animals jumping supports this. Three of the animals studied here also appeared to be attempting a front landing. Because of the extreme jump height, one cow may have begun to roll. The fourth calf appeared unable to achieve the conditioned landing position. It is significant that none of the animals landed on their sides which would be expected in a random fall. The injuries are consistent with impacts to the front and hindquarters. The repeated lumbar fractures, both whiplash and compressional, may be as much a result of jump height as landing position.

Ethnographic accounts of bison jumps are few, but they point to similar observations. Zenas Leonard, a 19to century fur trader, makes this comment on Crow buffalo jumping:

> "When they are in a country suitable, these people will destroy the buffalo by driving a herd of some hundreds to the edge of a convenient rocky precipice, when they are forced headlong down the craggy descent." (Leonard, in Verbicky-Todd 1984:128).

This implies that bison take a forward plunge in a rimrock kill. It is significant that most literature on this subject refers to rimrock kills as "jumps" rather than "falls" (Hurt 1963:2). Fidler's 1792 account of a Piegan jump states:

> "[we] . . . crossed a creek a little above a high steep face of rocks on the East Bank of the Creek, which the Indians uses as the purpose of a buffalo Pound, by driving whole heards before them and breaking their legs, necks, etc. in the fall, which is perpendicular about 40'." (Fidler in Verbicky-Todd 1984:124).

Similar bison jump injuries are described to S.A. Barrett by Blackfoot informants in 1921:

> "Here the bank rises in a sheer bluff about one hundred and fifty feet high and it was at this point that the Indians drove the buffalo over the brink, breaking legs, necks and backs in the fall." (Barrett, in Verbicky-Todd 1984: 127).

Both the ethnographic data and professional observations suggest that most bison probably attempted to land on their front quarters. Bison are more likely to land on their heads or front quarters than elk, because of their massive frontal weight (Dr. Malcom Blessing, personal communication, 1983). Mandible, cervical, and cranial injuries would be expected. The ethnographic mention of broken backs is in reference to a 150 foot jump. Thus, whiplash fractures might only occur in bison during high jump situations, while in elk, it apparently occurs below 70 feet.

Leg fractures, except for a single dislocation, were not observed in this elk sample, yet the above and other ethnographic accounts mention broken legs as a common injury. This may be due to the small elk sample. Other leg fractures that might occur at a jump are compressional and transverse. A compressional fracture was described earlier in reference to elk vertebrae. A transverse fracture is a horizontal snapping of the bone. These would be caused by a side blow to the long bone, as would occur if the animal hit the bone laterally on an object or was hit with a heavy object. Transverse fractures may be more common when there are numbers of animals piling on top of one another.

It would appear that ungulates, when faced with a jump situation, might attempt to instinctively land on their forefeet. This landing position creates a consistent pattern of fractures and internal damage. The basic difference between injuries incurred by bison and elk in a jump situation is probably not so much in the pattern of breakage but in the degree of injury given the same jump height. Bison may suffer greater injury in a higher jump because of their heavier mass, but this is undocumented.

IMPLICATIONS ON PREHISTORIC BISON JUMPING

The elk data may shed some light on certain phenomena observed in prehistoric bison jumping, including location of fractures and dismemberment in faunal assemblages at jump sites, quantity of projectile points used to kill bison, and choice of jump height.

If complete dislocations occur in the lumbar vertebrae, it is expected that few articulated lumbar units would occur in the butchered assemblage. Pelves, parts of crania, upper cervical vertebrae, and the anterior portions of maxilla and mandibles may reveal compressional fractures and crushing. Rib and limb fractures may also occur.

Ethnographic and archaeological data suggest that dismemberment of the cervical and lumbar units was not a common butchering practice (Gilbert 1969:289-290; White 1953:162-163; Kehoe 1967:69, 71).

If such units are found at jump sites, they may reflect jump injury. Limb and rib fractures incurred from jumps may be obscured by dismemberment and butchering processes because these units are often transported back to the campsite and processed further (White 1953:162-163; Frison 1970b:19; Lyman 1978:20).

To this author's knowledge, Frison has provided the only data available comparing faunal assemblages from pound and jump sites. In the discussion of the Wardell bison trap assemblage (Frison 1973), butchering is compared at that site to the Glenrock Buffalo Jump. A number of butchering differences between the two assemblages were noted. One is the locations of vertebral separations during butchering. At Wardell, separation was extremely variable, occurring anywhere between the seventh cervical and second lumbar. At Glenrock, separations usually occurred between the seventh cervical and second thoracic, the seventh and eleventh thoracics, the thirteenth and fourteenth thoracics, and the third and fourth lumbars (Frison 1973:48). At the Hawken site, articulated cervical and lumbar units were common, with separations usually occurring between the cervical and thoracic series and the last few thoracic vertebrae (Frison et al. 1976:50). Whiplash fractures might occur anywhere in the lumbars and possibly in the lower cervicals (Dr. Malcom Blessing, personal communication, 1982). It is highly unlikely however that separations would occur in the thoracic region because of the rib support and dorsal spines on the bison (Dr. Malcom Blessing, personal communication, 1982). While bison and elk have the same number of lumbars, the place of greatest weakness in bison may be between the third and fourth, rather than between the fifth and sixth. The particular separations between the third and fourth lumbars observed at Glenrock may be due to jump injury.

Frison also noted certain long bone fractures at the Glenrock and Kobold jumps which were not typical of butchering and attributed them to jump injury (Frison 1970b:14, 16; 1970a:29). A photograph of a fractured femur in the Kobold report (Frison 1970O: Figure 7b,c) was shown to Dr. Blessing. The break was identified as a transverse fracture, caused by a lateral force to the outside of the leg. He felt that transverse, compressional and dislocation fractures could all occur at jump sites, depending upon the position of the legs and the forces brought against them (Dr. Malcom Blessing, personal communication, 1982). Thus, limb bones revealing jump injury may be expected in faunal assemblages from jump sites.

The elk data may also provide an explanation for the paucity of projectile points found at certain prehistoric kill sites. Only one elk out of 19 survived the 70 foot jump (a 5.4% survival rate). One or two projectiles are all that would be needed to dispatch such a lone survivor:

> "Only one arrow is needed to kill a buffalo, provided it is shot by a strong man and goes between the ribs. A strong shot that hits a rib would go through the rib bone, but would not penetrate the animal deep enough to kill. A boy might require three or four arrows to kill a buffalo." (Bull Head, in Kehoe 1967:78).

Bull Head received this information in 1919 from They-Already-Stood-Around, a medicine woman who had once called the buffalo for a drive.

Frison has attributed the

small number of projectile points found at the Big Goose Creek and Glenrock jumps as due to the lethal nature of the jump (Frison 1978: 235, 1970B:42). In order to test this assumption, point frequencies and bison MNI (Minimum Number of Individuals) data were gathered on rimrock and non-rimrock kill sites where this data was available (Table 3). Bison considerably outnumber projectile points at all jump sites. The lowest jump, Kobold, presented the highest point to bison percentage (78%). No projectile points were found at the two jumps higher than 80 feet. Four of the non-jump sites produced more points than bison, which is expected. Five others, however, revealed small numbers of points. Obviously other factors are also influencing the percentage of points to numbers of bison on a site. These might include site disturbance, bone preservation, use of wood tips, and the amount of projectile point curation. Although this sample of sites is small, the low point frequencies consistently occur at Paleo-Indian and Middle Plains Archaic sites. Projectile points were larger during these periods because they tipped atlatl darts or spears. They required a greater investment of time and material to make than did the smaller Late Prehistoric arrow points, and appear to have been heavily curated (Bradley 1974: Hughes 1981). This data is tentative, but does suggest that fewer points are found at rimrock sites throughout the history of bison jumping on the Plains. High jumps, perhaps 80 feet or more, may not produce any projectile points.

Lastly, the severity of injury incurred by the elk in a 70 foot jump may be a factor in explaining why prehistoric bison jumps tend to be low:

> ". . . very few jumps have a vertical cliff exceeding a height of 30 feet but below the cliff at many jumps, a talus slope often very

	Jump Height	# of Points	Bison MNI	% Frequency*	Cultural Affiliation**	Reference
JUMP SITES						
Vore, WY	50	217	850	25.5	Lt. Preh.	Reher and Frison 1980
Glenrock, WY	40	152	251	61.0	Lt. Preh.	Frison 1970b
Kobold, Lev.II, MT	30	51	65	78.0	Mid. Arch.	Frison 1970a
Bonfire Shelter, Lev. II, Tx.	65	8	27	30.0	Paleo	Dibble and Lorraine 1968
Bonfire Shelter, Lev. III, Tx.	65	38	197	19.3	Paleo	Dibble and Lorraine 1968
Dry Island, MT	162.5	0	?	--	Mid. Arch.- Lt. Preh.	Wright and Ball 1982
Milk River, MT	80-100	0	?	--	?	Keyser 1979
NON-JUMP SITES						
Wardell, WY	pound	436	274	159.0	Lt. Preh.	Frison 1973; Reher 1973
Casper, WY	sand	60	74	81.0	Paleo	Frison 1974; Reher 1974
Rex Rodgers, TX	draw	5	6	83.0	Paleo	Speer 1978
Jones-Miller, CO	draw	104	300	34.7	Paleo	Stanford 1978
Muhlbach, Alberta	pound	61	100	61.0	Mid. Arch.	Gruhn 1969
Donovan, MT	pound	2	10	20.0	Mid. Arch.	Keyser 1979
Boarding School, MT	pound	440	280	157.0	Lt. Preh.	Kehoe 1967
Itasca, MN	?	24	16	150.0	Paleo	Shay 1971
Piney Creek, WY	slope	259	121	214.0	Lt. Preh.	Frison 1967
Hawken, WY	arroyo	45?	100	45.0	Ear. Arch.	Frison et al. 1976

*Computed by dividing number of points by bison MNI and multiplying by 100 to produce percentage.

**Cultural designations used are from Frison (1978). Abbreviations are: Paleo - 11,000 to 65,00 B.P., Ear. Arch. - 6500 to 4500 B.P., Mid. Arch. - 4500 to 1500 B.P., and Lt. Preh. - 1500 to 200 B.P.

TABLE 3: Frequency of projectile points to bison, selected kill sites.

steep, would continue the tumbling plunge of the unfortunate bison." (Arthur 1975:75).

Archaeological data supports this. A number of jump sites on the western Plains and Idaho are reported where data on jump height was available (Table 4). This list includes only rimrock jumps. Kills with a steep slope, such as the Boarding School Bison Drive and Piney Creek, were omitted. The cultural affiliation of these jumps is also given based on radiocarbon dating or point typology. The average jump height for the 41 jumps is 42.1 feet. This is offset somewhat by the 162.5 foot Dry Island jump. In reality, 80% of the jumps are less than or equal to 50 feet. Jumps without pounds underneath the dropoff range from ten to 162.5 feet. Jumps of ten feet or less may have a pound associated to entrap the animals. The data suggests that rimrocks ten feet and higher are enough to slow or maim the bison, whereas, jumps higher than 50 feet are used infrequently. The majority of the jumps occur in the Late Prehistoric Period after the bow and arrow replaced atlatl spears.

To make a statement that hunters appeared to choose low jumps over high jumps when a choice was possible, one has to assume that both high and low cliffs were available. This is a very difficult assumption to test without visiting all jump locations. Other characteristics also had to be present to make a jump work, including a gathering basin with a large bison herd nearby, an adequate number of hunters, and an effective approach to the dropoff (Arthur 1975:75; Frison 1972:15). Jumps with a perpendicular cliff need only be between to 15 feet high to achieve the goal (Frison 1972:16).

High jumps are obviously less advantageous than low jumps. The elk data reveals that in a 70 foot jump, carcass damage is considerable, producing bruised meat, ruptured internal organs, and difficulty in butchering. The ruptured organs mean the animals must be eviscerated quickly so the meat does not spoil as fast. Further, ruptured organs might deprive the Indians of parts considered delicacies. A number of ethnographic accounts reveal that Indians feasted on the livers, heart, kidneys, brains, and brisket, either raw or cooked, during butchering. De Smet witnessed this butchering scene at an Assiniboine pound :

> "While men cut and slash the flesh, the women, and children in particular, devour the meat still warm with life -- the livers, kidneys, brains & c . . ." (De Smet in Verbicky-Todd 1984: 51).

By Schaeffer's account, the Blackfoot also made a feast out of the internal organs:

> "Immediately following the killing, a "feast" was held. Choice portions such as the tongue, heart, and liver were removed from several animals, hauled back to camp on a travois, and there cooked." (Schaeffer, in Verbicky-Todd 1984: 123).

The Cree also indulged in the internal organs during butchering as revealed in this account by Robert Jefferson during the latter 19th century:

> "Flaying is done as best it may since the floor is too crowded for scientific work but the hides are stripped off; tid-bits of raw liver, fat, and kidney assuage the immediate pangs of hunger, while meat is being stripped from the bones . . ." (Jefferson, in Verbicky-Todd 1984:99).

Another disadvantage would be the difficulty of shooting maimed

	Jump Height (in feet)	Cultural Affiliation	Reference
Saskatchewan			
Sabin (DhNe-1)	35	not used	Kehoe 1973
Manitoba			
Harris	25	LM Arch-Lt Preh	Hlady 1970
Alberta			
Head-Smashed-In	35-40	M Arch-Lt Preh	Reeves 1978b
Old Woman's	25	LM Arch-Lt Preh	Forbis 1962
Dry Island (ElPF-1)	162.5	Lm Arch-Lt Preh	Wright and Ball 1982
Wyoming			
Glenrock	40	Lt Preh	Frison 1970b
Vore	50	Lt Preh	Reher and Frison 1980
South Fork, Shoshone Riv.	30e	?	personal observations
Big Goose Creek	50	Lt Preh	Frison 1967
Steamboat Mtn Jump	10-75	?	Hurt 1963
Montana			
Milk River (24HL52)	80-100	?	Keyser 1979
24HL55	60e	?	Keyser 1979
English (24HL46)	40e	Lt Preh	Keyser 1979
Keogh (24ST401)	60	Lt Preh	Conner 1962
Kobold (24BH406)	25-30	M Arch-Lt Preh	Frison 1970a
Wahkpa Chu'gn	40-76	LM Arch	Davis and Stallcop 1966
Emigrant (24PA309)	10(p)	LM Arch	Arthur 1962
Emigrant (24PA308)	15	Lt Preh	Arthur 1962
Unnamed, or Holy Family Mission	25	?	Kehoe 1967
Bull With Calf	22	not used	Kehoe 1967
Old Agency	50+	Lt Preh	Kehoe 1967
Choteau	30	?	Hurt 1963
Madison (24GA104)	35	Shoshone	Taylor 1975
Sleeping Buffalo	50	Lt Preh	Hoy 1973
Highwood Creek (24CH1002)	60	Lt Preh	Hurt 1963
Taft Hill	30	Lt Preh	Hurt 1963
Badger Creek	35-50	Lt Preh	Davis 1978
Shortridge	50	? (few)	Lewis 1941
Marsh	50	?	Lewis 1941
Cashman	10-50	?	Lewis 1941
Three Buttes	30	Lt Preh	Hurt 1963
Ulm	10-20	Lt Preh	Hurt 1963
Kelly Ranch	50	? (few)	Hurt 1963
Spring Creek	20	?	Hurt 1963
Schultz	30-50	?	Hurt 1963
Conlin	10(p)	Lt Preh	Hurt 1963
Caghagen's Jump	20	?	Lewis 1941
Kevin Rim	100	? (few)	Lewis 1941
Texas			
Bonfire Shelter	65	Paleo	Dibble and Lorraine 1968
Idaho			
Five Fingers	9-39	M Arch	Agenbroad 1978
Y Jump	11-27	M Arch	Agenbroad 1978
N = 41	mean = 42.1	range = 10 to 162.5 feet	

e = estimated; (p) = pound structure at base; (few) = reference observations on number of points found in kill deposits; Paleo = 11,000 to 6500 B.P.; M Arch = 4500 to 2500 B.P.; LM Arch = 2500 to 1500 B.P.; Lt Preh = 1500 to 200 B.P.

TABLE 4: Bison jump heights.

animals from the top of a high jump with an atlatl or spear. A bow and arrow would be easier. This might account for the increase in buffalo jumping in the Late Prehistoric Period. It would also be more difficult for those involved in the driving to get below to dispatch any escaping animals. Short rim-rock jumps would lessen or eliminate the above disadvantages and still accomplish the purpose.

SUMMARY

The South Fork elk jump provided a unique opportunity to study the kinds of stress and injuries incurred in a 70 foot jump by large ungulates. The most consistent injuries were whiplash dislocations of the fifth and sixth lumbar vertebrae, probably due to the force of impact in the fall. Other injuries were consistent with points of impact, such as the head, face, sternum, and pelvis. Internal damage was fatal, and consisted of ruptured livers, misplaced organs, and rectal prolapses. These are the result of great internal pressure caused by the impact. The injuries suggest that the animals were landing either on their fore- or hindquarters, and not on their sides.

An effort was made to compare these types of injuries to those that might have occurred in a prehistoric bison jump. Because of their greater weight, bison are more likely to hit harder than elk. It is suggested here that both animals, when faced with a dropoff, will instinctively attempt to land on their front feet and injuries should be consistent with that landing position. The higher the jump, however, the more difficult it will be to maintain a floating jump position, and impact position may vary. The elk data was fairly consistent with this concept. Ethnographic accounts also suggest that bison tended to "plunge," "jump," or otherwise go over the rimrock in a non-random manner, and accounts of their injuries coincide with those at the elk jump. It appears that jumps produce a fairly consistent set of injuries for both animals.

The elk data was used to explain certain phenomena observed at prehistoric bison jump sites, including the location of fractures and dismemberment in faunal assemblages, the lack of projectile points, and the predominant use of low rimrocks. Very little study has been done comparing faunal assemblages from rimrock and non-rimrock sites, but it is possible that certain vertebral separations and leg fractures may be observed. The elk data should be kept in mind when analyzing bone from jump sites. The data reveal that jumps over 70 feet would require very little killing to dispatch the maimed animals, which would account for consistently low numbers of projectile points to animal carcasses at jump sites. In extremely high jumps, no projectile points should be expected.

The elk data also provides one possible explanation for the predominance of low versus high jumps on the Plains. The severity of the injuries ruin meat and internal organs, which would make high drop-offs a less desirable choice.

<u>Additional Note</u>

A taphonomic sidelight to this study was the observation of the jump site one year after the jump event. Most heads, lower legs and internal organs were left at the site. One year later, all that remained were approximately six mandibles, three metapodials, and one spike bull head with antlers.

All were completely cleaned of flesh with evidence of carnivore gnawing, except the metapodials with attached feet.

ACKNOWLEDGEMENTS

Without the help of many people, this project would not have been possible. First of all, Sally and Weber Greiser brought the incident to my attention and motivated me to do something about it. Mary Asvig, Steve Bates and James and Robert Hamilton of Cody, Wyoming donated their individual elk carcasses, and readily provided their observations. Dave Bragonier and Time Fagan of the Cody Game and Fish Office shared their knowledge and experience concerning the incident. Wayne Becker of Powell, Wyoming, gave up a Saturday morning to show the jump location and share what he had witnessed. The West Park County Hospital donated the use of their portable X-ray machine and film. Pete Kure of the Radiology Department X-rayed the carcasses. Dr. Millard J. Smith, radiologist and my father, and Dr. Malcom Blessing, veterinarian, both read the X-rays and analyzed the injuries. This paper was aided by discussions with Dr. Tom Thorne, Game and Fish Department veterinarian, Stan Strike and Tom Cook, science teachers at Cody Junior High School, and Dr. Bruce Watne, mathematics and astronomy professor at Northwest Community College. Thanks to all of you! A final thanks goes to my family who endured considerable neglect during the writing of this paper. I take full responsibility for any errors or omissions on this copy.

REFERENCES CITED

Academic American Encyclopedia
1985 Bison. volume 3:299. Grolier, Inc.

Agenbroad, Lawrence
1978 Buffalo jump complexes in Owyhee county, Idaho. Plains Anthropologist Memoir 14:213-221.

Anthony, H. E., editor
1937 Animals of America. Garden City Publishing, Garden City, New York.

Arthur, George
1962 The Emigrant Bison Drive of Paradise Valley. Montana Archaeological Society Memoir 1:16-27.

1975 An introduction to the ecology of early Historic communal bison hunting among the Northern Plains Indians. Archaeological Survey of Canada, National Museum of Man, Mercury Series 37.

Blood, D. A., and A. L. Lovaas
1966 Measurements and weight relationships in Manitoba elk. Journal of Wildlife Management 30:135-140.

Bradley, Bruce
1974 Comments on the lithic technology of the Casper site materials. In: The Casper site: A Hell Gap Bison kill on the High Plains (G. C. Frison, ed.), pp. 191-198, Academic Press, New York.

Conner, Stuart
1962 Unusual characteristics of the Keogh Buffalo

Jump. Montana Archaeological Society Memoir 1:8-11.

Davis, Leslie B.
1978 Twentieth Century commercial mining of Northern Plains Bison kills. Plains Anthropologist Memoir 16:254-286.

Davis, Leslie B., and Emmett Stallcop
1966 The Wahkpa Chu'gn site (24HL101), Late Period occupations in the Milk River valley, Montana. Montana Archaeological Society Memoir 3.

Dethier, V. G., and Elliot Stellar
1970 Animal Behavior. Prentice-Hall, New Jersey.

Dibble, David S., and Dessamae Lorraine
1968 Bonfire Shelter: A stratified Bison kill site, Val Verde county, Texas. Texas Memorial Museum Miscellaneous Papers 1.

Elliot, L. Paul, and William F. Wilcox
1957 Physics: A modern approach. MacMillian Company, New York.

Forbis, Richard G.
1962 The Old Woman's Buffalo Jump, Alberta. National Museum of Canada Bulletin 180:56-123.

Frison, George C.
1967 The Piney Creek sites, Wyoming. University of Wyoming Publications 33:1-92.

1970a The Kobold site, 24BH406: A post-Altithermal record of buffalo jumping for the Northwestern Plains. Plains Anthropologist 15:1-35.

1970b The Glenrock Buffalo Jump, 48CO304. Plains Anthropologist Memoir 7.

1971 The Buffalo pound in Northwestern Plains Prehistory: Site 48CA302, Wyoming. American Antiquity 36:77-91.

1972 The role of buffalo procurement in post-Altithermal populations on the Northwestern Plains. University of Michigan, Museum of Anthropology, Anthropological Papers 46:11-20.

1973 The Wardell Buffalo trap 48SU301: Communal procurement in the Upper Green River Basin, Wyoming. University of Michigan, Museum of Anthropology, Anthropological Papers 48.

1974 The Casper site: A Hell Gap Bison kill on the High Plains. Academic Press, New York.

1978 Prehistoric Hunters of the High Plains. Academic Press, New York.

Frison, George C., Michael Wilson, and Diane Wilson
1976 Fossil bison and artifacts from an early Altithermal Period arroyo trap in Wyoming. American Antiquity 41: 28-57.

Gilbert, B. Miles
1969 Some aspects of diet and butchering techniques among prehistoric Indians in South Dakota. Plains Anthropologist 14:277-294.

Gruhn, Ruth
1971 Preliminary report on the Muhlbach site: A Besant Bison trap in Central Alberta. National Museums of Canada Bulletin 232(4):128-156.

Heiligenberg, W.
1972 The influence of specific stimulus patterns on the behavior of animals. In: Grzimek's Encyclopedia of Ethiology (Bernard Brzimek, ed.). Van Nostrand Reinhold, New York.

Hlady, Walter M.
1970 The Harris Bison runs near Brandon. In: Ten Thousand Years: Archaeology in Manitoba (W. M. Hlady, ed.). Archaeological Society of Manitoba, Winnipeg.

Hoy, Judy
1973 Six bison kill sites in Phillips county, Montana. Archaeology in Montana 14(3):1-34.

Hughes, Susan S.
1981 Projectile point variability: A study of point curation at a Besant kill site in southcentral Wyoming. Unpublished M.A. Thesis, Department of Anthropology, University of Wyoming, Laramie.

Hurt, Wesley R.
1963 Survey of Buffalo jumps in the Northern Plains. U.S. Department of the Interior, National Park Service.

Kehoe, Thomas F.
1967 The Boarding School Bison Drive site. Plains Anthropologist Memoir 4.

1973 The Gull Lake site: A prehistoric drive site in southwestern Saskatchewan. Milwaukee Public Museum, Publications in Anthropology and History 1.

Keyser, James D.
1979 Late Prehistoric Period Bison procurement on the Milk River in north-central Montana. Archaeology in Montana 20(1):1-241.

Knight, Richard R.
1966 Bone characteristics associated with aging in elk. Journal of Wildlife Management 30:369-374.

Lewis, H. P.
1941 Bison kills in Montana. Unpublished manuscript on file, National Park Service, River Basin Surveys, Lincoln, Nebraska.

Lyman, R. L.
1978 Prehistoric butchering techniques in the Lower Granite Reservoir, southeastern Washington. Tebiwa 13:1-25.

McDonald, Jerry N.
1981 North American Bison: Their classification and evolution. University of California Press, Berkeley.

Meagher, Mary Margaret
1973 The Bison of Yellowstone National Park. National Park Service, Scientific Monograph Series 1.

Medicine Crow, Joe
1978 Notes on Crow Indian Buffalo jump traditions. Plains Anthropologist Memoir 14:249-253.

Peterson, Robert, Jr., and Susan S. Hughes
1980 Continuing research in Bison morphology and herd composition using chronological variation in metapodials. Plains Anthropologist Memoir 16:170-190.

Quimby, Don C., and Donald E. Johnson
1951 Weights and measurements of the Rocky Mountain elk. Journal of Wildlife Management 15:

Reeves, Brian O. K.
1978a Bison killing in the southwestern Alberta Rockies. Plains Anthropologist Memoir 14:63-78.

1978b Head-Smashed-In: 5500 years of Bison jumping in the Alberta Plains. Plains Anthropologist Memoir 14:151-174.

Reher, Charles A.
1973 The Wardell Bison bison sample: Population dynamics and archaeological interpretation. University of Michigan, Museum of Anthropology, Anthropological Papers 48:89-105.

1974 Population study of the Casper site Bison. In: The Casper site: A Hell Gap Bison Kill on the High Plains (G. C. Frison, ed.), pp. 113-124. Academic Press, New York.

Reher, Charles A., and George C. Frison
1980 The Vore site, 48CK302, a stratified Buffalo jump in the Wyoming Black Hills. Plains Anthropologist Memoir 14.

Shay, C. Thomas
1971 The Itasca Bison kill site: An ecological analysis. Minnesota Historical Society.

Speer, Roberta D.
1978 Bison remains from the Rex Rodgers site. Plains Anthropologist Memoir 14:113-127.

Taylor, Dee C.
1975 Preliminary excavations at the Madison Buffalo jump, 24GA314. Special Report of the Montana Game and Fish, Bozeman.

Thenius, Erich, and Fritz Walther
1972 Horned Ungulates. In: Grzimek's Animal Life Encyclopedia, volume 13. Van Nostrand Reinhold, New York.

Verbicky-Todd, Eleanor
1984 Communal Buffalo hunting among Plains Indians. Archaeological Survey of Alberta, Occasional Paper 24.

Volume Library, The
1982 Deer. pp. 29. Southwestern Company, Nashville, Tennessee.

White, Theodore E.
1953 Observations on the butchering techniques of some aboriginal peoples, no. 2. American Antiquity 19:160-164.

Wright, Milton J., and Bruce F. Ball
1983 First results from Dry Island Buffalo Jump Provincial Park, 1982. Archaeological Survey of Alberta, Occasional Paper 21:161-170.

Susan Hughes
Bighorn Basin Consulting
P.O. Box 612
Cody, Wyoming 82414

IDENTIFICATION AND CHARACTERIZATION OF SURFACES AT THE MCKEAN SITE

MARCEL KORNFELD AND M. L. LARSON

ABSTRACT

Over the past several years of reinvestigation at the McKean site we have come to understand the site as being more complex than originally thought. This complexity lies largely in the nature of the site formation processes responsible for the archaeological record. As a result, considerable effort has been directed to the identification and characterization of living surfaces. This paper describes such analysis for one part of the McKean site excavated in the summer of 1984.

INTRODUCTION

In his rewriting of Northwest Plains prehistory George Frison said "...the Northwest Plains area could never support forms of political and social organization higher then simple bands" (1978:19). While this still seems to be supported by the evidence, it is now clear that simple bands can exhibit a great deal of interesting variation and complexity (Price and Brown 1985). The present research, by investigating the formation processes of the McKean site (48CK7) is an initial step in interpreting the basic settlement and subsistence strategies, and through this towards understanding the variation and complexity of High Plains band organization.

Recently it has been argued that the McKean site represents 5000 years of more or less uninterrupted occupations (Kornfeld 1983; Kornfeld and Frison 1985), instead of a period of occupation and abandonment, followed by another occupation and a final abandonment (Mulloy 1954). Preliminary evidence for a different set of formation processes has been presented presented (Kornfeld 1983; Kornfeld and Frison 1985), but the necessity of additional information and more in depth analysis was obvious. This paper contributes new, but still preliminary evidence and carries the analysis beyond that presented previously. We want to answers three questions about one partially excavated area of the site: 1) Can we separate the features and their associated activity areas?; 2) What is the "function" of each feature, i.e., what activities occurred there?; and 3) Where does the McKean site fit in the organization of McKean cultural system?

STRATIGRAPHIC ANALYSIS

Our analysis is restricted to a partially excavated block area in the eastern portion of the site designated by Mulloy as Locality II. This area is located on the north side of an east/west drainage, where it is well protected from the prevailing north/northwest winds. Excavation in this particular area revealed a large quantity of rock and uncovered at least six features (hearths). Although strata were seen in the profiles of this excavation area, they represent soil units not depositional units (Reider 1985) and are only partially useful for defining cultural stratigraphy. To define cultural stratigraphy a different analytical technique is necessary.

This analysis began by plotting all tools from the excavation area on two north to south backplots. Tools found in place were plotted in their exact provenience, while those coming out of screened material were plotted in the center of their excavation unit (i.e., either 50 x 50 x 5 cm or 1 x 1 m x 10 cm).

Among the tools plotted were several chronologically diagnostic projectile points (Figure 1). Only two of these have unquestionable typological and contextual association. These suggest that the entire excavation area, except for the one deep feature dates, from the Late Archaic period to present. This is consistent with what we know of other parts of the site. The one deep feature is older than the other hearths, but without radiocarbon dates or associated chronologically diagnostic items its culture-historical affiliation is unknown. In any case, the features and artifact assemblage discussed in this paper date to within the last 2000 to 2500 years (the one deep feature is excluded from most subsequent analyses). This period is preserved within a soil matrix that varies between 40 cm and 75 cm in thickness.

The tools do not form a clear spatial pattern suggestive of depositional units or "living floors"

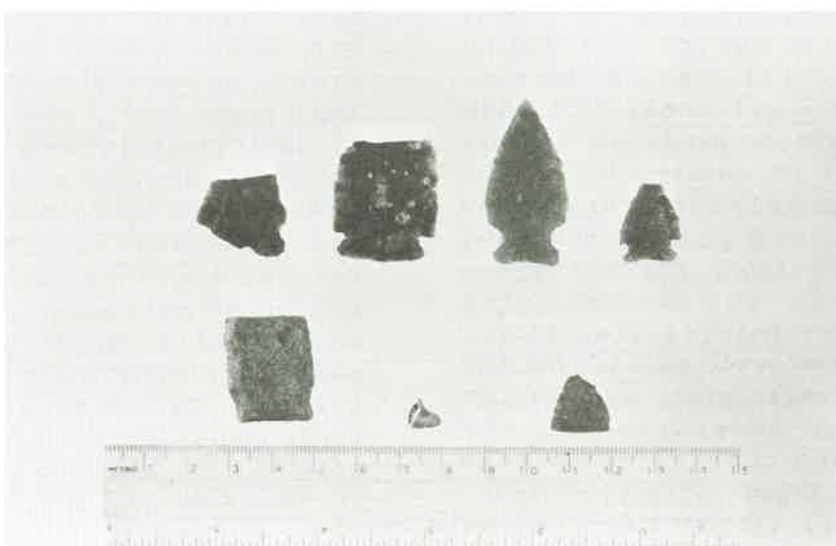


FIGURE 1: Projectile points from analyzed excavation area at Locality II.

(Figure 2). However, there is some clustering of tools in the deposit, located in vicinity of two of the five features. Aside from these clusters, which incidentally do not automatically indicate an association of tools and features, the tools were scattered in an unpatterned fashion. That is, "living floors" are not immediately obvious, but some tool locations suggest that they may yet be identified.

To impose some order on these items, we plotted a "rock layer" and graphs of chipped stone frequencies by level on a backplot (Figure 3). The "rock layer" was a concentration of fire altered rocks encountered over a large area, i.e., several adjoining square meters, at a uniform elevation. The chipped stone frequencies were from one unit portrayed in the backplot. Location of the peaks and valleys in adjoining units is of interest. By this type of overlay we can suggest several surfaces; there are peaks and valleys that correspond to some of the features and may constitute their "living floors", making it possible to assign parts of the assemblage to several different horizontal clusters.

Some of these clusters are clearly related to the features, but others are not. For example, an intermediate level is present which has no feature associated with it. Supporting our definition of levels are distributions of several pieces of identical lithic raw material within clusters. In two instances chipped stone items that were undoubtedly removed from the same core have been found within the same cluster or within the clusters at the same level. In one case, three thinning flakes with similar curvatures and flake patterns from the same level represent a series in a biface reduction sequence. These material type

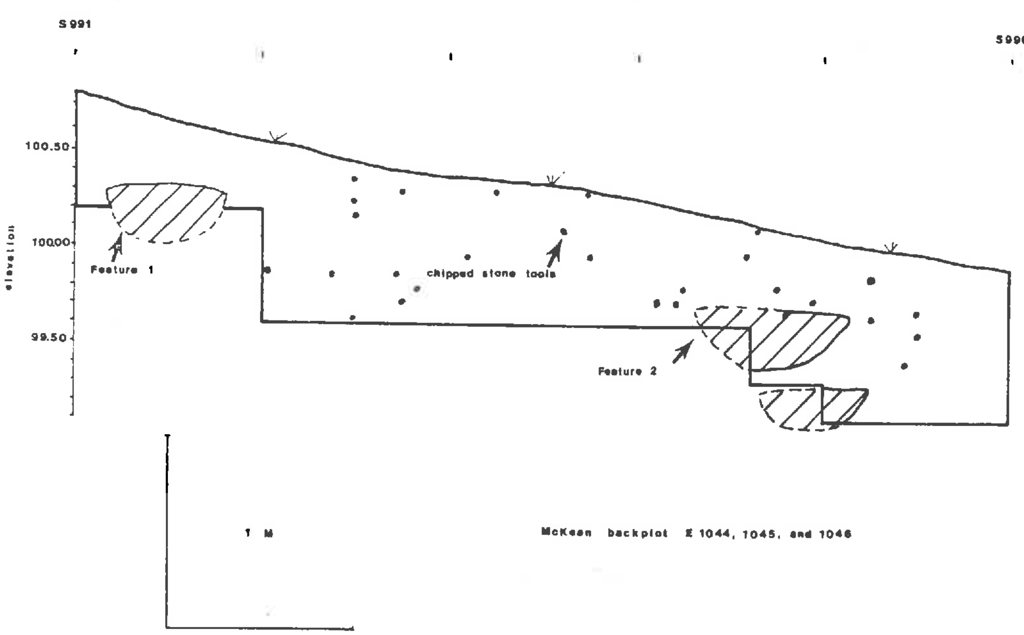


FIGURE 2: Blackplot of E1044, 1045, and 1046/N991-996, showing features and chipped stone tools

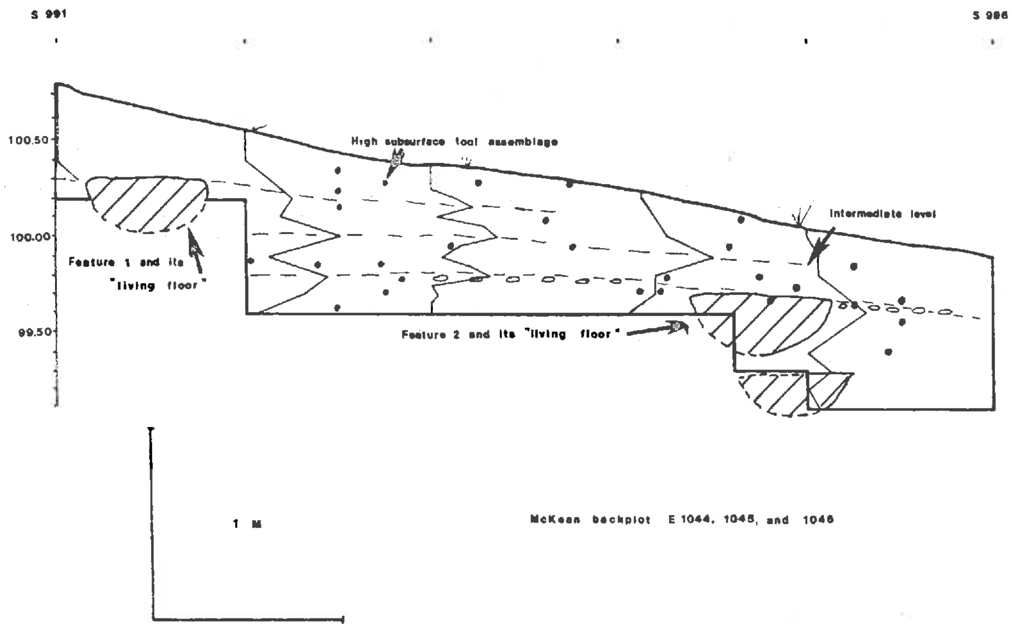


FIGURE 3: Backplot of E1044, 1045 and 1046/N991 to 996, showing separate assemblages.

"fits" occur in the eastern portion of the Intermediate level and in the lower level assemblages, associated with Features 2 and 3.

To summarize, we have isolated "living floors" associated with each of the four features (dotted lines starting at each of the features; Figures 3 and 4), the Intermediate level without any features, several tools that are immediately below the present ground surface, associated with little or no debitage, and one feature without a "living floor" (this last is the one deep hearth). The lack of an associated "living floor" is probably the result of the small area excavated around this feature. Thus, by examining the vertical distribution of tools, debitage, features, and all mapped items we have isolated seven separate assemblages in five distinct levels.

LATE ARCHAIC TO LATE PREHISTORIC PERIOD LIVING FLOORS AS SEEN IN THE CHIPPED STONE ASSEMBLAGE

In this part of the paper we examine the chipped stone assemblage to infer the function of this area of the site and of the individual features, and to distinguish activities at each feature. All seven assemblages will not be a part of this discussion. The one deep hearth is left out of the present discussion as it does not contain any associated artifacts and only a small edge of it has been excavated. In addition, some comparisons will be made between assemblages with features, while other analysis will exclude the assemblage of high tools that are not associated with any features.

We began the analysis by calculating size and density of feature assemblages. To make size estimates several correction factors were developed, because the sample sizes of chipped stone tools and debitage differ between features. The differences are the result of excavation constraints and choice of analytical units.

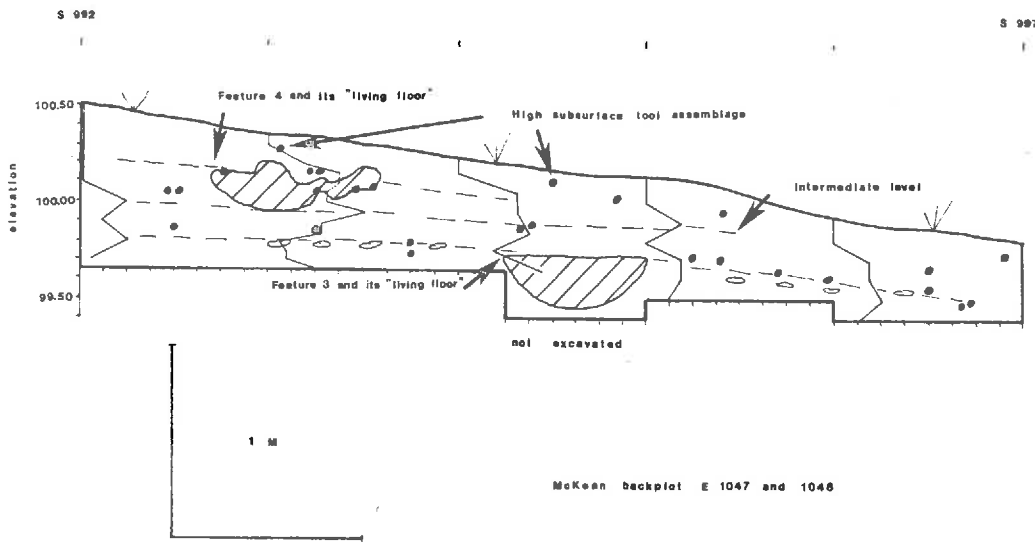


FIGURE 4: Backplot of E1047 and 1048/N992 to 997, showing separation of assemblages.

Specifically, tools from the entire excavation area have been analyzed, but the only debitage analyzed was that screened through 1/4 inch mesh dry screens. To estimate assemblage size, an area of two to three meters in all direction from a feature (25 square meters) is considered to be the "living floor" associated with that feature (e.g., Binford 1983; Enloe 1983). The size of the analyzed fraction of the associated "living floor" was calculated based on how many of the surrounding units were analyzed. That number was then used as a correction factor for estimating assemblage size of each feature (Table 1).

The total number of chipped stone tools for each feature is estimated between 15.0 and 19.6 items (Table 2). This is a small range of numbers of artifacts. Furthermore, three of the features contain an estimated 19.0, 19.1,and 19.6 tools, while one contains 15 tools. The latter is estimated on the basis of only three tools from 20% of its area excavated. Clearly, this feature, with the smallest area excavated, has the greatest chance of being least representative, which might account for even the small variability observed.

This similarity in assemblage size is interesting in another important respect, namely in identifying the function and organization of the McKean site. We suggests that only organizationally similar occupations would leave approximately equivalent remains. That is, even though different activities may have been carried on at each feature the relationship between these activities and the rest of the cultural system is, at some level, similar. This supports the redundant use of the site suggested by Ingbar (1985) and Ingbar et al. (1983).

The estimated amount of 1/4 inch debitage associated with each feature varies between 100 and 183 pieces (Table 2). This indicates some, but not major chipping activity. Although up to 183 items are associated with the features this is no greater than 7.3 items

Feature Number	Correction Factor For Tools	Correction Factor For Debitage
1	.20	.08
2	.56	.12
3	.68	.16
4	.36	.08

TABLE 1: Correction factors for tools and debitage.

Feature Number	No. Tools in Sample	Estimated No. of Tools	Debitage in Sample	Estimated Total
1	3	15	8	100
2	11	19.6	22	183.3
3	13	19.1	26	168.8
4	7	19	11	137.5

TABLE 2: Estimated assemblage size per feature.

per square meter (Table 3). Parry and Speth (1984: 63) for example, found a density of 146 flakes per square meter in a camp site in southern New Mexico. Although their site is not strictly comparable to the McKean site, it does suggest that the McKean site is on the low end of the density spectrum. Also of note here is the comparison between the density of the chipped stone tools and debitage from features and from the Intermediate level (Table 3). In the Intermediate level, tools are in considerably lower density and flakes are in a higher density than assemblages in association with features. Features were not found in the Intermediate level, but there is a possibility that a feature does exist outside the excavation area. Thus, the Intermediate level may represent part of an assemblage at some distance from a feature, while the rest of the chipped stone assemblages represent parts close to features. In either case, while comparing features, the Intermediate level simply has no counterpart among the feature assemblages.

DEBITAGE

At this point it is necessary to characterize the chipped stone debitage of the various "living floors." For this analysis and partly because of the small sample processed thus far (102 items, comprising 8% to 16% of each feature) only simple analytical categories were used. Debitage categories included flake types, cortex cover, raw material type and size class.

The flakes types include: Shatter (angular debris), thinning flakes (mainly thin, often lipped flakes, byproducts of biface manufacture or rejuvenation), other "regular" flakes (those not identified as thinning), and unidentified flakes (broken, etc.). The cortex

Feature Number	Flake Density Per Square Meter	Tool Density Per Square Meter
1	4.00	0.60
2	7.33	0.78
3	6.50	0.76
4	5.50	0.77
Intermed. level	8.75	0.42

TABLE 3: Flake and tool densities.

cover categories include: no cortex, some cortex, mostly or all cortex, and unidentifiable. The size category includes three sizes: 1/4 to 1/2 inch, 1/2 to 1 inch, and greater than 1 inch. The raw material categories include: Morrison Quartzite, Cloverly Formation Quartzite, Other Quartzite, Knife River Flint/Silicified Wood, Hartville Chert, Other Chert, Basalt, and Miscellaneous/Unidentified (see Reher 1985, for most of these type descriptions). Perhaps the most important distinction is between the local and exotic sources. Cloverly Formation Quartzite and Hartville Chert can be considered exotic, Morrison Quartzite, Basalt and Knife River Flint-like Chert are locally available (within a few miles of the site), while Other Chert, Other Quartzite and Miscellaneous categories may be either local or exotic.

The most abundant raw material is the local Morrison Quartzite (Table 4a). This is followed by the Miscellaneous material class, Other Quartzite, and Cloverly Formation Quartzite. The rest of the classes comprise less than 10% of the assemblage each.

The individual features vary from this general pattern. The four features and the Intermediate level are also all dominated by Morrison Quartzite, with a maximum of 54.5%. If we combine all local materials its range among the features is 50.0% to 65.1%, while combining all the non-local material results in a range from 3.8% to 36.4%. The unaccounted frequency is the result of unidentified source of several material types. We can suggest that the differences between features are partly the result of conditions preceding occupation of the McKean site. That is, local material (Morrison quartzite, etc.) was known to be available near the McKean site, however the material brought to the site from a distance to supplement it likely varied with the time of the year and the immediately preceding tasks. It is also noteworthy that the Intermediate level has the highest relative frequency of the Miscellaneous raw material type. We suggest that the Intermediate level represents a different part of the cultural system than the feature assemblages, a fact already suspected by the lack of features, and supporting such an interpretation. The higher frequency of the Miscellaneous raw material type also suggests that the Intermediate level may be a result of multiple inseparable occupations. The Miscellaneous category includes several raw material types, and multiple occupations are more likely to introduce different raw material types than a single occupation.

In the flake type category the largest relative frequency of debi-

RAW MATERIAL	FEATURE NUMBER 1 #	%	2 #	%	3 #	%	4 #	%	Interm. #	%	TOTAL #	%
Morrison qt.	3	37.50	10	45.50	13	50.00	6	54.50	14	40.00	46	45.10
Cloverly qt.			3	13.60	1	3.85	4	36.40	4	11.40	12	11.80
Other qt.	1	12.50	4	18.20	4	15.40	1	9.09	3	8.57	13	12.70
KRF like chalced.	1	12.50	1	4.55	2	7.69			1	2.86	5	4.90
Hartville ch.			1	4.55					1	2.86	2	1.96
Chert	2	25.00			2	7.69			5	14.3	9	8.82
Basalt					2	7.69					2	1.96
Miscellaneous	1	12.50	3	13.60	2	7.69			7	20.00	13	12.70
TOTAL	8	100.0	22	100.0	26	100.0	11	100.0	35	100.0	102	100.0

TABLE 4a: Raw material distribution by feature.

FLAKE TYPE	FEATURE NUMBER 1 #	%	2 #	%	3 #	%	4 #	%	Interm. #	%	TOTAL #	%
Shatter	1	16.70			2	11.10			7	26.90	10	14.90
Thinning	2	33.30	4	40.00	10	55.60	6	85.70	11	42.30	33	49.30
Other regular	3	50.00	6	60.00	6	33.30	1	14.30	8	30.80	24	35.80
TOTAL	6	100.0	10	100.0	18	100.0	7	100.0	26	100.0	67	100.0

TABLE 4c: Flake type distribution by feature (with unidentified category excluded).

FLAKE TYPE	FEATURE NUMBER 1 #	%	2 #	%	3 #	%	4 #	%	Interm. #	%	TOTAL #	%
Shatter	1	12.50			2	7.69			7	20.00	10	9.80
Thinning	2	25.00	4	18.20	10	38.50	6	54.50	11	31.40	33	32.40
Other regular	3	37.50	6	27.30	6	23.10	1	9.09	8	22.90	24	23.50
Unidentified	2	25.00	12	54.50	8	30.80	4	36.40	9	25.70	35	34.30
TOTAL	8	100.0	22	100.0	26	100.0	11	100.0	35	100.0	102	100.0

TABLE 4b: Flake type distribution by feature (with unidentified category included.

CORTEX	FEATURE NUMBER 1 #	%	2 #	%	3 #	%	4 #	%	Interm. #	%	TOTAL #	%
None	5	62.50	16	72.70	19	73.10	10	90.90	28	80.00	78	76.50
Some	1	12.50	6	27.30	6	23.10	1	9.09	6	17.10	20	19.60
Nearly all/all	2	25.00									2	1.96
Unidentifed					1	3.85			1	2.86	2	1.96
TOTAL	8	100.0	22	100.0	26	100.0	11	100.0	35	100.0	102	100.0

TABLE 4d: Amount of cortex on flakes by feature.

SIZE	1 #	1 %	2 #	2 %	3 #	3 %	4 #	4 %	Interm. #	Interm. %	TOTAL #	TOTAL %
1/4 to 1/2 inch	3	37.50	9	40.90	9	34.60	8	72.70	20	57.10	49	48.00
1/2 to 1 inch	2	25.00	11	50.00	12	46.20	3	27.30	12	34.30	40	39.20
>1 inch	3	37.50	2	9.09	5	19.20			3	8.57	13	12.70
TOTAL	8	100.0	22	100.0	26	100.0	11	100.0	35	100.0	102	100.0

TABLE 4e: Artifact size by feature.

tage is unidentified (Table 4b), represented mostly by broken flakes. The unidentifiable debitage was removed from further consideration (Table 4c). Thinning flakes predominate in the flake assemblage, accounting for nearly 50% of the remaining debitage. Regular flakes are the next largest category (35.8%) followed by shatter (14.9%). The features vary from each other in respect to these flake classes and the Intermediate level is different again, with the largest relative frequency of shatter. This flake class again differentiates the Intermediate level assemblage from other assemblages and suggests this level represents a structurally different part of the system. Such differences lend further support to our separation of assemblages.

The high frequency of thinning flakes suggests that manufacture or rejuvenation of tools, especially bifacial tools, was an important activity in this area of the McKean site. The size of most of the thinning flakes is less than 1 cm, thus they are more likely rejuvenation than manufacturing debris. Since tool rejuvenation is often done in the context of the activity which dulled the item in the first place, this provides us with additional information about such activities. This process was apparently not equivalent at all features. It played a greater role at Feature 4 than at any other feature and the smallest role at Feature 1. This is also supported by the quantity of cortex, since the amount of cortex varies inversly with the biface and other tool manufacturing and rejuvenating processes. In this category the assemblage from Feature 1 has the largest frequency of nearly or completely cortex covered flakes, while Feature 4 assemblage has the largest frequency of flakes with no cortex (Table 4d).

At Feature 2, the high frequency of regular flakes suggests a different chipped stone reduction process than at other features. Presently, we do not know why this is so, but we will investigate this variability further.

TOOLS

The tools were divided into four morpho-functional classes (Table 5a). Some differences and similarities in proportions of these classes are present among the features. The representativeness of the tool assemblage (three items) from Feature 1 may be questionable because of small sample size. Thus, it is mostly excluded from the subsequent discussion.

Considering the projectile points, the assemblages are remarkably uniform. Each assemblage has one projectile point accounting for between 8.3% and 14.3% of their respective sample. The features

	FEATURE NUMBER													
	1		2		3		4		Interm.		High		TOTAL	
ARTIF. CLASS	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Proj. Points			1	10.00	1	8.33	1	14.30	1	12.50	1	11.10	5	10.20
Bifaces			2	20.00	2	16.70	3	42.90	2	25.00	3	33.30	12	24.50
Scrapers			2	20.00	2	16.70							4	8.16
Flake tools	3	100.0	5	50.00	7	58.30	3	42.90	5	62.50	5	55.60	28	57.10
TOTAL	3	100.0	10	100.0	12	100.0	7	100.0	8	100.0	9	100.0	49	100.0

TABLE 5a: Artifact classes present by feature.

	FEATURE NUMBER													
	1		2		3		4		Interm.		High		TOTAL	
MODIFICATION	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Light	1	33.30	2	40.00	3	50.00	3	100.0	4	80.00	3	60.00	16	59.30
Heavy	2	66.70	3	60.00	3	50.00			1	20.00	2	40.00	11	40.70
TOTAL	3	100.0	5	100.0	6	100.0	3	100.0	5	100.0	5	100.0	27	100.0

TABLE 5b: Degree of modification on flake tools.

	FEATURE NUMBER													
	1		2		3		4		Interm.		High		TOTAL	
LENGTH MOD EDG	#	%	#	%	#	%	#	%	#	%	#	%	#	%
<25% of edge	1	33.30	2	40.00	5	71.40	1	33.30	5	100.0	4	80.00	18	64.30
>25% of edge	2	66.70	3	60.00	2	28.60	2	66.70			1	20.00	10	35.70
TOTAL	3	100.0	5	100.0	7	100.0	3	100.0	5	100.0	5	100.0	28	100.0

TABLE 5c: Extent of modification on flake tools.

	FEATURE NUMBER													
	1		2		3		4		Interm.		High		TOTAL	
TOOL RAW MAT	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Morrison qt.	1	33.30	6	55.00	3	23.10	1	14.30	3	37.50	4	44.40	18	35.30
Cloverly qt.					2	15.40	1	14.30	1	12.50	2	22.20	6	11.80
Other qt.	1	33.30	2	18.00	6	46.20			2	25.00	1	11.10	12	23.50
KRF like chal			1	9.10			1	14.30					2	3.92
Hartvile ch	1	33.3			1	7.69			1	12.50			3	5.88
Other chert			1	9.10	1	7.69	3	42.90			1	11.10	6	11.80
Basalt							1	14.30					1	1.96
Miscellaneous			1	9.10					1	12.50	1	11.10	3	5.88
TOTAL	3	100.0	11	100.0	13	100.0	7	100.0	8	100.0	9	100.0	51	100.0

TABLE 5d: Raw material used for tool manufacture.

vary more in their portions of bifaces (16.7% to 42.9%), but this is only a difference between two and three items. The last of the curated tools, the scrapers are only present at two features (Features 2 and 3) and are entirely absent around the rest of the hearths. Basically, the feature assemblages and the two non-feature assemblages are similar in the proportion of curated to non-curated tools, but differ in the types of curated tools present in each assemblage.

Except for the projectile points, which appear to be common, the other curated tools suggest that different activities were anticipated for the various McKean occupations before arriving at the location. Therefore, different tools were brought to the site. It appears that the tools brought to the site were rejuvenated, used, and discarded. This can be seen in that the largest fraction of thinning flakes is at Feature 4, which also has the largest absolute frequency of bifaces. These bifaces would have been brought to the site in a usable state, rejuvenated and discarded when no longer functional. The thinning flakes were generated during this process. Supporting this inference is the raw material proportion of the curated tools (Table 6). Morrison Quartzite, the local material, accounts for the fewest of the curated tools, for a considerably larger portion of non-curated tools, and for a still larger portion of the debitage (see discussion above; Table 4a).

Non-curated tools comprise 57% of the assemblage (Table 5a). These vary in the type and degree of modification. Some are heavily retouched and utilized, others had no retouching, but were still worn out. However, most of the non-curated tools showed only minor utilization (Table 5a,b). Specifically, we think that the curated tools made of exotic raw materials were brought to site, rejuvenated, and abandoned when no longer functional. Local material was collected immediately for expedient tools and to replace expended curated tools.

CONCLUSION

Our main goal of separating this part of the McKean site into different components proved successful. Seven assemblages were isolated, five of these are features (hearths) and their associated "living floors", one is a level with a denser concentration of chipped stone than underlying or overlying levels without any features, and the last is a collection of chipped stone tools immediately below the present ground surface, not associated with any features or with much debitage.

The wide variation in sample sizes of each of these resulted in our inability to fully analyze and compare all assemblages. Nevertheless, it is possible to suggest that several different components of the cultural system are repre-

TOOL RAW MAT	Curated #	Curated %	Non-curated #	Non-curated %	TOTAL #	TOTAL %
Morrison qt.	6	23.10	13	41.90	19	33.30
Cloverly qt.	5	19.20	2	6.45	7	12.30
Other qt.	7	26.90	6	19.40	13	22.80
KRF like chal	1	3.85	1	3.23	2	3.51
Hartvile ch			3	9.68	3	5.26
Other ch	4	15.40	4	12.90	8	14.00
Basalt	1	3.85			1	1.75
Miscellaneous	2	7.69	2	6.45	4	7.02
TOTAL	26	100.0	31	100.0	57	100.0

TABLE 6: Raw materials used for curated versus non-curated tools.

sented. First, the feature and Intermediate level (non-feature) assemblages were found to differ from each other in the organization of the cultural system. This was seen in the inverse relationship of densities of tools and debitage and was supported by the variation of raw material in the debitage. Second, the feature assemblages were found to be different in some respects, but similar in others. Namely, all (but one with an inadequate sample) were found to represent an aspect of organization related to projectile points, i.e., hunting (evidence for use of projectile points for other activities has not been found). However, aspects of cultural system related to use of other curated tools varied among the assemblages. Perhaps we can suggest that the site represents evidence of encounter type settlement-subsistence behavior with special emphasis on hunting. By this characterization we are not implying that hunting is of primary importance for the groups involved. Ethnographically evidence is abundant for daily hunting attempts most of which prove unsuccessful (Lee 1979:267; Tanaka 1980:72). Such groups are frequently characterized as depending largely on gathered resources. Continuous encounter hunting may be responsible for low density and even distribution of hunting equipment, such as projectile points, which we find at the site. The variability among the assemblages may then be the result of the type, success, and failure of recently past and anticipated activities. Presently this is only a suggestion, but further analysis will be conducted to evaluate this and other ideas presented in this paper.

ACKNOWLEDGMENTS

We would like to thank Linda Ward-Williams, the Bureau of Reclamation, the Wyoming Recreation Commission and its new State Archeologist, Mark Miller, for supporting the research at the McKean site. Eric Ingbar read an initial draft of this paper at the Plains Conference in 1984 and provided criticism and advice for our analysis. Larry Todd provided several ideas during the McKean project, some of which were touched on in this paper. Bill Fawcett read a draft of this paper and contributed constructive criticism forcing us to clarify several obscure statements. We also could not have completed this analysis without the help of the 1984 field crew and many volunteers who provided the initial hard labor. Any errors in the analysis and interpretation are of course our own.

REFERENCES CITED

Binford, Lewis R.
1983 In pursuit of the past. Thames and Hudson, London.

Enloe, Jim
1983 Site structure, A methodological approach to analysis. Hilaksa'i: UNM Contributions to Anthropology 2:28-39, Albuquerque.

Frison, George C.
1978 Prehistoric hunters of the High Plains. Academic, New York.

Ingbar, Eric
1985 Chipped stone assemblages from the McKean site (48CK7) as indicators of

settlement and subsistence patterns. In McKean/Middle Plains Archaic: Current research, edited by Marcel Kornfeld and Lawrence C. Todd. Occasional Papers on Wyoming Archaeology 4:87-94.

Ingbar, Eric, Dave J. Rapson, and Lawrence C. Todd
1983 Middle Plains Archaic lithic technology and adaptation: The McKean site, 1956 to 1985. In Archaeological investigations at 48CK7, the McKean site: Preliminary report. Compiled by Marcel Kornfeld and George C. Frison, pp. 29-41. Prepared by the Department of Anthropology, University of Wyoming, Laramie. Report prepared for the Bureau of Reclamation, Billings, Montana Office.

Kornfeld, Marcel
1983 McKean site: A 1983 perspective. In Archaeological investigations at 48CK7, the McKean site: Preliminary report. Compiled by Marcel Kornfeld and George C. Frison, pp. 2-19. Prepared by the Department of Anthropology, University of Wyoming, Laramie. Report prepared for the Bureau of Reclamation, Billings, Montana Office.

Kornfeld, Marcel and George C. Frison
1985 McKean site: A 1983 preliminary analysis. In McKean-Middle Plains Archaic: Current research, edited by M. Kornfeld and L. C. Todd, Occasional Papers in Wyoming Archeology 4:31-44.

Lee, Richard B.
1979 The !Kung San. Cambridge University Press, London.

Mulloy, William
1954 The McKean site in northeastern Wyoming. Southwestern Journal of Anthropology 10:432-460.

Parry, William J. and John D. Speth
1984 The Garnsey site campsite: Late Prehistoric occupation in southeastern New Mexico. Museum of Anthropology, University of Michigan Technical Reports 15.

Price, T. Douglas and James A. Brown
1985 Prehistoric hunter-gatherers: The emergence of cultural complexity. Academic, New York.

Reher, Charles A.
1985 Patterns of lithic source utilization at the McKean site, 48CK7. In McKean-Middle Plains Archaic: Current perspectives, edited by M. Kornfeld and L.C. Todd. Occasional Papers on Wyoming Archaeology 4:95-103.

Reider, Richard G.
1985 Soil formation at the McKean archaeological site, northeastern Wyoming. In McKean-Middle

Plains Archaic: Current perspectives, edited by M. Kornfeld and L.C. Todd. Occasional Papers on Wyoming Archaeology 4:51-61.

Tanaka, Jiro
1980 The San. University of Tokyo Press, Tokyo.

Marcel Kornfeld
Department of Anthropology
University of Massachusetts
Amherst, Massachusetts

M. L. Larson
Department of Anthropology
University of California
Santa Barbara, California

PRELIMINARY INVESTIGATIONS AT THE SEMINOE BEACH SITE, CARBON COUNTY, WYOMING

MARK E. MILLER

ABSTRACT

The Seminoe Beach site contains surface evidence of intermittent human occupation in the western Hanna Basin for the past 10,000 years. Initial research has attempted both to delineate the natural and cultural stratigraphy of the site, and to evaluate its relationship to the depositional history of the Ferris-Seminoe dune field in which the site is located. Efforts have been hampered by the fluctuating level of Seminoe Reservoir and attendant impacts. Nonetheless, some observations and tentative conclusions are possible regarding the site's contribution to our understanding of the region's prehistory.

INTRODUCTION

The Seminoe Beach site (48CR1166) is located at the eastern edge of the Ferris-Seminoe Dune Field in the semi-arid Hanna Basin of southcentral Wyoming (Figure 1). This region is characterized by a broad expanse of stabilized sand traversed by several parabolic dunes. Most areas of dormant dunes have passed through multiple stages of plant succession (cf. Chadwick and Dalke 1965), and are anchored by sagebrush steppe vegetation. Silver sagebrush (*Artemisia cana*), big sagebrush (*Artemisia tridentata*), rubber rabbitbrush (*Chrysothamnus nauseosus*) or threadleaf sedge (*Carex filifolia*) may dominate the community depending in part on soil depth. Cultural remains at the site became exposed along the Seminoe Reservoir backwaters by repeated wave action and wind erosion following the completion of Seminoe Dam in the late 1930s. A local amateur collected several Hell Gap artifacts on the beach in 1969 and reported his discovery to this writer in 1980. The research potential of the site and ongoing impacts to the locality prompted the test excavations reported here.

Two principal research goals directed the initial investigations. First, we attempted to determine if the site contained direct evidence for the manufacturing stages of Hell Gap projectile point production. Second, data recovery was designed to assist in paleoenvironmental reconstruction of the site setting and the Ferris-Seminoe Dune Field. These goals were only partially fulfilled by the testing program, but new re-

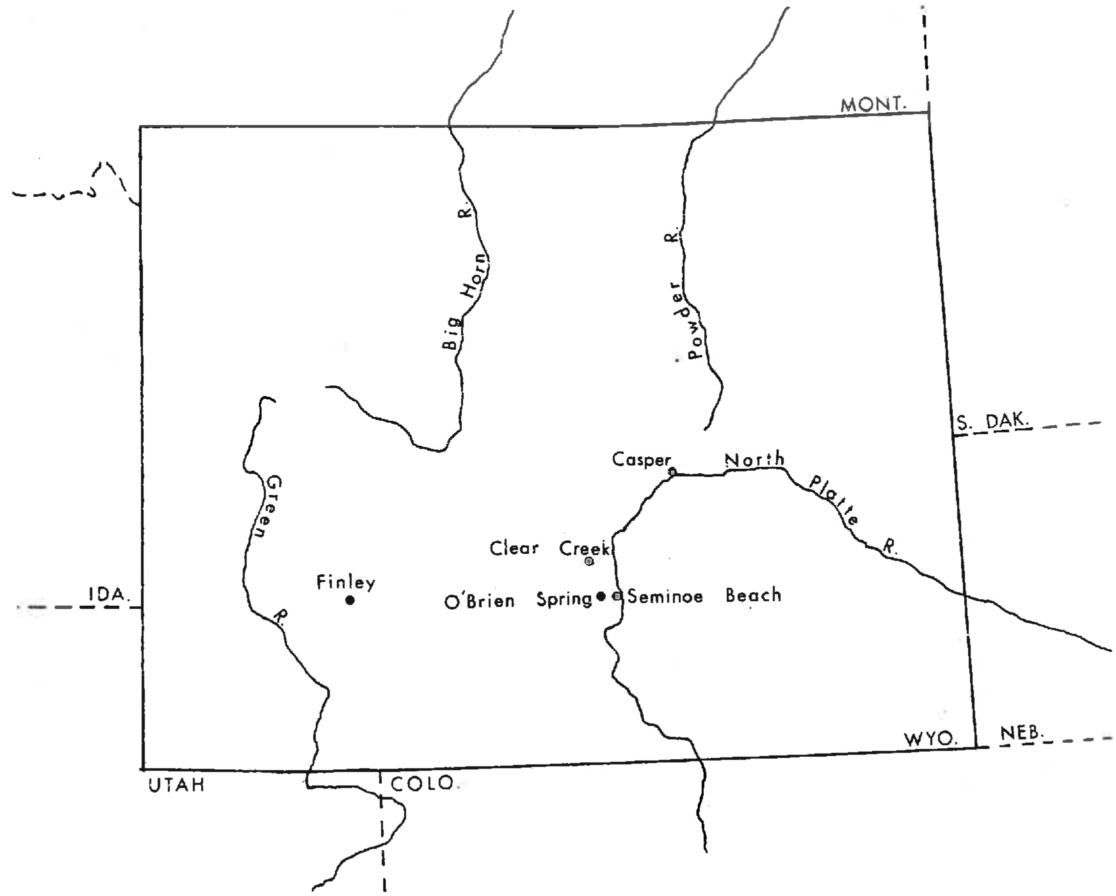


FIGURE 1: Location of archaeological sites and stratigraphic localities mentioned in text.

search directions have evolved.

THE SURFACE ARTIFACT ASSEMBLAGE

At least four amateur archaeologists have collected chipped stone artifacts from the surface of the Seminoe Beach site. These artifacts normally are exposed and subsequently displaced during periods of beach erosion, so none have been found in datable contexts. However, projectile points were crossdated with known assemblages from other sites, and some of the weaponry is characteristic of Paleoindian (ca. 11,500-7,500 B.P.), Early Plains Archaic (ca. 7,800-4,500 B.P.), Late Plains Archaic (ca. 3,200-1,500 B.P.) and Late Prehistoric (ca. 1,800-200 B.P.) types (see Frison 1978:83 for chronology).

Six whole and fragmentary Hell Gap projectile points from amateur collections were available for this study (e.g., Figure 2c,d). Most of these are made from a medium-grained quartzite which occurs as cobbles in nearby Pleistocene terraces. Similar artifact types are present in Paleoindian assemblages dating about 10,000 years ago (Frison 1978). The Casper site (Frison 1974), Jones-Miller (Stanford 1978), Hell Gap (Irwin-Williams et al. 1973), Sister's Hill (Agogino and Galloway 1965) and Agate Basin (Frison and

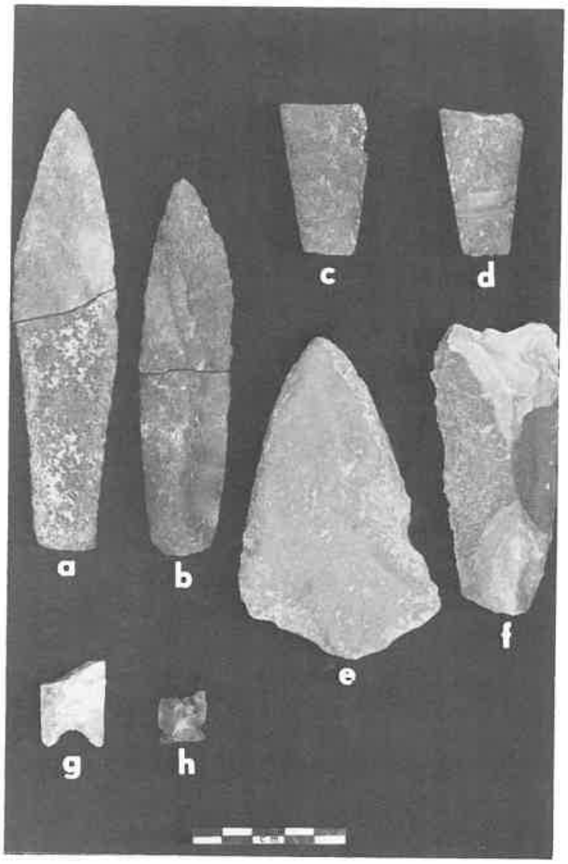


FIGURE 2: Artifacts from Seminoe Beach site. a: final stage Hell Gap preform; b: late stage Hell Gap preform; c,d: Hell Gap projectile point bases; e,f: flake tools; g: James Allen projectile point base; h: possible Early Plains Archaic projectile point base.

Stanford 1982) contain some of the best known Hell Gap components on the High Plains.

Twenty-one quartzite bifaces and biface fragments from one area of the site are believed to represent various stages of Hell Gap projectile point manufacture (Miller 1985). All specimens apparently were broken during manufacture. Thinning and shaping on some indicate advanced stages of production (e.g., Figure 2a, b). One is clearly Hell Gap in shape and represents a final stage preform that broke during an attempted removal of a step fracture (Figure 2a).

Sixty-one quartzite flakes also have been recovered from this same area. Most are debitage from biface manufacture, and are believed to be the product of Hell Gap projectile point production since they are made from the same raw material. Some flakes were made into tools (e.g., Figure 2 e,f), but only nonutilized flakes are present in the University of Wyoming sample.

Two projectile point bases are similar to those described from the James Allen site by Mulloy (1959). One of these (Figure 2g) is curated at the University of Wyoming. James Allen projectile points date between 7900-8000 B.P. at the type site (cf. Mulloy 1959, Frison 1978).

One side-notched projectile in the University collection may be Early Plains Archaic in age (Figure 2h). It was collected on a compacted beach surface littered with fire-cracked cobbles and carbonized root tubules. Other side-notched points have been recovered by amateurs in the same area. Apparently, the reservoir destroyed a significant portion of an Early Plains Archaic component. No McKean artifacts are known to have been collected at the site, but large corner-notched points reminiscent of the Late Plains Archaic commonly occur along the backwaters. One Late Prehistoric side-notched point from the site is curated at the University.

A distinctive characteristic of the raw materials used for projectile points at the site is that medium-grained quartzite occurs almost exclusively in the Hell Gap assemblage. Later projectile points are made from a greater variety of materials including quartzite, chert and chalcedony, all of which could have been procured from local terrace gravels.

TEST EXCAVATIONS

Five excavation units were opened at the Seminoe Beach site. Four were hand excavated tests and one was a backhoe trench (Figure 3). Test units one and four exposed buried cultural remains which are described here. Test units two, three and the backhoe trench were excavated primarily to reveal the depositional history of the site, discussed in a later section. No intact, cultural components were found in these last three areas.

TEST UNIT 1

Most of the overburden in test unit 1 was removed by a backhoe. Excavations in a gridded area of approximately 3.8 square meters exposed a buried cultural level that had been eroding from the cut bank of a stabilized dune (Figures 4, 5). No diagnostic artifacts were discovered on this surface, but at least two features and an oxidized sandstone scatter were found.

Feature one is the remnant of a basin shaped fire pit partially filled with fractured pieces of oxidized sandstone. Feature two is a circular concentration of charcoal stained sand that extends into the unexcavated portion of the dune. The rest of the level consists of diffuse organic stain, sparse charcoal flecks, oxidized sandstone fragments, eight nonutilized flakes, occasional fragments of unidentified burned bone and a fractured quartz river cobble.

Carbonates have accumulated on the lower surface of many of the specimens, just as they have on the Hell Gap artifacts found on the exposed surface of the site. This

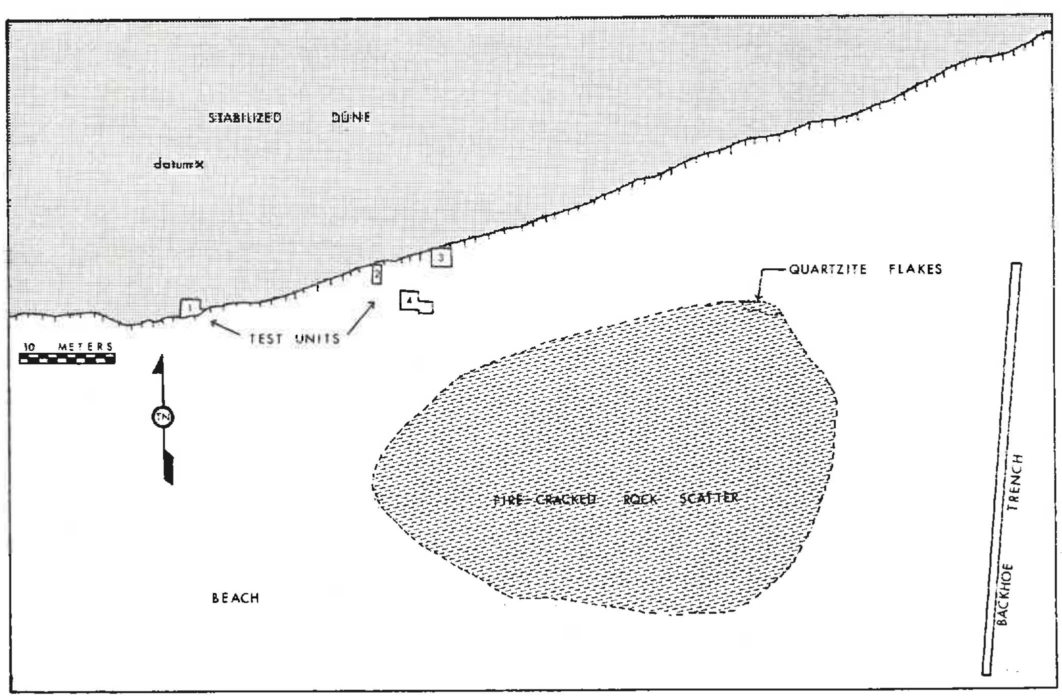


FIGURE 3: Excavated areas and distribution of surface evidence at Seminoe Beach site.

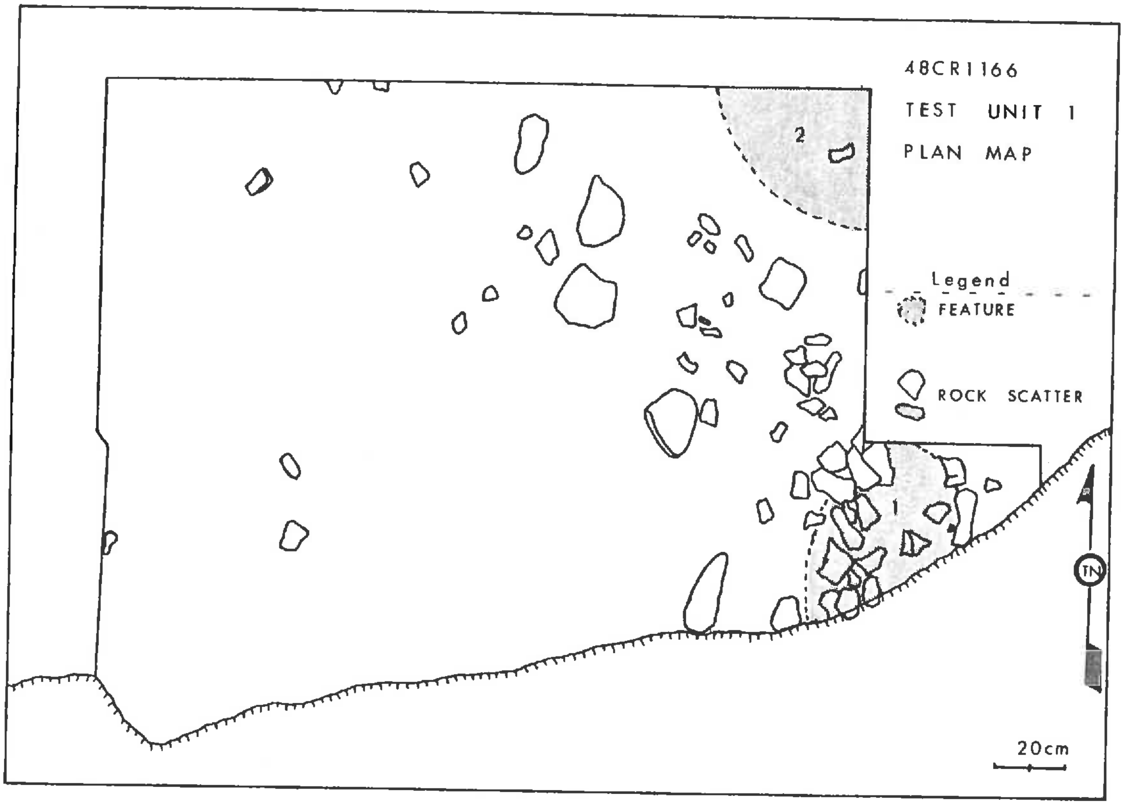


FIGURE 4: Plan map of features and burned rock scatter in Test Unit 1.

component did not yield an adequate sample of charcoal for radiometric dating, but its stratigraphic position suggests a post-Altithermal age.

Charred pieces of cottonwood (Populus sp.) and big sagebrush were identified from flotation samples collected in test unit 1. The nearest source of cottonwood probably was the banks of the North Platte River approximately 1.5 kilometers east, which now are inundated by Seminoe Reservoir. No evidence for seeds or other edible plant resources was detected (Dueholm 1985).

TEST UNIT 4

Beach erosion during the summer of 1983 uncovered a shallow fire pit near Hell Gap artifacts discovered by an amateur in 1982. The feature was buried again in the fall of 1983 by eolian sediments. Approximately five square meters were excavated in 1984 in an attempt to relocate and date the fire pit. When exposed, the feature appeared to have been dug through the lower portion of a limonitic, stained sand and into a gray, sandy clay. The contact between the stained sand and the sandy clay is the same zone that is thought to have produced some of the Hell Gap materials, based on information from surface collectors.

No diagnostic artifacts were found in the test unit, but five fire fractured rocks were located on the surface around the fire pit. Five nonutilized flakes were recovered from the fill of the feature and from the area around it. The flakes were made from chalcedony,

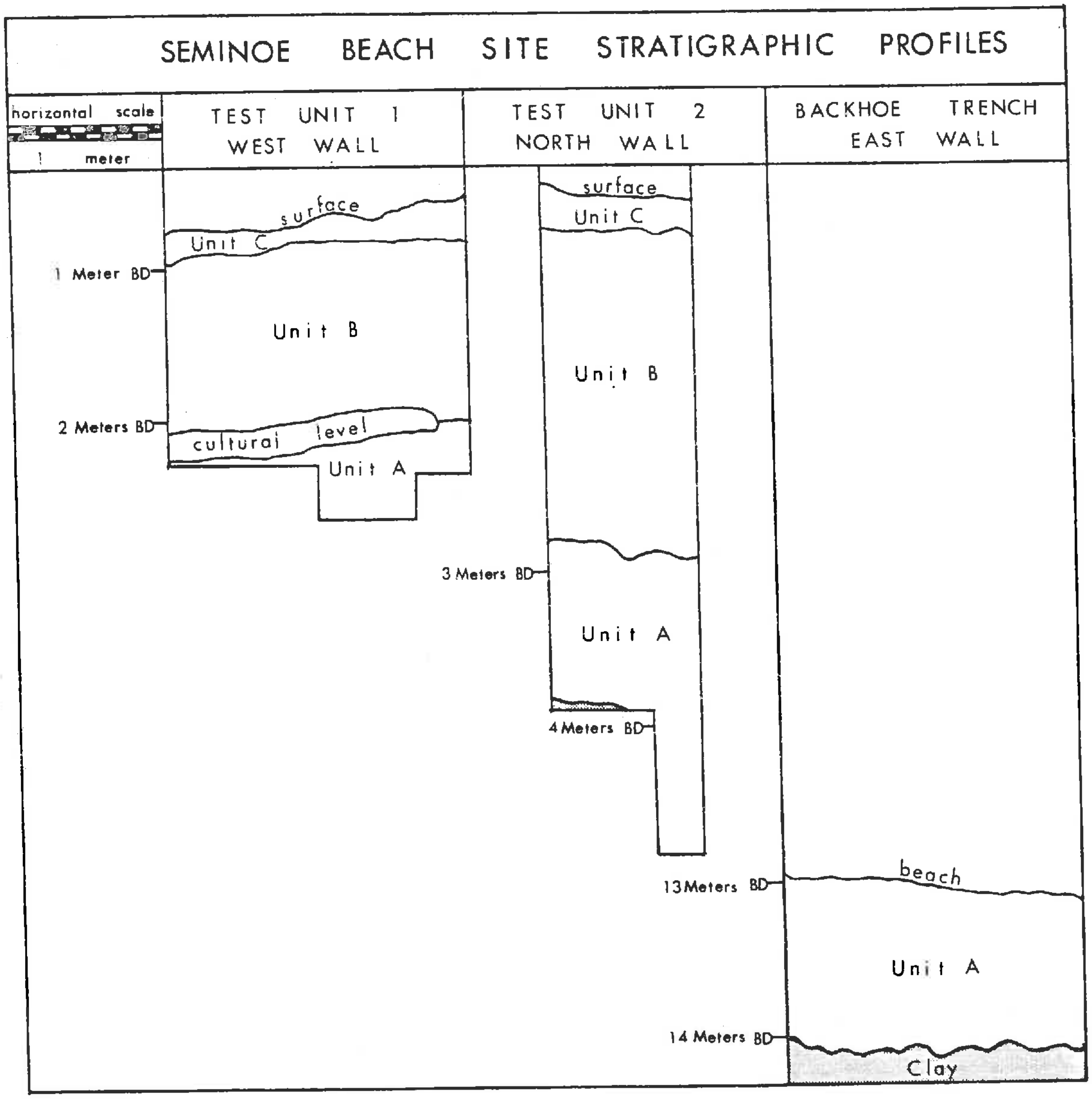


FIGURE 5: Stratigraphic profiles from three excavated areas.

chert and quartzite. Debitage within the feature was fire blackened.

The basin shaped feature was partially truncated by wave action, but it did yield sufficient charcoal for a radiocarbon date. An age of 5,360±170 years: 3410 B.C. (RL-1881, MASCA corrected to 4220 B.C.±210) was obtained. Locally available greasewood (Sarcobatus vermiculatus) and big sagebrush had been burned as fuel in the fire pit. Several other deflated features and oxidized sandstone scatters occur on a compacted surface near this feature, and may be contemporary with it.

SITE STRATIGRAPHY

Three stratigraphic profiles illustrate the postulated depositional and pedogenic history of the

Seminoe Beach site (Figure 5). Four lithological units are present. The oldest unit is an exposure of upper Cretaceous Lewis Shale. Three unconsolidated, eolian sand deposits overly the bedrock, and are labeled A, B, and C from the oldest to most recent. Microstratigraphic analysis has not yet been conducted to determine whether these units represent dune or interdune deposits. But, based on a brief survey of surface dune morphology and cut bank exposures, there appears to be one stabilized, dune remnant (Unit B) superimposed over another (Unit A). A buried, vegetated surface separates the two along portions of the cut bank, although it cannot be traced along the entire exposure.

The bedrock unit is weathering in place and forms an old land surface at the base of the dune deposits. This undulating, clayey surface slopes down nearly 10 meters from northwest to southeast in the area between the first test unit and the backhoe trench. Texture grades from a gray clay nearest the bedrock, to a sandy clay with numerous shaley inclusions above. The sandy clay probably derives some of its character from overlying eolian deposits, as well as from the shaley bedrock. The boundary between bedrock and clay is abrupt, whereas the boundary between the sandy clay and overlying sands is more transitional. Thickness of the clay above bedrock varies from a few centimeters in portions of the backhoe trench to over a meter in Test Unit 2.

Unit A is the remnant of a thick eolian sand that grades from medium-grained texture in the lower portion to fine-grained sands near the top, with some low angle cross-bedding. It is unknown whether this change in texture represents a depositional break, fluctuating wind velocity or some other paleoenvironmental factor. Calcium carbonate precipitates are present throughout the upper portion, and these can be classified as a Bkb horizon following current Soil Conservation Service nomenclature (see Bettis 1984). Limonitic, rust-colored staining occurs in the lower portion of the unit overlying black, manganese oxides and other low chroma mottles. Together, these constitute a gleyed (Bgb) horizon.

We suspected that the gleying was produced by variable levels in the reservoir, until similar staining was found in a parabolic dune approximately two kilometers to the west and over 20 meters above the highest reservoir elevation. This paleosol may have formed from fluctuating water levels in ancient, interdunal ponds. But this is highly conjectural since no pond deposits have been found at the site.

The relationship between gleying and the depositional history of Unit A is not completely understood. Detailed stratigraphic and pedological analysis is necessary to obtain a more complete picture.

Exposures of Unit A suggest the presence of a composite soil. One surface exposed area consists of a compacted, oxidized sand which is more resistant to erosion than surrounding eolian deposits. This surface is littered with calcified root tubules that apparently were redeposited from an overlying facies. The tubules suggest that a portion of the unit was once vegetated. In one area the oxidized surface is covered with fire-cracked rock and other cultural debris that may be contemporary with the Early Plains Archaic fire pit.

The occurrence of diagnostic, Paleoindian artifacts and an Early Plains Archaic fire pit on the oxidized surface suggests several possibilities. There may have been a 5,000 year period of dune stability between these occupational episodes, although this is unlikely for an eolian environment in this region during the Altithermal. Alternatively, a Holocene erosional cycle may have exposed an old, buried surface containing the Paleoindian component before Early Plains Archaic settlement. Here, the oxidized zone may still contain an intact Paleoindian component if remnants exist beneath the stabilized dune. A third possibility is that the Hell Gap materials eroded from an upslope portion of the gray clay surface and redeposited onto the oxidized sand below. Only additional work at the site may clarify the relationship between natural and cultural stratigraphy in this area.

A second cultural level is exposed at the top of Unit A above the densest, most compact carbonates, and it probably postdates the lower level containing mixed cultural components. Present evidence does not demonstrate whether the dune was stabilized or active during this occupation. However, the organic staining and dispersed charcoal flecks from this level can be traced along the cut bank profile at nearly the same stratigraphic position as the buried, vegetated surface mentioned earlier.

A fire pit from 48CR1420 (Miller 1980) about a kilometer away occurs in a similar stratigraphic and pedologic context to the upper cultural level at the Seminoe Beach site. Both occupations may be contemporary. The feature at 48CR1420 produced a radiocarbon age of 840±110 years: A.D. 1110 (RL-1381, MASCA corrected to A.D. 1130±110).

Unit B is a fine-grained eolian sand containing low angle cross-bedding and soil development, but no cultural evidence. It lies directly over the uppermost cultural level at the site and seems to rest conformably on Unit A. However, if the buried, vegetated surface exposed in the cut bank proves to separate these two units, then an unconformity would exist along portions of the profile. Calcium carbonate precipitates are present in the lower portion of the unit. The upper segment is characterized by a developing humic A horizon in the root zone of the present stabilized dune. Similar dune sands and soil development occur in several areas throughout the Seminoe-Ferris Dune Field.

Unit C is a fine-grained, eolian coversand principally derived from the loose sediments along the reservoir beach. Consequently, the deposit is less than 50 years old. It occurs sporadically over the surface of the stabilized dune where it has been anchored by vegetation.

CORRELATING SAND DUNE STRATIGRAPHY

Ahlbrandt and others (1983) recently have summarized the history of dune formation in Wyoming and adjacent areas. They distinguish four phases of dune activity that extend back to the early Holocene (ca. 10,000 B.P.). Their dune phases are compared tentatively with stratigraphic sequences from several localities in Wyoming (Figure 6).

The depositional and erosional events at these localities do not necessarily correlate with each other. One or two site specific stratigraphic sequences are too small of a sample to reflect the entire history of dune field formation, particularly when analysis is

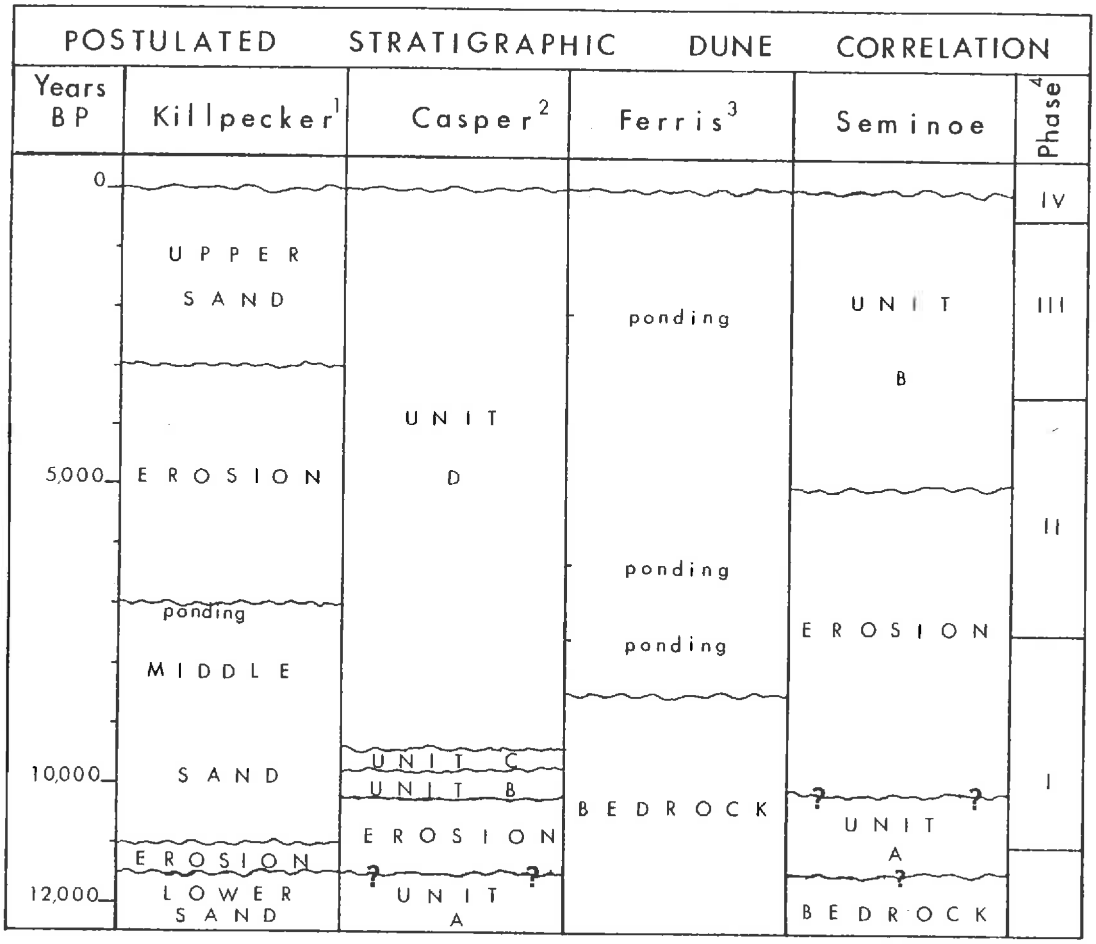


FIGURE 6: Comparison of dune formation events at four Wyoming localities. 1 = Ahlbrandt 1974; 2 = Albanese 1974; 3 = Gaylord 1982; 4 = Ahlbradt et al. 1983.

restricted to a small portion of the entire field. Multiple profiles are needed from throughout each dune field, and they should include distinctive stratigraphic markers as well as diagnostic artifact technofacies. Consequently, the stratigraphic comparisons and chronological organization offered here must be used with caution.

Ahlbrandt and others (1983: 379) argue that no direct evidence currently exists for late Pleistocene dunes in Wyoming. However, they do recognize that the Lower Sand unit at the Finley site (Moss et al. 1951, Ahlbrandt 1974) may be an exception. This pale green unit formed in a reducing atmosphere which may reflect the colder late Pleistocene climate (Ahlbrandt et al. 1983:386). However, too little is known about the depositional environment and the absolute age of the unit to make a positive determination.

Other Wyoming evidence also may indicate late Pleistocene eolian activity. Albanese (1974) argues that the 10,000 year old Casper site occurs in the trough of a parabolic dune. This is a minimum age for the formation of this topographic feature. If the ancient parabolic dune formed by a growing blowout on a stabilized sand surface, as many similar features do today (see Flint 1971:246), then the inception of eolian deposition at Casper may be much older than 10,000 years.

The Hell Gap artifacts eroding from the Seminoe Beach site are the earliest artifacts recorded from the Ferris-Seminoe Dune Field. If these implements can be found in place resting on eolian deposits, they might indicate a minimum age of 10,000 years for dune activity at the site.

Gaylord's (1982) chronology for the Ferris portion of the field is based on radiocarbon dates and dune migration rates, and it suggests that eolian activity may not have begun until about 10,330 B.P. This date refers to the inception of eolian sands at the eastern edge of the Battle Spring Basin, and not to the actual deposition of sediments at his study site on Clear Creek 38 kilometers away. Since the Seminoe Beach site is approximately 55 kilometers from the Battle Spring Basin, one might expect that eolian deposition would be later than at Clear Creek if the sands derive from the same source. If the source is the same, and if Gaylord's (1982) reconstruction is accurate, then sand might not have deposited at Seminoe Beach by 10,000 B.P. Obviously, source analysis needs to be conducted at the Seminoe Beach site.

Intact Clovis and Folsom sites have not been recorded for Wyoming's dune field environments. Isolated finds of Folsom are known from some blowout areas (e.g., Moss et al. 1951), but present evidence does not demonstrate contemporaneity with dune formation before 10,000 B.P.

Ahlbrandt et al. (1983) recognize a brief pluvial period following Phase I dune formation. This episode of increased effective moisture may correspond with the ponding associated with Cody Complex artifacts at the Finley site (Moss et al. 1951, Ahlbrandt 1974: 53), the ponding overlying the Hell Gap materials at the Casper site (Albanese 1974) and Gaylord's (1982) pre-Altithermal ponding at the Clear Creek locality in the Ferris dunes. No ponding was observed at the Seminoe Beach site, but there is evidence for a fluctuating water table. Pond sediments, if they existed at all, may have been removed by erosion following Hell Gap occupation at the site.

Preliminary research at the O'Brien Spring site (48CR29) several miles west of Seminoe Reservoir may help clarify the paleoenvironmental history of the Ferris-Seminoe Dune Field. An ancient pond deposit and evidence for a fluctuating water table are present. This site contains a buried, organic stained paleosol exposed in the bank of a dry tributary arroyo above the present water table. Post-Altithermal cultural material is associated with the modern spring channel. At some time, the water table apparently dropped, the spring outlet migrated, and the new stream channel truncated the older tributary.

Pollen analysis at O'Brien Spring indicates a change from moist to drier conditions between the time the ancient spring sediments were deposited and the present (Beiswenger 1984). These sediments contain less than 2% pine (<u>Pinus</u>), 30% sagebrush (<u>Artemisia</u>), 40% Chenopodiaceae-Amaranthacea and less than 2% greasewood (<u>Sarcobatus</u>). A surface pollen sample collected above the ancient spring contains 8% <u>Pinus</u>, 21% <u>Artemisia</u>, 50% Chenopodiceae-Amaranthaceae, and 19% <u>Sarcobatus</u>. Eventually, analysis of the pollen deposited in the contemporary spring sediments may aid in further paleoenvironmental reconstruction at the site. A radiocarbon date has not been obtained for the buried spring deposit, but it likely predates the Altithermal. Artifacts reportedly have been found in the ancient spring area, but the author has not yet seen any specimens.

Evanoff (personal communication 1983) identified several aquatic snails from the ancient spring deposit as Stagnicola elodes. This species is widespread in the Rocky Mountain area and commonly occurs in interdunal ponds in the Ferris-Seminoe Dune Field. The same species also occurs along the shoreline of Seminoe Reservoir near the Seminoe Beach site, where the snails may derive from the reservoir itself.

Phase II dune formation is associated with Altithermal aridity (Ahlbrandt et al. 1983:387). Considerable eolian activity may have occurred during this phase. Erosion in the western portion of the Killpecker dunes increased eolian deposition downwind (Ahlbrandt et al. 1983). The Killpecker tail sands contributed some source material to the deposits in the Ferris dunes, where most of the deposition occurred under dry climatic conditions between 7,660 B.P. and 6,460 B.P. (Gaylord 1982). Eolian transport of sands in the dune field at the Casper site (Albanese 1974) also may have increased during the Altithermal. As mentioned earlier, there appears to be a stratigraphic hiatus at the Seminoe Beach site between 10,000 and 5,360 years ago that may have been caused by wind erosion. Until Hell Gap artifacts are found in place and in datable context, the record of this period will remain unclear. At any rate, eolian deposition buried the site following 5,360 B.P.

Even if dry Altithermal conditions increased dune movement in the Seminoe Beach area, aridity did not reduce the North Platte River volume enough to allow the dune field to establish itself across the river. Apparently, the river continued to remove eolian sands as suspended sediment and bedload even during prolonged droughts. This raises some interesting implications about the regional environment during the Altithermal. The area may not have been as arid as we originally anticipated. If adequate levels of stream flow were maintained during this period, then the area might have been more attractive for human occupation, and less likely to be abandoned in favor of higher elevations.

Phase III dune formation postdates the Altithermal and Phase IV represents recent dune formation following the last few hundred years. Immature soils are forming in presently stabilized dunes in the Killpecker, Casper and Ferris-Seminoe systems and modern ponding is present in several locations.

SUMMARY AND CONCLUSIONS

Preliminary investigations at the Seminoe Beach site were not as conclusive as hoped, and neither research goal was completely achieved. Hell Gap artifacts were not found in place and only tentative correlations of dune field stratigraphy and paleoenvironmental conditions were possible. Nonetheless, the site has contributed to our knowledge of Hanna Basin prehistory and has demonstrated considerable research potential. Evidence for Early Plains Archaic occupation of Wyoming's intermountain basins has expanded considerably in recent years (Creasman 1983, Miller 1984, McGuire 1984, Eakin 1984), and the radiocarbon date from the Seminoe Beach site adds to this data base.

The artifact assemblage from the site is significant for several reasons. Several Hell Gap projectile point production stages are represented, and are made from a quartzite that was likely quarried from nearby Pleistocene river gravels. Nonutilized bifaces were broken during manufacture, which argues that weapon production was taking place on site. The site is one of the best candidates we have at present for a Hell Gap projectile point production sequence. In addition, the presence of James Allen projectile points also is notable because the geographic distribution and temporal span of this Paleoindian manifestation is still poorly known.

Altithermal climatic conditions may have precipitated local shifts in settlement pattern and economic orientation rather than a regionwide abandonment of semi-arid basin environments. The fact that occupations were present in dune environments during the late Altithermal suggests that there were episodes of reduced dune activity that made settlement more attractive, and possibly that dune settings were specifically sought out by the inhabitants.

The paleoenvironmental record is largely incomplete for the Seminoe dunes. Some of the evidence from the Seminoe Beach site is comparable to Gaylord's (1982) reconstruction from the Clear Creek area in the Ferris dunes, and to other depositional sequences (see Figure 1). Dating resolution of the dune history is still poorly developed. Evidence from other localities, such as O'Brien Spring, eventually may help fill some of the gaps in the record from the Seminoe Beach site.

ACKNOWLEDGMENTS

I want to thank Rogers Duthie of Rawlins for reporting the site location, and the Bureau of Reclamation for permitting test excavations. Several individuals interested in Wyoming archaeology assisted in various tasks during fieldwork. Among these were John and Evelyn Albanese, George and Mary Brox, Rogers Duthie, Jim and Mike Farver, Ross and Cheryl Hilman, Dave McGuire, Bill J. Scoggin, William E. Scoggin, and Sean Scoggin. John Albanese provided insights concerning the geology of the site. Bud Paris operated the backhoe. Mariah Associates, Inc. allowed the use of their antiquities permit for the initial research and provided much of the field equipment. The University of Wyoming provided space during analysis and report preparation. I gratefully acknowledge the Wyoming Archaeological Foundation for funding these preliminary investigations and the Wyoming Recreation Commission for their financial support during the preparation of this report. The two anonymous reviewers provided valuable suggestions that helped me revise and improve an earlier version of the manuscript. Any errors or omissions are solely the responsibility of the author.

REFERENCES CITED

Agogino, George A. and Eugene Galloway
1965 The Sister's Hill site: A Hell Gap site in north-central Wyoming. Plains Anthropologist

10:190-195.

Ahlbrandt, Thomas S.
1974 Dune stratigraphy, archaeology, and the chronology of the Killpecker Dune Field. in Applied Geology and Archaeology: The Holocene History of Wyoming, edited by Michael Wilson, The Geological Survey of Wyoming, Reports of Investigations 10:51-60.

Ahlbrandt, Thomas S., James B. Swinehart and David G. Maroney
1983 The dynamic Holocene dune fields of the Great Plains and Rocky Mountain basins, U.S.A. In Eolian Sediments and Processes, edited by M.E. Brookfield and Thomas S. Ahlbrandt, pp. 379-406, Elsevier Science Publishers B.V., Amsterdam.

Albanese, John
1974 Geology of the Casper archaeological site. In The Casper Site: A Hell Gap Bison Kill on the High Plains, edited by George C. Frison, pp. 173-190. Academic Press, Inc.

Beiswenger, Jane
1984 Pollen analysis of O'Brien Spring sediment. Ms. on file, Department of Anthropology, University of Wyoming, Laramie.

Bettis, E. Arthur III
1984 New conventions for the designation of soil horizons and layers. Plains Anthropologist 29:57-59.

Chadwick, Howard W. and Paul D. Dalke
1965 Plant succession of dune sands in Fremont County, Idaho. Ecology 46:765-780.

Creasman, Steven D.
1983 The Altithermal: Paleoenvironmental reconstruction and subsistence change in southwest Wyoming. Paper presented at the 41st Plains Conference, Rapid City, South Dakota.

Dueholm, Keith H.
1985 Botanical analysis of flotation samples from 48CR1166. Ms. on file, Wyoming State Archaeologist's Office, Department of Anthropology, University of Wyoming, Laramie.

Eakin, Daniel H.
1984 The Split Rock Ranch site: A possible Early Plains Archaic pithouse site from Fremont County, Wyoming. Paper presented at the 42nd Plains Conference, Lincoln, Nebraska.

Flint, Richard Foster
1971 Glacial and Quaternary Geology. John Wiley and Sons, Inc.

Frison, George C. (editor)
1974 The Casper site: A Hell Gap Bison kill on the High Plains. Academic Press, New York.

Frison, George C.
1978 Prehistoric hunters of

the High Plains. Academic Press, Inc.

Frison, George C. and Dennis J. Stanford
1982 The Agate Basin site: A record of the Paleoindian occupation of the northwestern High Plains. Academic Press, Inc.

Gaylord, David R.
1982 Geologic history of the Ferris Dune Field, south-central Wyoming. In Interpretation of windflow characteristics from eolian landforms, edited by Ronald W. Marrs and Kenneth E. Kolm, The Geological Society of America, Special Paper 192:65-82.

Irwin-Williams, Cynthia, Henry Irwin, George Agogino, and C. Vance Haynes
1973 Hell Gap: Paleo-indian occupation on the High Plains. Plains Anthropologist 18:40-53.

McGuire, David J.
1984 An Early Archaic pit-house structure in the Hanna Basin, southcentral Wyoming. Paper presented at the 49th annual meeting of the Society for American Archaeology, Portland, Oregon.

Miller, Mark E.
1980 Archaeological investigations at site 48CR1420 along Seminoe Reservoir in south-central Wyoming. Ms. on file, Wyoming State Archaeologist's Office, Department of Anthropology, University of Wyoming, Laramie.

1984 Early Plains Archaic occupation in the Hanna Basin, Wyoming. Paper presented at the 49th annual meeting of the Society for American Archaeology, Portland, Oregon.

1985 Manufacturing Technology of Hell Gap Projectile Points at the Seminoe Beach Site in Wyoming. Ms. on file, Wyoming State Archaeologist's Office, Department of Anthropology, University of Wyoming, Laramie.

Moss, John H., in collaboration with Kirk Bryan, G. William Holmes, Linton Satterthwaite, Jr., Henry P. Hansen, C. Bertrand Schultz and W. D. Frankforter
1951 Early Man in the Eden Valley. University of Pennsylvania, Museum Monographs No. 6.

Mulloy, William T.
1959 The James Allen site near Laramie, Wyoming. American Antiquity 25:112-116.

Stanford, Dennis
1978 The Jones-Miller site: An example of Hell Gap Bison procurement strategy. In Bison procurement and utilization: A symposium, edited by Leslie B. Davis and Michael Wilson, Plains Anthropologist Memoir 14:90-97.

Mark E. Miller
Wyoming State Archaeologist's Office
Department of Anthropology
University of Wyoming
Laramie, Wyoming

ANALYSIS OF SHELLWORKING TRACES ON EXPERIMENTAL AND ARCHAEOLOGICAL BLADELET DRILLS

ROBERT R. PETERSON, JR.

ABSTRACT

High magnification microwear analysis was used to test the hypothesis that small bladelet drills found in some California archaeological sites were used in the manufacture of shell beads. Similar tools were produced by the author and used to drill several types of shell as well as other materials. Comparison of microwear traces on the experimental tools with those on archaeological specimens confirmed that the latter had been used to drill shell objects. Some variation in the types of objects produced could also be inferred, based on the location of the polish.

INTRODUCTION

Worked shell comprises an important class of aboriginal artifact in California. From the beginnings of systematic archaeological research in this area, shell beads, ornaments and implements have been recognized as both time markers and indicators of social complexity. Recent work (King 1981; Arnold 1983) has focused on the function of beads and ornaments in the establishment and maintenance of social order in Chumash society and the dynamics of production and distribution of bladelets used in the manufacture of shell artifacts.

The working of shell required a suite of specialized tools, the most commonly encountered of which have been small bladelet drills. The morphology of these tools left little doubt that they functioned as drills, but examination of macroscopic wear patterns provided little additional information. The development of high magnification microwear analysis (Semenov 1964; Keeley 1980; Keeley and Newcomer 1977) provided a means to obtain additional information about the use of these tools. The generally held assumption was confirmed that these were bead working tools by determining the material on which the drills were used. The tools investigated were a suite of experimentally produced scrapers, saws, and drills and a sample of drills from two archaeological sites on Santa Cruz Island, California.

The primary purpose of the research discussed here was to obtain information which could help to identify tools used for shellworking. This required information on the types of evidence left on such tools and on the way shell-working traces developed. The paper will mainly discuss shell microwear traces and shellworking implements, although tools used on other types of materials were examined for comparison. In addition, Keeley (1980) provides considerable documentation of microwear traces left by materials other than shell.

TECHNOLOGY OF SHELLWORKING

There is a great variety of worked shell objects in California archaeological collections. This variety makes possible somewhat more detailed types of analysis than simply identification of worked material. This analysis is dependent on knowledge of some of the technology which went into the production of these artifacts.

SHELL ARTIFACTS

Rectangular drilled beads of _Olivella biplicata_, _Haliotis_ sp., and _Mytilus californianus_ appear as early as 6000 B.C., in the Early Period, along with spire and base ground _Olivella_ shells (King 1981: 46-53). From this time on, the number and variety of shell artifacts increases and many types of shell ornaments form useful time markers for the Channel region. Twenty-one types of shell are listed by King (1981:170) as having been commonly used in bead and ornament manufacture. Techniques used to make these artifacts include chipping, abrading, punching, drilling, and incising. Before the contact period, nearly all these activities were performed using stone tools, including various types of abraders, burins, saws, and drills.

Marine shells vary widely in their overall size, shape, thickness, surface characteristics, and hardness, and so are suitable for production of many different artifact types. A few of the shell artifacts commonly encountered in California are illustrated here (Figure 1). They range from small olive shell (_Olivella biplicata_) wall or cup disks to large Pismo clam (_Tivella stultorum_) tube beads or fishhooks of mussel (_Mytilus californianus_).

The most common beads after the first phase of the Middle Period were the _Olivella_ wall variety (King 1981:195). This bead type made up most of the shell money used in the Channel area and a considerable amount of energy was expended in its production. Other types of beads were made from other portions of the olive shell (Figure 1a-c). The _Olivella_ shell is small and hard and beads made from this shell were generally less than 10 mm in diameter and under 2.5 mm in thickness. _Mytilus californianus_ is a much larger bivalve and is suitable for the production of large disk beads, pendents, and fishhooks. Its shell is somewhat thicker than that of the _Olivella_, but softer. Abalone (_Haliotis_ sp.) are larger, up to 30 cm in diameter, with a lustrous interior. The outer epidermis can be peeled away to produce two shiny surfaces. Abalone are suitable for the production of disk beads, pendents, fishhooks, and some types of tube beads. The overlapping plate microstructure of the abalone shell gives the shell a tensile strength of about 14,500 pounds per square inch and a toughness comparable to plexiglass (Birchall and Kelly 1983:105-106). This shell is also considerably thicker than that of the mussel. The Pismo clam is a thick and hard shell found on sandy

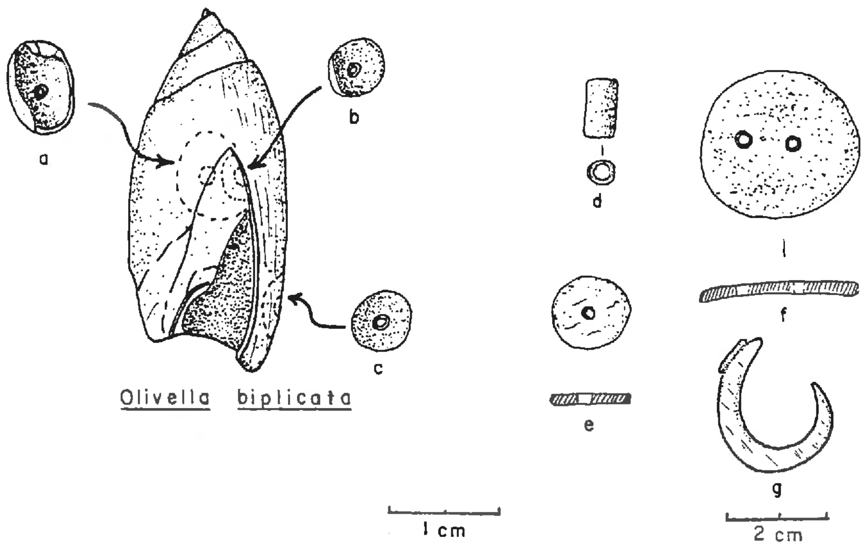


FIGURE 1: Common shell artifacts found in California archaeological sites. Left - Olivella biplicata shell showing parts used for (a) full-lipped beads, (b) callus-cup beads, and (c) wall disk beads. Right - (d) Tivella stultorum tube bead, (e) Haliotis sp. disc, (f) Mytilus californianus disc, (g) Haliotis sp. shanked fishhook.

beaches and was mainly used in the production of various kinds of tube beads. Its shell is often over 10 mm in thickness. The types of beads, ornaments, and fishhooks produced from these and other marine shells changed through time and shell artifacts have proven to be the most reliable chronological indicators for most sites on the California coast.

DRILLS

The small bladelet drills were used to make holes for stringing or suspension of beads and ornaments, but to produce fishhooks, a large diameter drill was used to remove the center of a shell disk to form the hook portion of the implement. Tools apparently used for bead, ornament, and fishhook manufacture have been recovered from archaeological contexts in the Santa Barbara Channel region.

The most commonly identified shell working tool is the bladelet drill. The bladelets and their manufacturing process have been described by Arnold (1983:11-16). They are small, narrow, percussion detached blades with a triangular or trapezoidal cross section. Drills were further retouched at one or both ends to produce a bit strong enough to withstand the rotational stress of drilling (Figure 2).

Based on size, their regular occurrence in association with bead detritus, and on ethnographic accounts of bead making, the assumption that these artifacts were used in bead manufacture was safe. This assumption was further strengthened by the discovery, on San Miguel Island, of a bead maker's kit in a small pouch. The kit contained drills, unmodified bladelets, Olivella beads, and bead blanks (Rozaire 1978:34). The development of microwear analysis techniques

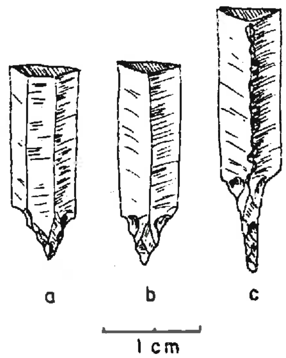


FIGURE 2: Common bladelet drill types from California archaeological sites. (a) Category 1 drill on trapezoidal bladelet, (b) Category 1 drill on triangular bladelet, (c) Category 2 drill on triangular bladelet with retouched dorsal ridge.

has, however, provided a means of testing the assumption directly be determining the type of material the bladelet drills were used on.

METHODS

There were two phases to this present analysis. The first involved the production and use of a series of replicative artifacts. The second phase was the microwear examination of these artifacts and comparison with a sample of bladelet drills from two archaeological sites on Santa Cruz Island, off the coast of California. Replicative artifacts included scraping and cutting tools as well as a series of bladelet drills used on several types of shell, wood, bone, antler, and steatite. The goal of this phase was to obtain firsthand information on the nature of shell polish and its formation. Some useful information on shell microwear was provided by Yerkes (1983) in a discussion shellworking tools from the Cahokia site, near St. Louis, Missouri. Yerkes included descriptions and photographs of shell polish but for this study, an examination of actual specimens was felt to result in more reliable identifications.

PRODUCTION OF EXPERIMENTAL TOOLS

The initial operation of the analysis was the production of a series of flake and blade tools. To facilitate comparison, the tools were all produced of grey or dark grey Monterey chert. The cutting and scraping tools were all unmodified flakes, and the bladelets were struck from small cores. The flaking procedures were those discussed by Arnold (1983). Both hard and soft hammer percussion were used. The bladelets were driven off by striking a prepared platform at one end of a ridge strengthened by grinding or light percussion. A successful attempt drove off a narrow flake which followed down the length of the ridge. The 11 bladelets produced were roughly comparable to archaeological specimens, although not as consistent in size. The experimental bladelets tended to be somewhat larger nor were the intact experimental specimens as long as the majority of the archaeological specimens. They were, however, adequate for the replications. Examples of both triangular and trapezoidal types were produced.

One end of each bladelet was retouched with an antler tine pressure flaker to produce a drill bit. The tip was generally triangular in cross section and tapered to a point. The length of this tip was variable and depended to a great extent on the quality of the bladelet on which the tip was made. On some specimens, this retouch appears to have produced some microwear traces.

MICROSCOPIC EXAMINATION

The preparation of both experimental and archaeological specimens was performed using the techniques outlined by Keeley (1980). Each specimen was cleaned in dilute Hydrochloric acid (HCl) and detergent and, if necessary, an ultrasonic cleaner.

Preliminary examination was made using a binocular microscope and low magnification to determine the characteristics of the tip or edge. High magnification examination was performed using an Olympus BH series incident light microscope and magnification ranging from 100 to 400X. Examination was first performed at 100X; scanning along the ridges and, on bladelets, over the extreme tip. Once microwear traces were found, they were identified using higher magnification. Due to the extremely small areas of polish on most of the tools, a magnification of 400X was often necessary to make the identification. Usually examination of a bladelet started with the extreme tip, as this was the area found most likely to have intact microwear traces. High magnification search along the edges of a drill is extremely time consuming because of the changing orientation of the ridges which makes constant reorientation of the tool necessary; a few traces were therefore probably missed on some drills.

RESULTS

Both the experimental tools and the archaeological sample exhibited traces of polish which could be identified as resulting from shellworking. The microwear traces are distinctive and can easily be differentiated from those of bone or wood.

MICROWEAR TRACES ON EXPERIMENTAL TOOLS

Examination of the scraper revealed small patches of flat, lustrous polish on the extreme edge of the tool at points of direct contact with the shell. To locate any polish, the tool was oriented so that it was nearly edge-on to the microscope lens. The polish formed only on projecting points where friction was highest, and the patches were extremely small. Some of the polish exhibited striations perpendicular to the tool edge in the direction of motion.

Discovery of microwear traces on the experimental drills appeared to be a measure of success in judging when to quit drilling with a particular specimen. The crunch of fracturing rock during drilling usually meant that no traces of microwear would be found on the specimen. As on the scraping tools, the patches of polish were extremely small and spalling of the tip or edge usually removed them. As a result, several of the experimental drills did not appear to have any microwear traces on the bit. The same appears to be the case with the archaeological specimens, many of which exhibited evidence of damage to the tip.

Microwear traces on the experimental bladelet drills occurred on points of high friction such as the extreme tip, projecting points or ridges, or places where an edge changed direction (Figure 3). The most likely location for polish formation appears to be the extreme tip, probably because rotational friction is constant and this area wears down enough initially to form a smooth surface and does not spall off as often as the edges. The whole tip area may acquire a general luster, but only the high points usually have identifiable shell

USE OF EXPERIMENT TOOLS

The scraping and cutting tools were simply held in the hand for use, although that such tools were hafted prehistorically is highly probable. The scraper was primarily used to produce well developed shell polish, and not to replicate aboriginal activities. Two unmodified flakes were used to incise small grooves in abalone shell to replicate polish patterns which might result from producing decoration on some bead and ornament types.

The bladelet drills were mounted in split shaft hand drills. This consisted of a straight stick (1/2, 1/3, or 1/4 inch dowel) with a split on one end, into which the base of the drill was inserted. The stick was then tightly wrapped with cord.

No glue or other adhesive was necessary, as there was little or no problem with the bladelet shifting in the mounting once tied in. Archaeologists have noted that few of the bladelets recovered archaeologically show any signs of asphaltum (tar from natural oil seeps). Given the Chumash propensity to use asphaltum as a kind of universal adhesive, tar would be expected to have been used on the bladelets as well (Larry Wilcoxon, personal communication, 1985). However, that use of tar was likely not necessary and, as the bits probably broke with some regularity, simply tying them to the shaft was more expedient. The bladelets could then be unmounted easily and a new bit inserted.

To drill a bead blank, the drill was rotated between the palms of the hands while pressure was applied downward. There is no evidence that the Chumash used either the pump or bow drill, but there is ethnographic evidence for use of this type of hand drill (Arnold 1983:23).

The experimental tools were used to drill Olive shell bead blanks, _Tivella_ sp., _Haliotis_ sp., and _Mytilus californianus_ shells; as well as wood, bone, antler, and steatite. Each specimen was used on only one type of material. The drills were generally used to produce several holes, and the time spent actually drilling was recorded. The olive shell bead blanks were small wall and callus fragments chipped form _Olivella biplicata_ shells recovered from local California beaches. The shells were supported on a leather pad during drilling, although there is some ethnographic evidence for the use of a stone or wood anvil aboriginally (Arnold 1983:23-24).

Drilling of _Olivella_ was efficient, taking anywhere from 45 seconds to six minutes to drill a single hole, depending on the amount of wear on the drill tip. Wetting of the drill tip or the surface of the shell seemed to increase the efficiency. This may be due to the adherence of shell powder acting as an abrasive. Also, the smaller diameter drill shafts appeared to produced more efficient drilling, probably due to higher rotation speeds. In addition, abalone shell appeared to produce more edge damage on the drills than did _Olivella_ shell. These factors could not be quantified for this report.

Due to the need to recover the drill tip intact, drilling was usually stopped before the tip could be damaged. Thus, the replication materials likely did not see as much activity as an aboriginal tool, whose owner was not interested in saving the tip for examination.

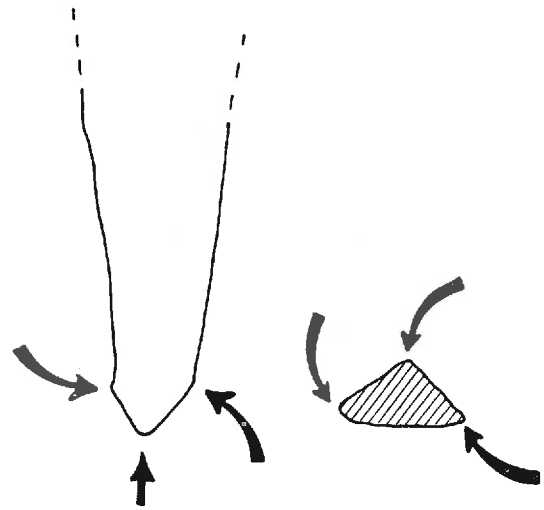
polish.

Three to five minutes of drilling was sufficient to produce identifiable polish and the degree of development appears to be directly related to the drilling time. The holes drilled on experimental pieces were all less than 3 mm in depth. This is also reflected in that all the shell polish noted was less than 3 mm from the extreme tip of the tool.

MICROWEAR TRACES ON ARCHAEOLOGICAL SPECIMENS

The archaeological sample examined so far consists of 23 bladelet drills: 19 from SCRI-195 and 4 from SCRI-206. Both these sites are on Santa Cruz Island, located about 20 miles off the California coast near Santa Barbara. This island appears to have been the source of a large percentage of the bladelet drills and bead money used in southern California. Bladelets were non-randomly selected from a collection of several thousand. Only complete specimens which showed evidence of having been retouched into drills and subsequently utilized were selected for the analysis. As of this writing, several additional specimens from SCRI-206 have been measured, but have not been examined under the microscope.

Measurements on the drill bits were made by orienting them against a metric grid. Drill tips fell generally into two basic shape categories (Figure 4). Category 1 drills were short and steeply tapered, and Category 2 drills were long with more nearly parallel sides. The latter were rare, making up less than 20% of the sample, even though drills of this type were specifically selected for. However, possibly some of the



DRILL TIP

POLISH DEVELOPMENT POINTS

FIGURE 3: Schematic representation of major shell polish development points on a drill tip (much enlarged).

blunt, Category 1 drills are the end products of a process of attrition, having been reworked, intentionally or by use, from Category 2 drills.

Microwear polish was found on 18 (78%) of the specimens examined. The polish was definitely identifiable as shell on 11 (48%) of the bladelets and considered as probable shell on another three (13%). One drill exhibited a small patch of what appeared to be bone or antler polish besides the shell polish. This could represent drilling of these materials or could be a manufacturing trace. The shell polish on the archaeological tools was identical to that noted on the experimental ones and tended to occur in the same areas.

Only two specimens exhibited

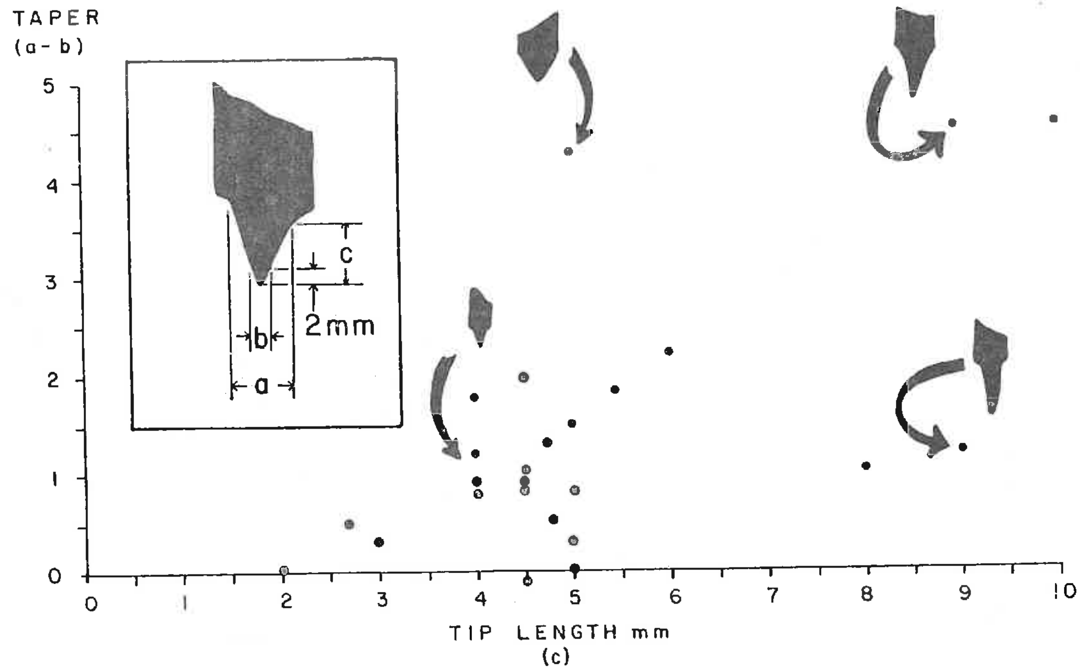


FIGURE 4: Bladelet drill tip shape categories for a sample of drills from SCRI-206. Inset shows measurements used. Bladelets below 7 mm in length are considered Category 1, those above are Category 2.

identifiable shell polish farther than 2 mm from the extreme tip of the bit. Both of these were Category 2 drills with bits considerably longer than the average. One had polish traces 7 mm from the tip and the other had traces 5 mm up the bit. These tools may have been used to drill *Tivella* sp. tube beads or some other form of ornament with a thick cross section. The majority of the other drills could have been used to produce *Olivella*, *Mytilus*, or *Haliotis* beads or ornaments.

DESCRIPTION OF SHELL MICROWEAR TRACES

As noted above, patches of identifiable shell polish are extremely small. They have a silvery or dull luster and an angular appearance. The polish has a flat surface which appears to fill in the microtopography of the rock, and, in particularly well developed patches, the polish looks like the surface of a piece of galena or pyrite (Figure 5). Occasionally there are one or more round bubbles or beads on the surface. Striations are common on the surface of well-developed shell polish and appear to reflect the position of the patch in relation to movement of the working edge. On the working edges of the scraping tools and drills, the striations ran perpendicular to the edge of the tool in the direction the edge traveled. On the drill tips, the striae reflected the rotation of the bit.

Shell microwear traces most closely resemble those of wood, but well developed examples are easily identifiable. For comparison, several holes were drilled in seasoned pine using drills of the same type

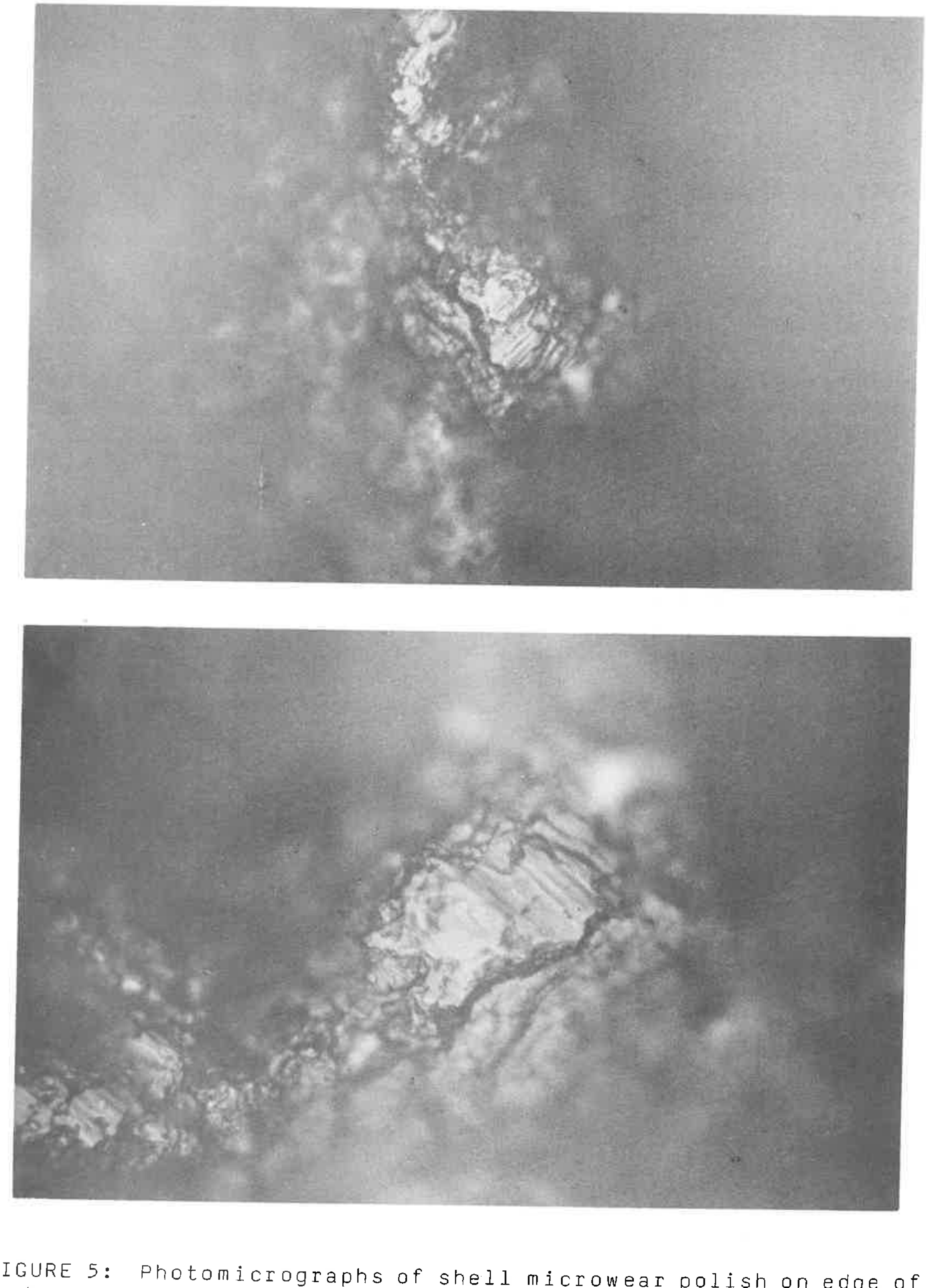


FIGURE 5: Photomicrographs of shell microwear polish on edge of an archaeological bladelet drill. Top picture is at 200X, lower at 400X. Note broad striations on polish surface.

used on shell. The wood drills were efficient and could drill a five to ten mm deep hole in approximately one minute. This points up one difference between wood and shell polish as seen on drills. Shell drills will rarely have polish traces as far up the bit as a wood drill. Wood drills also appeared to have more of a tendency to spall. This could be simply the result of the greater depth of penetration, which exposes more of the drill to rotational stresses. In appearance, wood polish differs from shell in that wood polish has a rounded surface, while shell polish is generally flat and angular. Shell is also more restricted in location than wood, which can invade a considerable distance back from an edge. Shell is found only on the extreme edge of the tool and even here, only on the points of high friction.

CONCLUSIONS

The addition of high magnification microwear studies to the field of lithic analysis has provided a powerful tool with which to interpret prehistoric activities. In this analysis, by examination of microwear traces, identification was confirmed of bladelet drills as shellworking tools. From the presence of specimens with evidence of deep drilling, the production of tube beads or ornaments at these sites was inferred. Future studies of larger samples of lithic artifacts from the Santa Barbara Channel sites may make possible more definitive statements about subsistence and economic adaptations on the central California coast.

The research also produced valuable information on the nature of shell microwear traces and how they can be identified. Shell microwear has been demonstrated to be distinctive enough that there should not be a problem to identify shellworking tools if they are produced of suitable materials and preservation is reasonable.

REFERENCES CITED

Arnold, Jean Eloise
1983 Chumash economic specialization: An analysis of the quarries and bladelet production villages of the Channel Islands, California. Unpublished PhD dissertation, Department of Anthropology, University of California, Santa Barbara.

Birchall, J. D., and Anthony Kelly
1983 New inorganic materials. Scientific American 248(5):105-106.

Keeley, Lawrence
1980 Experimental determination of stone tool uses. University of Chicago Press, Chicago.

Keeley, Lawrence H., and M. H. Newcomer
1977 Microwear analysis of experimental flint tools: A test case. Journal of Archaeological Science 4:29-62.

King, Chester D.
1981 The evolution of Chumash society: A comparison study of artifacts used in social system maintenance in the Santa Barbara Channel region before A.D. 1804. Unpublished PhD disserta-

tion, Department of Anthropology, University of California, Davis.

Rozaire, C. E.
1978 Archaeological investigations on San Miguel Island, California. Los Angeles County Museum of Natural History, Los Angeles.

Semenov, S. A.
1964 Prehistoric Technology. Cory, Adams, and Mackay, London.

Yerkes, Richard W.
1983 Microwear, microdrills, and Mississippian craft specialization. American Antiquity 48:499-518.

Robert Peterson
Department of Anthropology
University of California
Santa Barbara, California

DETERMINATION OF SEX OF *BISON* UPPER FORELIMB BONES: THE HUMERUS AND RADIUS

LAWRENCE C. TODD

ABSTRACT

Studies of the bones of modern bison serve as the basis for determining the sex of bones represented in archaeological sites. Measurements of the distal humerus and proximal radius from modern comparative specimens and from the Horner, Jones-Miller, Frasca, and Lamb Spring bison bonebeds are used to illustrate differences in the overall size ranges and sex ratios of bison recovered from Paleoindian period sites. The Horner and Frasca sites have approximately equal numbers of mature males and females while Jones-Miller is predominately female and the Lamb Spring assemblage is composed primarily of males.

INTRODUCTION

Investigations of archaeological sites on the Plains have often resulted in the recovery of large numbers of animal bones that evidence the hunting and consumption of game by prehistoric peoples. Research incorporating studies of these animal remains has played an increasingly important role in interpretations about the past inhabitants of Wyoming. One of the primary prey species, and hence the most intensively studied, has been the bison. Work by George Frison (1970, 1973, 1974, 1978a, 1978b, 1984; Frison, Wilson, and Walker 1978; Frison, Wilson, and Wilson 1976) and his colleagues and students at the University of Wyoming (e.g., Bedord 1974, 1978; Peterson and Hughes 1980; Reher 1970, 1973, 1974, 1977; Reher and Frison 1980; 1979; Wilson 1974) has been instrumental in pointing out the potential of the detailed study of the bison bones recovered during archaeological excavations.

Frison (1978a) has summarized the use of such studies in the development of archaeological interpretations:

> Within the past decade, there has been an increased emphasis on bison studies. The methodology is continually changing and is still very much in the formative stage. It is proceeding along a strongly interdisciplinary path...Aging animals by means of tooth eruption and epiphyseal fusion, butchering methods, procurement methods, and utilization of the food products are some of the lines of inquiry that are presently regarded as important for studies in cultural systems analysis. It is fairly well established that behavioral and biological studies of bison and other animal populations can reveal something of the activi-

ties of the human groups exploiting them (Frison 1978a: 44).

A major theme in these studies has been the analysis to determine the age and sex of bison found at archaeological sites. Aging studies have often relied on examination of the eruption and wear of dentition (Reher 1970, 1973, 1974; Reher and Frison 1980; Wilson 1974). Determination of the relative numbers of males and females represented in the bone samples has also been based on mandible studies, and, more commonly, on studies of lower leg bones (e.g., Bedord 1974, 1978; Hughes 1978; McCartney 1984; Peterson and Hughes 1980; Ziemens and Zeimens 1974). The importance of knowing the sex of animals at sites, and the interpretative potential of this information has recently been stressed by Speth in his work with a Late Prehistoric bison kill in New Mexico (1983).

The determination of the sex of bison bones is based on the consistent difference between the body size of males and females. This sexual dimorphism, which is a characteristics of most mammals, is particularly marked in modern bison with mature bulls being considerably larger than the females. The average weight of mature bulls has been estimated to be between 1600-1800 pounds while that of females is only from 800-900 pounds (Wheat 1972:107). Several studies have demonstrated that this difference in overall body size is reflected in a difference in the size of most bones of the skeleton (Duffield 1973; Speth 1983). One assumption made in the analysis of archaeological specimens is that this difference in size was also present in the past populations and can be used to determine the sex of animals whose bones are found in sites.

This paper presents a brief overview of examination of modern bison bones from collections for which the sex is documented. Differences in the size of bones upper front leg bones---the humerus (Figure 1c-d) and the radius (Figure 1a-b)---that can be used to distinguish males from females in these comparative specimens are described. Upper forelimb bones from several Paleoindian bison kill-butchery sites (Frasca [Fulgham and Stanford 1982]; Horner [Jepsen 1953; Frison 1978b; Todd 1983]; Lamb Spring [Rancier et al. 1982; Stanford et al. 1981; McCartney 1984]; Jones-Miller [Stanford 1974, 1978, 1979, 1984; Todd 1985]) are then used to estimate the numbers of male and female bison represented at the sites.

SIZE DIFFERENCES IN THE HUMERUS AND RADIUS

As noted, several studies have used lower limb bones to determine the sex of animals from archaeological sites. One reason that the lower leg bones have been studied is that they are frequently some of the most common, better preserved bones recovered in sites. However, in terms of differences in size between males and females, the upper limb bones may be somewhat easier to sex. Figure 2 illustrates the difference in the average size of male and female bones of the front leg. The "rotational length" (McDonald 1981:Figure 9) is the distance from the upper to the lower articular surface of each bone. This measurement gives an indication of the overall length of the element. The horizontal axis in Figure 2 is the difference in the average size of male minus female rotational lengths. The difference in size is greatest in

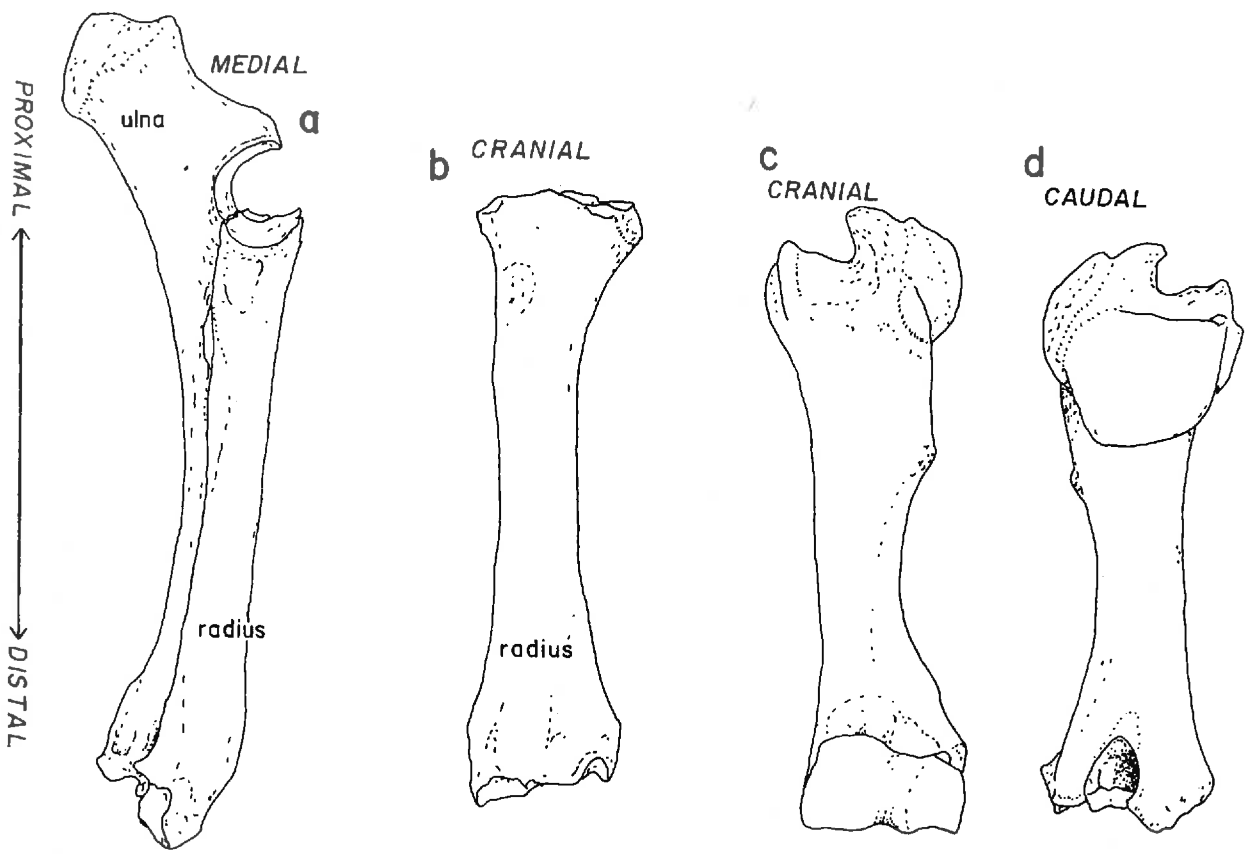


FIGURE 1: Left bison radius-ulna (a), radius (b), and humerus (c,d).

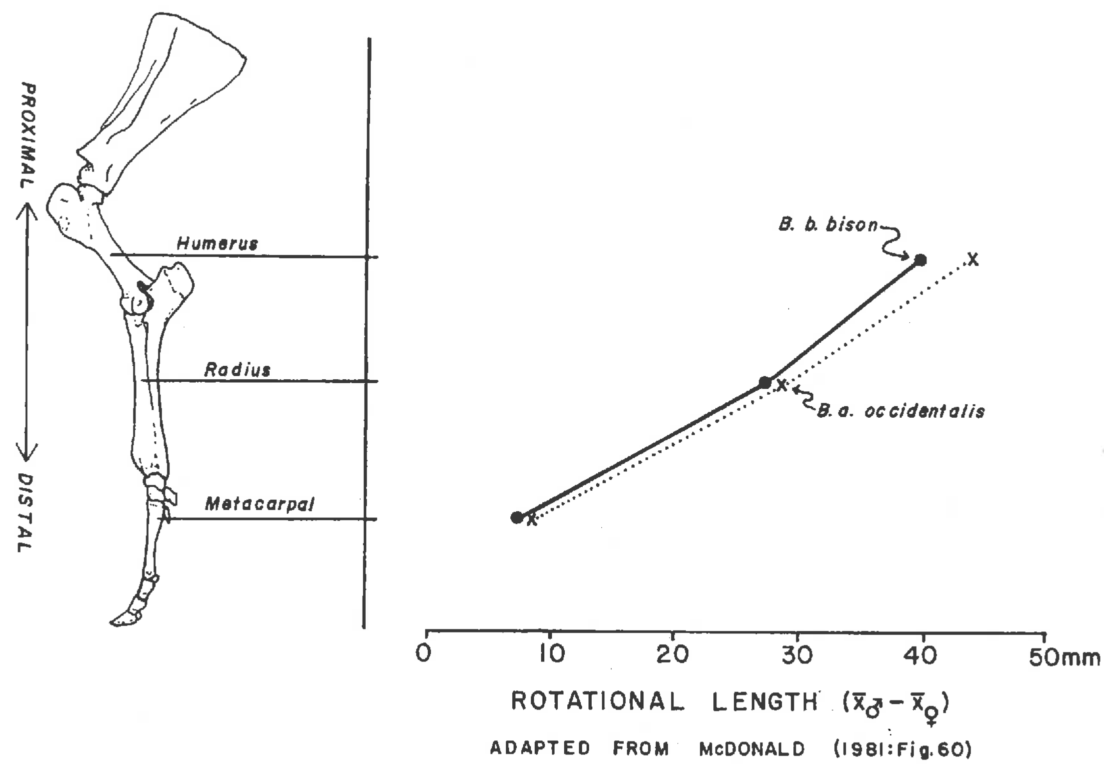


FIGURE 2: Differences in the average rotational length of male and female bison forelimb bones (data from McDonald 1981:Table 30).

the humerus and <u>least</u> in the metacarpal (a commonly studied lower limb bone). McDonald (1981:149) noted that "in both limbs the most proximal bone shows the greatest dimorphism and the most distal bone shows the least dimorphism...Generally, in both skulls and limb bones the larger the character the greater the dimorphism." Given these clear differences in absolute size of bison upper limb bones, studies of sexual make-up of archaeological assemblages using these elements seems feasible.

Rotational length (or similar measurements such as greatest length of the element) can obviously be used only with nearly complete bones. Upper leg bones from archaeological contexts are often broken either by human processing (Binford 1978, 1981) or by the actions of carnivores or other non-human agents (Binford 1981). However, portions of these bones, particularly the distal humerus, proximal radius, and distal tibia are frequently preserved intact. Two criteria for selecting metric attributes of bones to serve as sexual indicators for archaeological specimens are: 1) they can be measured on a large proportion of the recovered archaeological elements, and 2) they can be demonstrated to be sexually dimorphic in known-sex collections.

Since the distal humerus and proximal radius have higher survival/recovery potential, sexing of these portions has been given precedence in this study. It is necessary to determine which segments are most often complete enough to measure. Tables 1 and 2 give the percentages of damaged segments of distal humeri and proximal radii recorded from several archaeological collections. The measurements that are least likely to be damaged are the depth of the medial portion of the distal articular surface of the humerus (HM14; see Figure 4 for location of this measurement) which is unmeasurable in only 9.7% of the 383 bones examined, the breadth of the proximal articular surface of the radius (RD4; see Figure 5), the greatest depth of the proximal articular surface of the radius (RD9; see Figure 5), and the breadth of the distal articular surface of the humerus (HM7; see Figure 3).

These are all measurements that, based on survivorship alone, would be good candidates for additional study to determine sex. The second criterion noted above, the degree of absolute sexual dimorphism of mature animals, must also be taken into account. Tables 3 and 4 list the differences in means between known males and females in the comparative collections and between inferred male/female groupings from the archaeological collections. The measurements with the greatest differences in mean values for the distal humeri are the greatest articular breadth (HM7) and the greatest depth of the medial surface of the distal end (HM11). Plotting these two values against each other for the comparative sample and in cases such as Horner where both have a low percentage missing values (Table 2) reveals two distinct clusters of element sizes (Figure 3). For the comparative specimens, these correspond to known males and females. The Horner site humeri, although being from substantially larger bison than the modern animals, also exhibits clusters that are interpreted to be males and females.

In other assemblages, such as that from Jones-Miller, where a substantially greater number of the elements have broken components of the distal end, use of the HM11 measurement is not feasible since

SITE(a)	N	% UNMEASURABLE HM7(b)	HM8	HM11	HM14	HM18
Jones-Miller	286	32.2	63.3	60.1	10.5	53.1
Horner	39	7.7	12.8	12.8	2.6	----
Lamb Spring	17	23.5	82.4	82.4	5.9	76.5
Frasca	41	14.6	61.0	46.3	12.2	51.2
Total	383	27.4	58.7	54.8	9.7	48.6

a - All measurements taken by the author.

b - HM7, greatest breadth of distal articular surface; HM8, least breadth to olecranon fossa; HM11, greatest depth of distal (medial); HM14, greatest depth of medial portion of distal articular surface; HM18, height of lateral margin of distal articular surface; for full description of measurements see Todd (1983).

TABLE 1: Percentages of damaged, unmeasurable portions of coded bison humeri from several Paleoindian kill-butchery sites.

SITE	N	% UNMEASURABLE RD4(a)	RD8	RD9	RD10	RD12
Jones-Miller	279	28.3	55.9	28.7	36.6	30.5
Horner	37	5.4	21.6	2.7	5.4	8.1
Total	316	25.6	51.9	25.6	32.9	27.8

a - RD4, greatest breadth of proximal articular surface; RD8, greatest breadth of distal articular surface; RD9, greatest depth of medial portion of proximal articular surface; RD10, greatest depth of lateral portion of proximal articular surface; RD12, greatest breadth of the articular surface for the radial carpal; for full description of measurements see Todd (1983).

TABLE 2: Percentages of damaged, unmeasurable portions of coded bison radii from the Jones-Miller, and Horner sites. Only measurable proximal ends from Frasca and Lamb Spring have been coded.

it is unmeasurable in over 60% of the cases (Table 1). The HM14 measurement, while having less absolute dimorphism and a greater chance for overlapping cases, can also indicate clusters of males and females in the comparative as well as similar clustering of the Jones-Miller cases (Figure 4). These measurements can, with care, be used to develop estimates of sex ratios in even badly fragmented assemblages.

For proximal radii, two dimensions that are frequently complete, even in several damaged assemblages such as Jones-Miller, are the greatest breadth (RD4) and depth (RD9) of the proximal articular surface. Again, these measurements, when plotted against each other, indicate clusters of males and females (Figure 5) for the

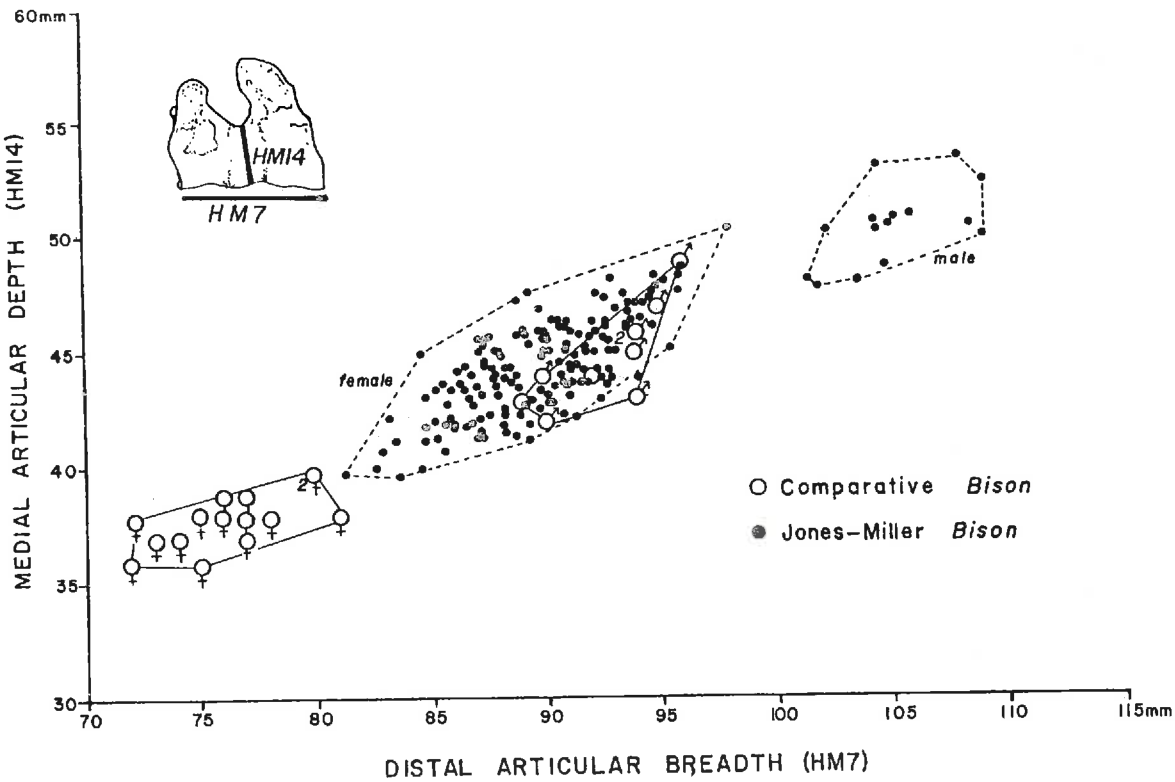


FIGURE 3: Plot of measurements of the distal humerus of modern, known-sex bison in comparative collections and of bison from the Horner site.

comparative specimens and presumably analogous clusters in the prehistoric case.

Due to differential breakage of some segments, bivariate plots such as those illustrated in Figures 3-5 cannot be used to determine the sex of all specimens in an archaeological assemblage. Depending on the condition of a collection, there can be a significant percentage of elements for which only one of the pair of measurements can be taken. In such cases the bivariate plots showing clusterings along two dimensions can provide a basis for estimating the sex of damaged bones. In Figure 3, for example, the largest individuals in the cluster of humeri inferred to be females from the Horner site have distal articular breadths (HM7) of 87mm. The smallest individual in the cluster interpreted to be males has a distal articular breadth of 91mm. This gives a good indication of where to expect a difference between the sizes of males and females to occur on a univariate histogram which can illustrate all elements for which only the HM7 measurement could be taken (Figure 6). This allows the estimation of sex for a larger number of the more fragmentary elements. The procedure can be repeated for the HM11 measurement and potentially further increase the number of sexed elements. Once most a group of elements have been classified by sex, ranges of minimum and maximum values and standard deviations of the means can be used to estimate the sex of elements for

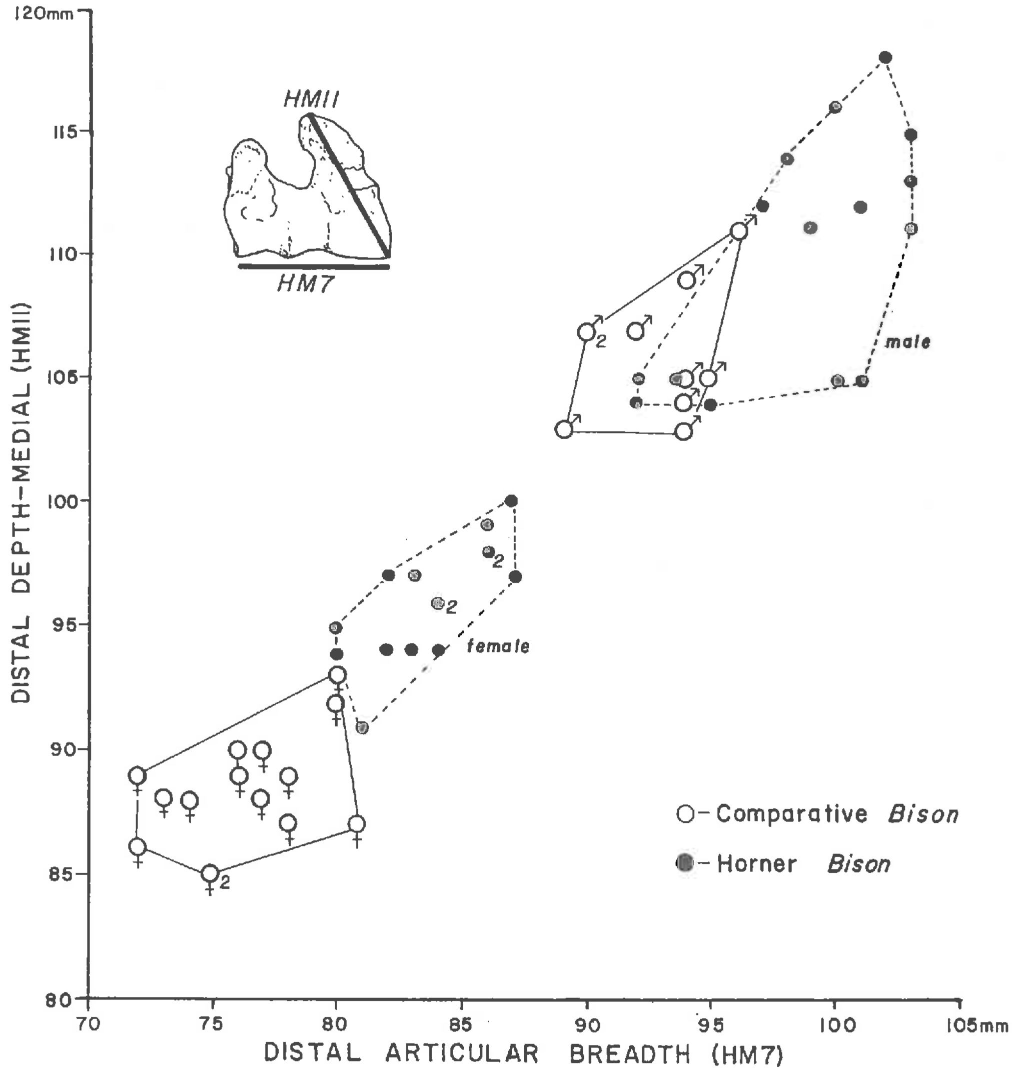


FIGURE 4: Plot of measurements of the distal humerus of modern, known-sex bison collections and of bones from the Jones-Miller site.

which neither of the primary measurements can be taken.

For bison humeri and radii, two of the consistently most useful measurements are those of the breadth of the distal and proximal articular surfaces respectively (HM7 and RD4). These measurements are not only of utility in determining the sex of individual specimens but also can serve to make a preliminary assessment of the possibility that a given radius and humerus have come from the same skeleton. As illustrated in Figure 7, the dimensions of these articular surface within an individual skeleton are highly correlated and usually within 1 mm of each other. This relationship can be used to refine Minimum Numbers of Individual (MNI) estimates (as suggested by Chaplin 1971) and also to lay the groundwork for the "anatomical reassembly" of forelimb bones (Todd 1983, 1985). Patterns of anatomically reassembled elements can further serve as a basis for studies of internal structure of a site. Other measurements of the limb

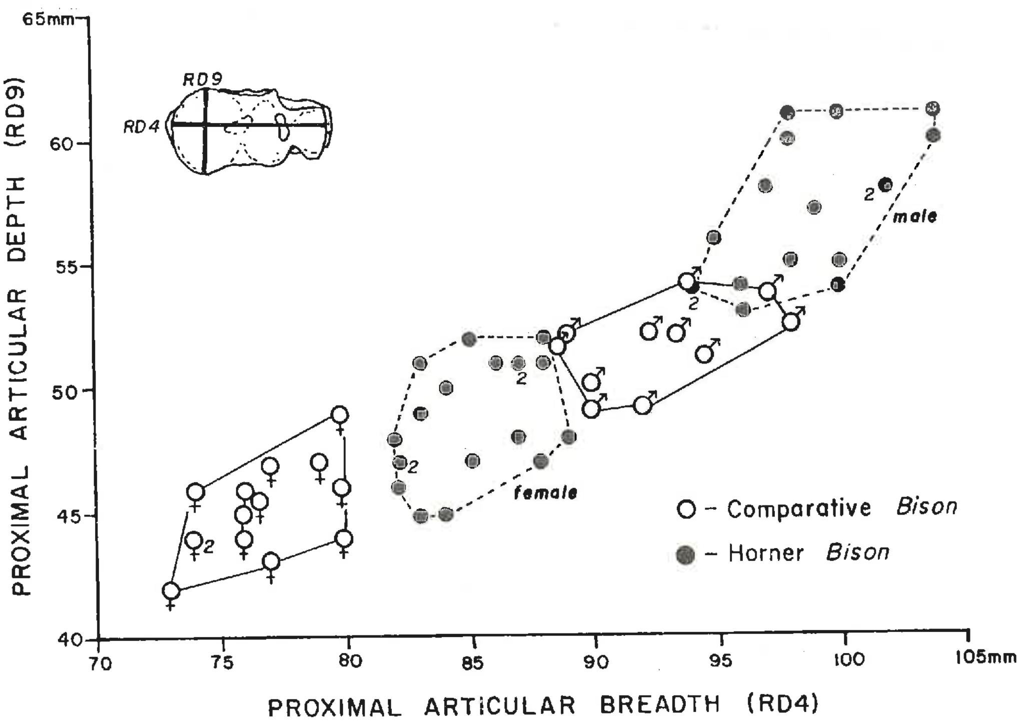


FIGURE 5: Plot of measurements of the proximal radius of modern, known-sex bison in osteological comparative collections and of bison from the Horner site.

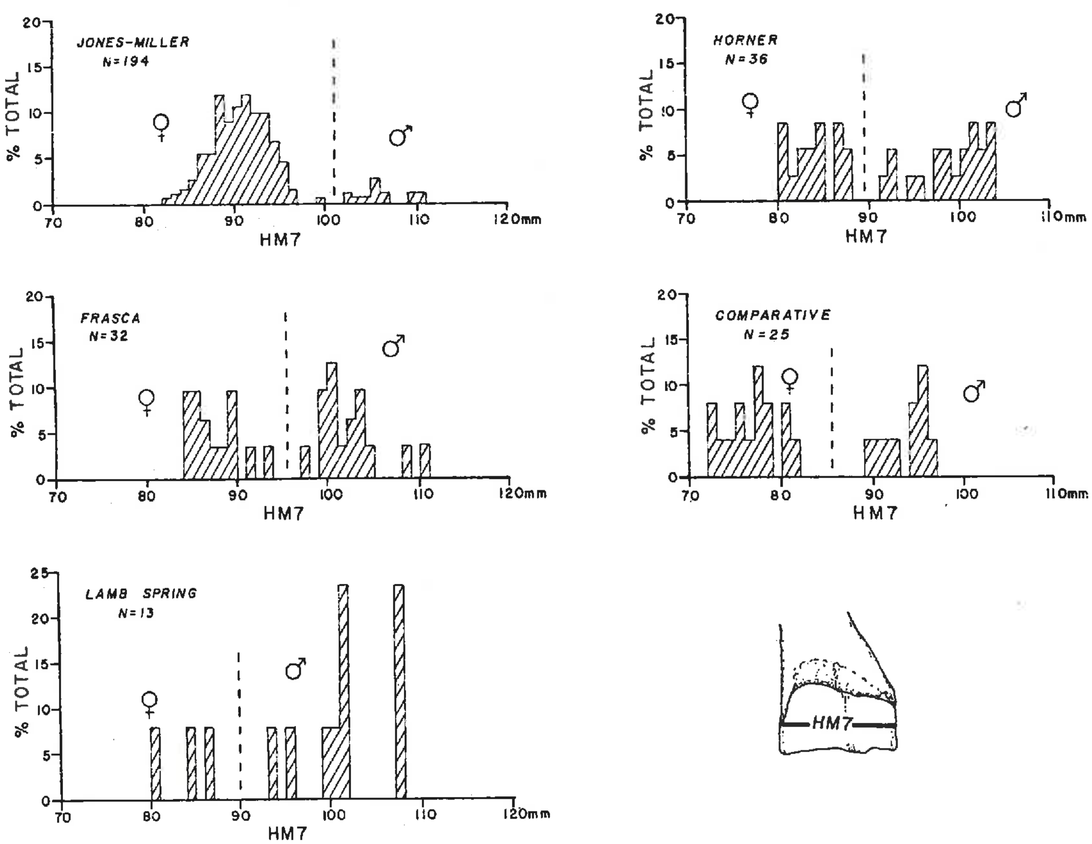


FIGURE 6: Histogram of width of the distal articular surface of the humerus (HM7) from the modern comparative sample and from several Paleoindian kill-butchery sites.

MEASUREMENT(a)	FEMALE N	MEAN	MIN	MAX	SD	MALE N	MEAN	MIN	MAX	SD	DIFF(b)
HM7											
Comparative	15	76.3	72.0	81.0	2.8	10	92.8	89.0	95.9	2.3	16.5
Jones-Miller	179	89.8	81.2	98.1	3.1	15	105.3	101.5	109.3	2.5	15.5
Horner	16	83.4	80.0	87.0	2.5	20	98.5	91.0	103.0	3.9	15.1
Lamb Spring	3	82.4	78.5	85.2	3.5	10	100.6	92.1	106.9	5.0	18.2
Frasca	15	86.6	83.2	93.0	2.9	17	101.3	96.4	109.8	3.4	14.7
HM8											
Comparative	15	24.9	21.0	30.0	2.4	10	26.5	19.0	36.0	4.6	1.6
Jones-Miller	85	27.5	16.8	34.3	3.0	3	30.3	24.7	37.9	6.8	2.8
Horner	15	25.9	23.0	30.0	2.2	17	27.6	21.0	36.0	3.6	1.7
Lamb Spring	1	29.2	----	----	---	2	31.5	29.9	33.1	2.3	----
Frasca	5	24.0	21.3	27.0	2.1	7	27.6	20.0	34.0	5.4	3.6
HM11											
Comparative	15	88.4	85.0	93.0	2.3	10	105.4	101.7	110.5	2.8	17.0
Jones-Miller	91	101.0	93.8	109.1	3.6	4	119.2	117.2	121.2	1.9	18.2
Horner	16	95.3	85.0	100.0	3.6	16	110.1	104.0	118.0	4.7	14.8
Lamb Spring	1	94.7	----	----	---	2	116.7	109.8	123.6	9.8	----
Frasca	7	98.5	97.5	99.7	0.9	10	115.3	110.8	124.0	3.8	16.8
HM14											
Comparative	15	37.8	36.0	40.0	1.2	10	44.9	42.2	48.8	2.1	7.1
Jones-Miller	177	44.6	39.7	50.5	2.1	15	50.5	47.9	53.5	1.8	5.9
Horner	16	42.1	39.0	45.0	1.8	20	48.0	43.0	52.0	2.3	5.9
Lamb Spring	3	41.8	39.2	43.3	2.3	13	48.1	44.9	52.9	2.3	6.3
Frasca	15	42.4	34.3	45.7	2.8	16	49.7	46.4	53.1	1.9	7.3
HM18											
Comparative	2	33.5	33.1	33.8	4.9	6	42.5	39.7	46.1	2.2	9.0
Jones-Miller	114	40.1	33.9	46.5	2.6	6	48.1	44.0	52.9	3.5	8.0
Horner	--	----	----	----	---	--	----	----	----	---	----
Lamb Spring	0	----	----	----	---	4	47.7	46.2	50.6	2.0	----
Frasca	8	39.9	34.5	43.6	3.2	8	47.2	44.0	50.2	2.2	7.3

a - all measurements by the author

b - (Male Mean)-(Female Mean)

TABLE 3: Summary of selected measurements of bison humeri. Comparative are known-sex bison from the University of Wyoming Anthropology Department and the National Museum of Natural History, Department of Zoology collections of B.b. bison.

bones can also be used for several purposes in the analysis of archaeological sites.

DISCUSSION AND CONCLUSIONS

Several measurements of the humerus and radius seem to provide consistent separation between groups of individual that, in known-sex comparative specimens correspond to males and females. Similar groupings in archaeological collections are inferred to represent sexually dimorphic size differences. Since many of the humeri and radii found in archaeological sites are broken, dimensions such as maximum length, which exhibit some of the greatest absolute sexual dimorphism, can often be used on only a small percentage of the bones recovered. Therefore, the present study has focused on measurements of those portions that

	FEMALE					MALE					
MEASUREMENT(a)	N	MEAN	MIN	MAX	SD	N	MEAN	MIN	MAX	SD	DIFF(b)
RD4											
Comparative	14	76.6	73.0	80.0	2.4	11	92.7	88.6	98.2	3.2	16.1
Jones-Miller	181	90.4	84.3	97.7	3.1	19	105.5	100.9	111.7	3.4	15.1
Horner	19	85.0	82.0	89.0	2.4	17	98.6	94.0	104.0	3.2	13.6
Lamb Spring	1	87.8	----	----	---	14	100.3	92.6	108.3	4.1	----
Frasca	7	87.9	84.1	91.8	3.1	13	101.2	95.6	108.6	3.9	13.3
RD8											
Comparative	13	71.5	66.0	76.0	3.0	4	88.3	87.0	90.0	1.3	16.8
Jones-Miller	83	86.3	80.0	99.1	3.4	7	104.2	100.7	107.5	2.5	17.9
Horner	15	80.1	78.0	84.0	2.1	15	96.2	90.0	102.0	3.5	16.1
Lamb Spring	--	----	----	----	---	--	----	----	----	---	----
Frasca	--	----	----	----	---	--	----	----	----	---	----
RD9											
Comparative	14	45.2	42.0	49.0	1.8	11	51.6	49.0	54.4	1.7	6.4
Jones-Miller	163	50.2	41.6	56.7	2.4	19	57.9	54.0	63.1	2.8	7.7
Horner	19	48.7	45.0	52.0	2.3	18	57.0	53.0	61.0	2.8	8.3
Lamb Spring	1	47.4	----	----	---	15	55.8	52.0	63.3	2.8	----
Frasca	7	48.5	44.7	50.9	2.5	10	55.8	51.9	60.5	2.4	7.3
RD10											
Comparative	14	26.7	23.0	29.0	1.5	11	34.0	29.8	38.0	2.5	7.3
Jones-Miller	152	32.1	23.9	38.8	2.0	14	39.2	35.7	41.8	2.2	7.1
Horner	19	29.9	27.0	33.0	1.8	17	36.2	31.0	40.0	2.5	6.3
Lamb Spring	1	26.8	----	----	---	8	37.2	34.3	39.5	2.2	----
Frasca	3	30.6	29.1	32.4	1.7	3	38.5	37.2	39.6	1.2	7.9
RD12											
Comparative	13	27.1	25.0	30.0	1.1	4	34.5	32.0	38.0	2.6	7.4
Jones-Miller	120	33.6	29.7	42.0	1.6	14	40.5	38.3	42.6	1.3	6.9
Horner	18	31.7	30.0	34.0	1.1	17	38.3	36.0	39.0	0.9	6.6
Lamb Spring	--	----	----	----	---	--	----	----	----	---	----
Frasca	--	----	----	----	---	--	----	----	----	---	----

a - all measurements by the author

b - (Male Mean)-(Female Mean)

TABLE 4: Summary of selected measurements of bison radii.

have the highest probability of being found intact. This is not to suggest that these should be the only measurements taken during a complete analysis and if time is available a full set of measurements should taken on all measurable bones in a collection.

One difficulty in sexing distal humeri and proximal radii is that without nearly complete shafts, it is sometimes difficult to estimate the age of the animal from which the element came. Males that are not fully skeletally mature may sometimes fall into the area between the male and female clusters and make assignment difficult. Care should be taken, especially in initially developing the expected size ranges for males and females, that only mature animals are used.

Figure 6 also illustrates the differences absolute sizes of the animals represented at the various sites. All bison from these Paleoindian period sites are clearly larger than the modern comparative animals. However, there is a great deal of variability of size within archaeological cases. The most

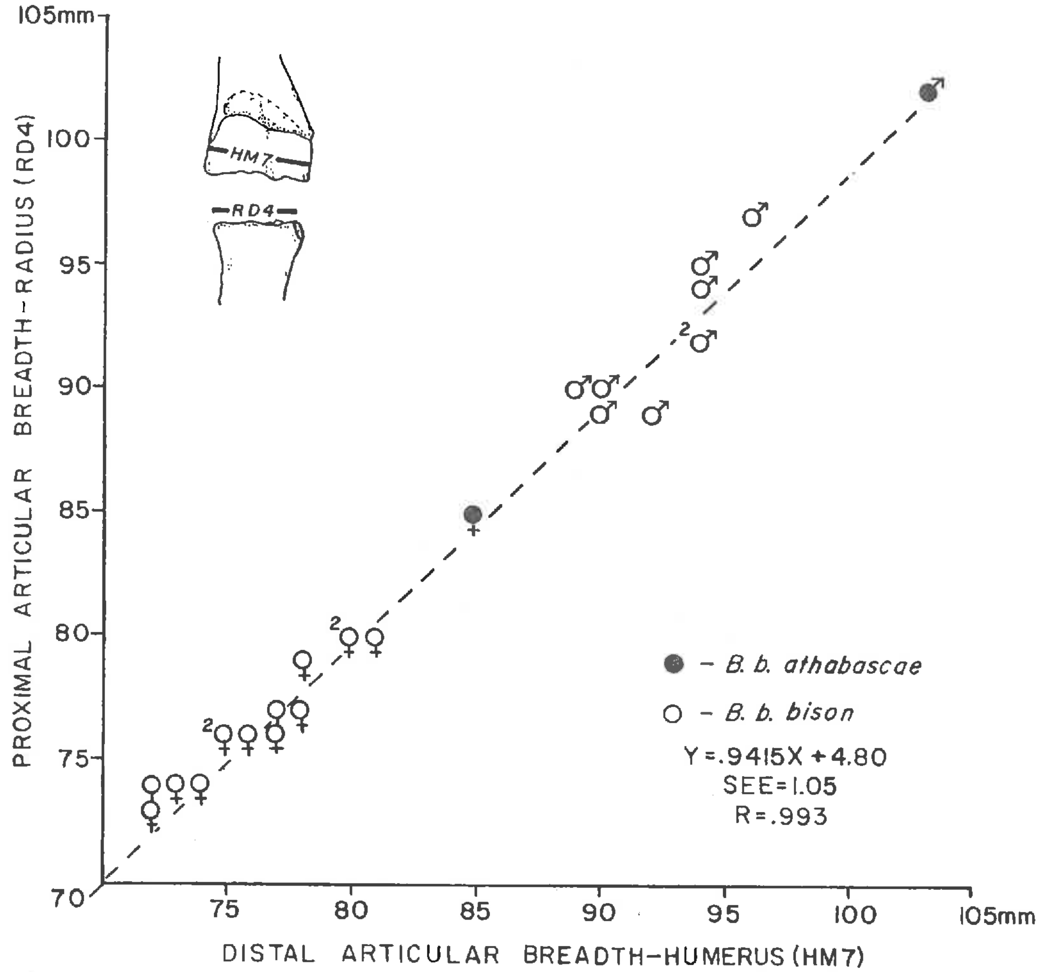


FIGURE 7: Relationship between the breath of the distal articular surface of the humerus (HM7) and the breadth of the proximal articular surface of the radius (RD4) from the forelimb of comparative bison skeletons.

extreme differences are between the animals represented at the Horner site and those from Jones-Miller with many of the smaller Horner males falling into the size range of the Jones-Miller females. The Jones-Miller bison are clearly larger than those at Horner. This provides another example of the point made by Zeimens and Zeimens (1974:246) that comparisons of mean sizes of all bones from a site, without distinction by sex, is apt to give an erroneous picture of the overall size of the animals represented. For Jones-Miller, where females greatly outnumber males the mean of all humeri is close to that of the females. At Horner, where there is a more equal sexual representation, the mean for all measurements falls approximately half way between that of the males and females and are, in fact, consistently larger than corresponding measurements of the Jones-Miller bison. Unless sexual differences are taken into account, comparisons of mean values of limb bone measurements will be of limited value in understanding regional or temporal differences in bison populations.

Another observation that can be made from Figure 6 is that sex ratios, based on measurements of the distal humeri, indicate a wide range of variability in the relative numbers of males and females at Paleoindian kill-butchery sites. They are approximately equal at Horner and Frasca. As McCartney's (1984) study of metapodials indicated, Lamb Spring is mostly males. The humeri data from Jones-Miller, with mostly females, compares well with Reher's (n.d.) interpretations based on study of mandibles. The numbers of males and females represented at a site has implications for the development of interpretations of hunting tactics, possible processing differences (Speth 1983), and of the behavior of the extinct forms of bison represented at these sites. These types of information can play an important role in the development of reliable models of subsistence strategies of Plains hunter-gatherers, and, as observed by Frison (1978a:44), the analytic methods continue to be refined. As illustrated here, for the Paleoindian period the sex ratio in kill sites is highly variable and points to the need for further research to determine the reasons for the differences. This discussion has presented a cursory overview of a type of research that can be used as one component in the development of an understanding the behavior of the earlier peoples of the Plains.

ACKNOWLEDGMENTS

This paper was prepared while in residence at the Smithsonian Institution during a Postdoctoral Fellowship. The archaeological collections from the Jones-Miller, Frasca, and Lamb Spring sites were studied there. The support of the Smithsonian and interest of Dr. Dennis J. Stanford made the data collection possible. The Horner site materials and many of the comparative bison are part of the University of Wyoming collections and Dr. George C. Frison allowed me to work with the collections and has encouraged and facilitated the research. Danny N. Walker has been consistently helpful in these studies. Sandy Todd assisted in preparation of this manuscript.

REFERENCES CITED

Bedord, Jean Newman
1974 Morphological variation in bison metacarpals and metatarsals. In: The Casper site: A Hell Gap Bison kill on the High Plains, edited by G.C. Frison, pp. 199-240. Academic Press, New York.

Binford, Lewis R.
1978 Nunamiut Ethnoarchaeology. Academic Press, New York.

1981 Bones: Ancient men and modern myths. Academic Press, New York.

Chaplin, Raymond E.
1971 The study of animal bones from archaeological sites. Seminar Press, London.

Duffield, L.F.
1973 Aging and sexing the post-cranial skeleton of bison. Plains Anthro-

pologist 18(60):132-139.

Frison, George C.
1970 The Glenrock Buffalo Jump, 48CO304: Late Prehistoric Period buffalo procurement and butchering. Plains Anthropologist Memoir 7.

1973 The Wardell Buffalo Trap, 48SU301: Communal procurement in the upper Green River Basin, Wyoming. Anthropological Papers of the Museum of Anthropology, University of Michigan 48.

1974 The Casper site: A Hell Gap bison kill on the High Plains. (editor). Academic Press, New York.

1978a Animal population studies and cultural inference. In: Bison procurement and utilization: A symposium, edited by L. B. Davis and M. Wilson, pp. 44-52. Plains Anthropologist Memoir 14.

1978b Prehistoric hunters of the High Plains. Academic Press, New York.

1984 The Carter/Kerr-McGee Paleoindian site: Cultural resource management and archaeological research. American Antiquity 49(2):288-314.

Frison, George C., Michael Wilson, and Danny N. Walker
1978 The Big Goose Creek site: bison procurement and faunal analysis. Occasional Papers on Wyoming Archaeology 1:1-50.

Frison, George C., Michael Wilson, and Diane J. Wilson
1976 Fossil bison and artifacts from an early Altithermal period arroyo trap in Wyoming. American Antiquity 41(1):28-57.

Fulgham, Tommy, and Dennis J. Stanford
1982 The Frasca site: A preliminary report. Southwestern Lore 48(1):1-9.

McCartney, Peter H.
1984 Taphonomy and archaeology of a Cody complex bison kill in Colorado. Unpublished manuscript on file, Department of Anthropology, Smithsonian Institution. Washington, D.C.

Jepsen, Glenn L.
1953 Ancient buffalo hunters of northwestern Wyoming. Southwestern Lore 19(2):19-25.

McDonald, Jerry N.
1981 The North American bison: Their classification and evolution. University of California Press, Berkeley.

Peterson, Robert R., Jr., and Susan S. Hughes
1980 Appendix 2: Continued research in bison morphology and herd composition using chronological variation in metapodials. In: The Vore site, 48CK302, a stratified buffalo jump in the Wyoming Black

Hills by C.A. Reher and G.C. Frison, pp. 170-190. Plains Anthropologist Memoir 16.

Rancier, James, Gary Haynes, and Dennis Stanford
1982 1981 Investigations at Lamb Spring. Southwestern Lore 48(2):1-17.

Reher, Charles A.
1970 Appendix II: Population dynamics of the Glenrock Bison bison population. In: The Glenrock buffalo jump, 48CO304: Late Prehistoric period buffalo procurement and butchering on the Northwestern Plains, by G.C. Frison, pp. 71-55. Plains Anthropologist Memoir 7.

1973 Appendix II: The Wardell Bison bison sample: Population dynamics and archaeological interpretation. In: The Wardell Buffalo Trap, 48SH301: Communal procurement in the upper Green River basin, Wyoming, by G.C. Frison, pp. 89-105. Anthropological Papers of the Museum of Anthropology, University of Michigan 48:89-105.

1974 Population study of the Casper site bison. In: The Casper site: A Hell Gap bison kill on the High Plains, edited by G.C. Frison, pp. 113-124. Academic Press, New York.

n.d. Archaeological and paleoecological analysis of Bison mandibles from the Jones-Miller site. Unpublished Manuscript on file, Department of Anthropology, Smithsonian Institution. Washington, D.C.

Reher, Charles A. and George C. Frison
1980 The Vore site, 48CK302, a stratified buffalo jump in the Wyoming Black Hills. Plains Anthropologist Memoir 16.

Smiley, Francis E.
1979 An analysis of cursorial aspects of the biomechanics of the forelimb in Wyoming Holocene bison. Unpublished M.A. Thesis, Department of Anthropology, University of Wyoming, Laramie.

Speth, John D.
1983 Bison kills and bone counts: Decision making by ancient hunters. University of Chicago Press, Chicago.

Stanford, Dennis J.
1974 Preliminary report on the excavation of the Jones-Miller Hell Gap site, Yuma County, Colorado. Southwestern Lore 40:30-36.

1978 The Jones-Miller site: An example of Hell Gap bison procurement strategy. In: Bison procurement and utilization: A symposium, edited by L.B. Davis and M. Wilson, pp. 90-97. Plains Anthropologist Memoir 14.

1984 The Jones-Miller site: A study of Hell Gap bison procurement and processing. National Geographic Society Research Reports: 1975 Projects.

Stanford, Dennis, Waldo R. Wedel, and Glenn R. Scott
1981 Archaeological investigations of the Lamb Spring site. Southwestern Lore 47(1):14-27.

Todd, Lawrence C.
1983 The Horner site: Taphonomy of an early Holocene bison bonebed. Unpublished Ph.D. dissertation, Department of Anthropology, University of New Mexico, Albuquerque.

1985 Formation of the Jones-Miller site bonebed. Unpublished Manuscript on file, Smithsonian Institution, Department of Anthropology. Washington, D.C.

Wheat, Joe Ben
1972 The Olsen-Chubbuck site: A Paleo-Indian bison kill. Society for American Archaeology Memoir 26.

Wilson, Michael
1974 The Casper local fauna and its fossil bison. In: The Casper site: A Hell Gap bison kill on the High Plains, edited by G.C. Frison, pp. 125-171. Academic Press, New York.

Zeimens, George and Sandy Zeimens
1974 Volumes of bison astragali. In: The Casper site: A Hell Gap bison illl on the High Plains, edited by G.C. Frison, Appendix I, pp. 245-246. Academic Press, New York.

Lawrence C. Todd
Department of Anthropology
University of Denver
Denver, Colorado

ARCHAEOLOGY OF THE UPPER PURGATOIRE RIVER VALLEY, LAS ANIMAS COUNTY, COLORADO: CHRONOLOGY AND ORIGINS

CARYL E. WOOD

ABSTRACT

Since the early 1950s, 48 archaeological sites have been investigated within the boundaries of the Trinidad Lake Project along the Purgatoire River in southeastern Colorado. Two multicomponent sites, 5LA1416 and 5LA1211 were extensively excavated. Information from, but not limited to, these sites was used to develop the chronology for the Upper Purgatoire Complex (A.D. 1000-1225), the earliest defined prehistoric cultural period for the region. Recent research in reevaluating radiocarbon dates may place the beginnings of this complex as early as A.D. 600. Elements of material cultura and evidence from physical anthropological assessments indicate this population may be directly tied to early Athabascan admixture with Plains populations that relate to the pre-Complex, indigenous populations in southeastern Colorado. Addditionally, contact with the Anasazi appears to have resulted in a strongly developed trade network which correlates with Pueblo II expansion into northern New Mexico. Finally, Plains elements which apparently culminated in the later Apishipa Focus and Panhandle Aspects to the east are seen here as well.

INTRODUCTION

The Trinidad Lake Project is located about five miles west of Trinidad in southeastern Colorado. Prehistoric and historic sites have been excavated within the area for some 30 years under the auspices of Trinidad State Junior College, National Park Service and U.S. Army Corps of Engineers. Research ceased in 1980 with the completion of dam construction and subsequent filling of the lake. Part 2 of the Trinidad Lake Cultural Resource Study titled "The Prehistoric Occupations of the Upper Purgatoire River Valley, Southeastern Colorado," was published then (Wood and Bair 1980). The following is a brief synopsis of that report.

ENVIRONMENT

The Purgatoire River Valley falls within the Raton Section of the Great Plains Physiographic Province (Fenneman 1931:37-47) which is an area of high mesas and plateaus dissected by deep canyons. Specifically, it is located on the Park Plateau which borders the Colorado-New Mexico state line at an elevation of 6200-6400 feet.

The Park Plateau is a semi-arid region with an annual average precipitation of 14 inches. This area of the Park Plateau falls within the Juniper-Pinon Woodland vegetation zone (Kuchler 1964).

CULTURAL SEQUENCE

Since the early 1950s, 48 sites have been investigated within the boundaries of the Trinidad Lake Project along the Purgatoire River (Figure 1). Information from these sites was used to develop a chronology for historic and prehistoric occupation in the valley (Table 1).

PALEOINDIAN, ARCHAIC AND EARLY PREHISTORIC (12,000 B.P. - A.D. 1000)

Paleoindian and Archaic components within this area have never been adequately defined. Information concerning these early manifestations is limited to isolated finds. An extensive survey by Lutz and Hunt (1979) along the high terraces north of the Purgatoire River defined early, middle and late Archaic components from ca. 4000 B.C. to A.D. 0. In their model for patterns of change based on subsistence, they note that early sites representing a total hunting and gathering subsistence base are generally located on high terraces above and away from major water sources. This may account for the dearth of these sites along the Purgatoire River. Additionally, they noted early Basketmaker-like projectile points retrieved from sites within the A.D. 0-400 time frame. A Woodland component follows from A.D. 400-1000. These, as well, have not been specifically identified in the Trinidad Lake area. The contributions of Lutz and Hunt will be discussed later.

UPPER PURGATOIRE COMPLEX (A.D. 1000-1225±):

Two multicomponent sites, 5LA1416 (Figure 2) and 5LA1211 (Figure 3), were extensively excavated during the project. Information from these two sites, as well as others, was used with past research to develop the chronological framework of the Upper Purgatoire Complex.

The Upper Purgatoire complex contains a single phase, named by Dick (1963) as the Sopris Phase. In turn, three subperiods were identified and dated by archaeomagnetic methods, ceramic cross dating and seriation and stratigraphic and architectural sequences (Wood and Bair 1980). These are the Initial Sopris Phase (A.D. 1000-1100), the Early Sopris Phase (A.D. 1100-1150) and the Late Sopris Phase (A.D. 1150-1225±).

Unfortunately, the dearth of accurate artifact provenience data accompanied by large scale excavations in multi-occupational sites before 1967, has limited our ability to determine significant temporal changes in artifact categories from site to site.

When comparing the artifact inventories as a whole, for single and multi-occupational sites with those in which provenience is known, the assemblages appear to be homogeneous. A basic hunting and gathering subsistence pattern appears to predominate throughout. A trend toward more sedentary patterns is seen in sequences of house construction and was presumably accompanied by incipient horticulture. Present evidence suggests

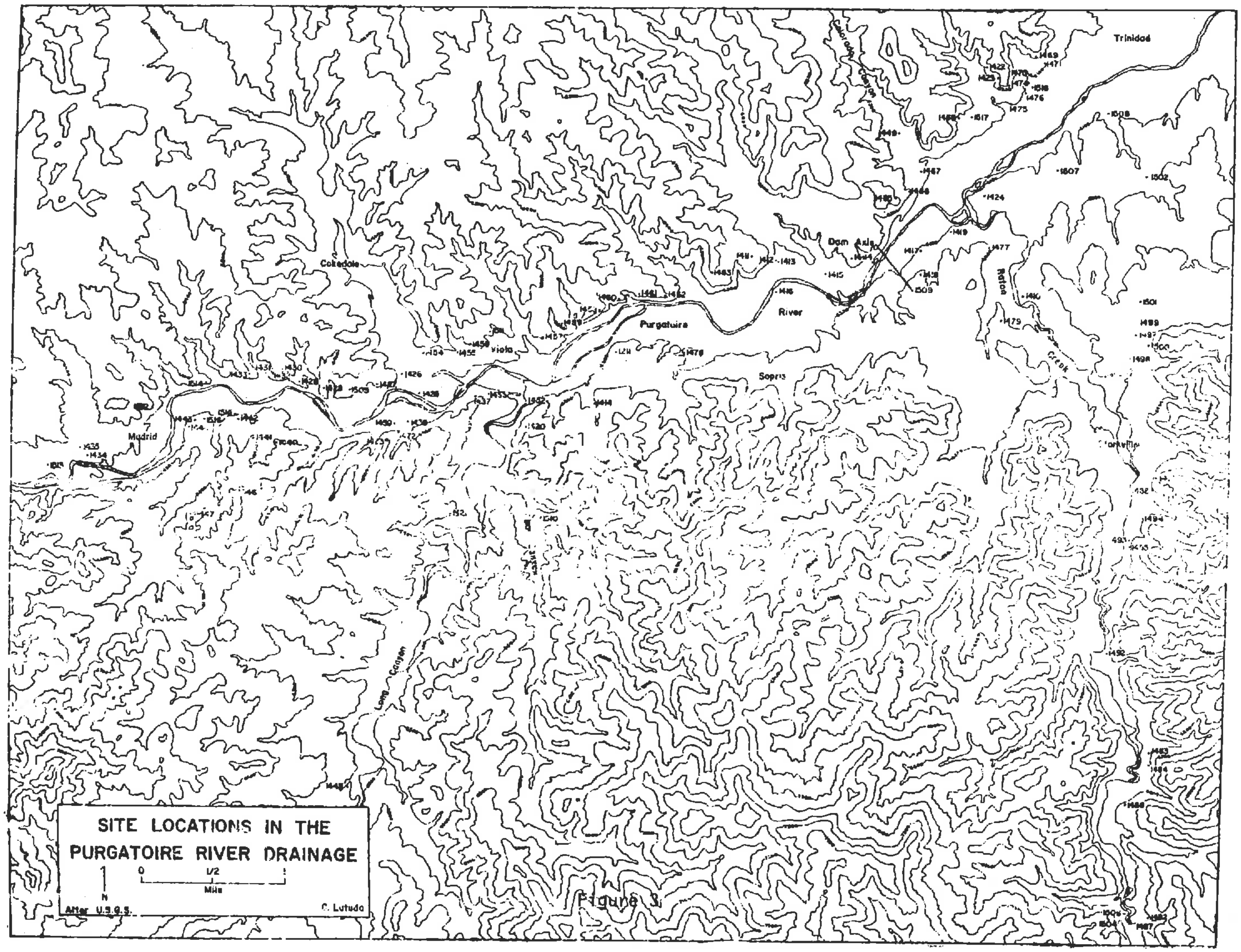


FIGURE 1: Site locations in Purgatoire River drainage, southeastern Colorado.

	TIME SPAN	BASIC ECONOMY
Modern	Post A.D. 1900	Coal mining
Ranchero Complex Baca Phase	A.D. 1860-1900	Sheep ranching Spanish-American
Nomada Complex	ca. A.D. 1525-1860	Nomadic hunting-gathering Plains Indian
Montanes Phase Carlana Phase	ca. A.D. 1750-1860 ca. A.D. 1525-1750	Ute, Comanche, etc. Apache (Jicarilla)
///////////?/////////?/////////?	/////////?/////////?	/////////?/////////?///////////
"Panhandle Culture"	ca. A.D. 1100-1450	Brief encursions of hunting parties from the east
Upper Purgatoire Complex	ca. A.D. 1000-1225+	Sedentary flood plain farming, hunting and gathering
Late Sopris Phase Early Sopris Phase Initial Sopris Phase	ca. A.D. 1150-1225 ca. A.D. 1100-1150 ca. A.D. 1000-1100	
Early Prehistoric	ca. A.D. 0-1000	Undefined
Archaic	ca. 6000 B.P.-A.D. 0	Undefined -- probable hunting and gathering
Paleoindian	ca. 12,000-6000 BP	Undefined -- probable big game hunting and gathering

TABLE 1: Proposed chronological outline for historic and prehistoric occupations in upper Purgatoire River valley, Las Animas County, Colorado.

there are three temporally separate, yet gradual, sequences of house construction from jacal to adobe, culminating in stone as the predominant construction material. Transitional phases of construction incorporating jacal and adobe or adobe and stone support this contention as well. Construction on the first or second terrace above the river was the preferred location. House structures are substantial and the majority exhibit mud-collared hearths within the structures. There is a consistent use of bell-shaped storage pits both within structures and on surrounding use surfaces. External firepits are also present on use surfaces but do not exhibit the mud collar. Additionally, contact with both Puebloan and Plains groups is evidenced by trade ceramics during the latter two subperiods of the Sopris Phase.

Initial Sopris Phase (A.D. 1000-1100)

The initial Sopris Phase has been characterized by the construction of semi-subterranean pit houses, jacal structures and campsites which may or may not have been associated with a jacal or brush superstructure. These are represented at the following sites:

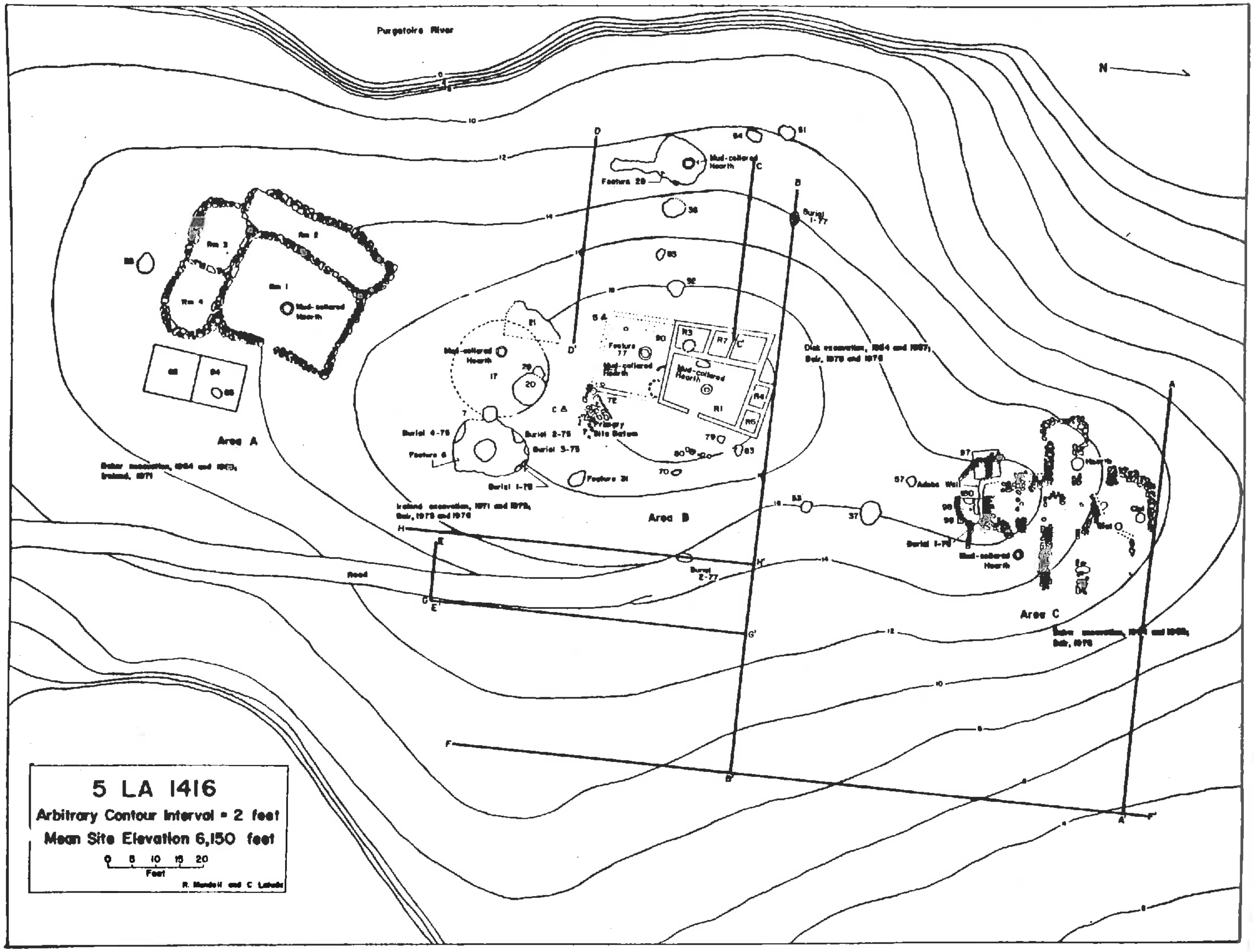


FIGURE 2: Plan map of site 5LA1416, Las Animas County, Colorado.

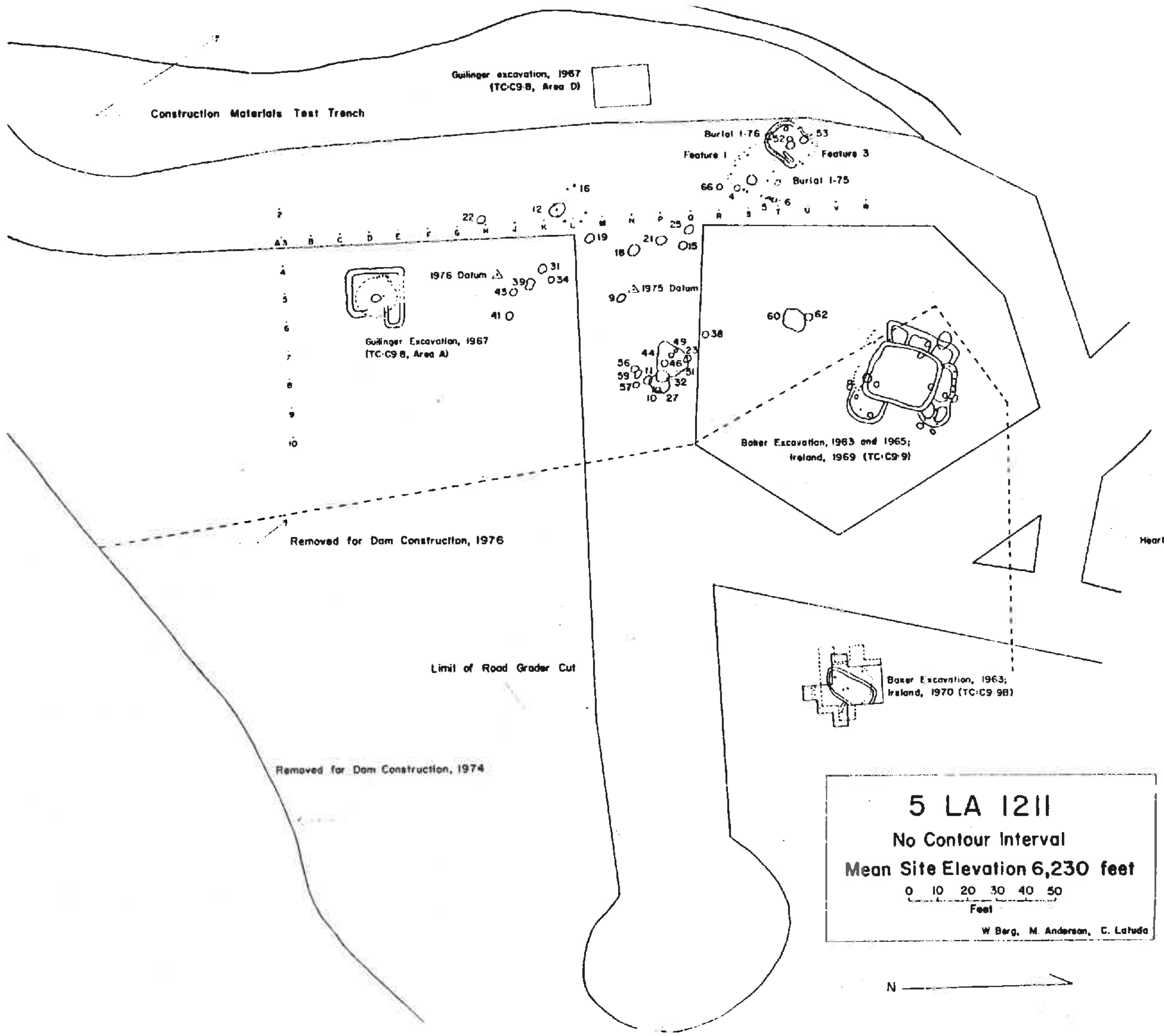


FIGURE 3: Plan map of site 5LA1211, Las Animas County, Colorado.

pithouses	5LA1414B, Feature 28; 5LS1211, Features 10 and 51
jacal structures	5LA1211, TC:C9:9B and TC:C9:8A; 5LA1416 A/B
campsites	5LA1416B, Level IV; 5LA1416C, Levels III and IV

Three archaeomagnetic dates are available for occupations from this phase. A hearth, Feature 90, located beneath the Level III room, Feature 77, at 5LA1416B produced a date of A.D. 1075±39. Feature 15, a storage pit associated stratigraphically with the Feature 51 and 10 pit houses and the floor level beneath the Feature 3-75 house, was dated at A.D. 1085±31. Finally, a hearth (Feature 53) beneath the previously mentioned floor level at Feature 3-75 exhibited a date of A.D. 1075±15. All archaeomagnetic dates have now been re-evaluated and will be discussed below.

Ceramic seriation revealed that Taos Gray-Sopris Plain was the predominant ware utilized. We are suggesting that Sopris Plain, a locally manufactured plain culinary ware, has its beginnings during the Initial Sopris Phase. Taos Gray Plain is virtually identical in morphology to Sopris Plain. It dates as early as A.D. 1000 at Pot Creek (Wetherington 1968:47).

A review of artifact inventories reveals no significant differences between this and succeeding subperiods, indicating a similar economy throughout the Sopris Phase. As previously mentioned, inaccurate provenience data prevents adequate comparisons. Basin metates predominate over other types, i.e., slab and trough. Corner-notched projectile points are slightly more abundant than side-notched and stemmed varieties. Elbow pipes appear now and continue throughout the Phase.

<u>Early Sopris Phase (A.D. 1100-1150)</u>

The Early Sopris Phase is characterized by the construction of adobe houses. Jacal construction incorporated within the basic adobe structure appears to be transitional between Initial and Early phases. These house forms are represented in the following sites:

adobe and jacal	TC:C9:8B (5LA1211B), Feature 3-75, 1-75
adobe	5LA1416B, Level II and III; 5LA1416C, Level II

Archaeomagnetic samples from Early Sopris Phase sites produced a date of A.D. 1140+43 for the jacal ramada (Feature 1-75) which is considered to be an addition to the Feature 3-75 jacal and adobe structure.

The Level III room, Feature 77, at 5LA1416B produced an archaeomagnetic date of A.D. 1090±41 from a hearth. Additionally, a hearth at the same stratigraphic level outside the structure was dated at A.D. 1090±17. It seems likely the use of mud as a predominant construction material began late in the Initial Sopris Phase after inhabitants noted the virtues of baked clay in jacal construction. Feature 3-75 utilized adobe as an apparent footing to hold posts for the jacal superstructure. This site represents the earliest date for adobe construction and is transitional between jacal and adobe architectural styles. The remaining adobe structures (5LA1416B and LA1416C) post-date this site and do not incorporate posts within the walls. Stratigraphic evidence that adobe construction precedes masonry is found at 5LA1416C. The Level II adobe structure directly underlies the Level I stone habitation. Lang (1977:6) notes that adobe and jacal surface structures appear during late Pueblo II times in the Northern Rio Grande.

Ceramics from this phase are, again, difficult to differentiate since provenience data is incomplete. Additionally, the plainware ceramics were combined with Incised wares in the same category. Apparently, the Taos Gray-Sopris Plain wares predominated as the major ceramic type. Incised wares were introduced now from contact with the northern Rio Grande pueblos. Some cordmarked, polished or corregated wares are present along with occasional Taos Black-on-White (B/W) and Red Mesa B/W. The latter ceramic type may correlate with Pueblo II (a.D. 850-1150) expansion northward into the Pecos and Canadian River areas toward the end of this period (Lang 1977:6). Finally, Lang (1977:7) notes that Red Mesa B/W is associated with turquoise mines in Cerrillos. Feature 6 at 5LA1416 produced both Red Mesa B/W and turquoise.

Artifact assemblages, again, show no significant variations. Trough metates replace the basin types during this phase. This is consistent with Lang's (1977:7) review of northern Rio Grande Pueblo II cultures. Lang also notes the introduction of the elbow pipe, an artifact type which continues here from the Initial Sopris Phase. Small disc beads of shell and stone appear now.

Maize is present in small amounts suggesting at least incipient horticulture. Hunting and gathering is still the preferred method of exploitation.

<u>Late Sopris Phase (A.D. 1150-1225+)</u>

Unfaced, horizontally laid, unmortared sandstone slab masonry replaces adobe as the preferred method of architectural construction during the Late Sopris Phase. Corners are curved and posts are occasionally incorporated in the walls presumably as roof supports. Structures assigned to this phase include 5LA1416/A and 5LA1416/C. Other Late Sopris Phase sites in the Purgatoire River area include 5LA1413 (TC:C9:4), 5LA1418 (TC:C9:24), 5LA1415 (TC:C9:19), TC:C9:40, 5LA1419 (TC:C9:28). Site TC:C9:9 exhibits four separate methods of construction including adobe, stone and adobe, stone and jacal (Ireland 1970:60-63). This site is considered transitional to adobe and stone construction from Early to Late Sopris Phases.

One archaeomagnetic date from this phase is available. Feature 31 in Area B of 5LA1416, a large subterranean pit with walls oxidized by heat, produced a date of A.D. 1195±13.

Ceramic evidence points to a decrease in Red Mesa B/W and a corresponding increase in Taos B/W. S. Peckham (personal communication, 1980) dates this ware at A.D. 1050-1150 or 1200 and stated that trade from A.D. 1150-1225 is consistent with evidence from the northern Rio Grande. Wetherington (1968:53) extends the Taos B/W dates to A.D. 1000-1400. Breternitz (1966:96) dates the indigenous manufacture of Taos B/W in the Northern Rio Grande at A.D. 1150-1250. Taos Gray Incised with herringbone motifs predominates, but Taos Gray-Sopris Plain is also abundant. Cordmarked and polished wares reveal a significant decline. It is believed that if the phase continued past A.D. 1225 to any extent, carbon painted

Santa Fe B/W should have replaced Taos B/W. Ireland (1970:135) notes that Santa Fe B/W was attributed to Upper Purgatoire Complex sites by Baker but identification was refuted by Peckham. All B/W sherds subjected to chemical tests during the 1975-1979 study revealed the use of iron pigments. To date, no Santa Fe B/W sherds have been demonstrated to occur in Upper Purgatoire Complex (Sopris Phase) sites.

The artifact inventory reveals that slab metates have replaced trough metates as the preferred type. Shell disc beads are present but not as abundant as in the Early Sopris Phase. Grooved mauls appear now, indicating a late trade of this item or concept from the northern Rio Grande (Lang 1977:7, 10).

"Panhandle Culture" (ca. A.D. 1100-1450)

Although there is ample evidence of Panhandle Culture groups or influence throughout the Chaquaqua Plateau east of Trinidad, Colorado (Campbell 1976; Wood-Simpson 1976), there does not seem to be any significant penetration of this cultural manifestation in the upper Purgatoire or even the Park Plateau in general. This opinion has recently been reaffirmed by Campbell (1976). A distinctive feature of Panhandle Culture sites, dating between ca. A.D. 1100 and 1450 (Lintz 1978), is the predominate use of Alibates dolomite as a lithic source. Distinctive alternatively-beveled, diamond-shaped knives and side-notched and basally concave projectile points, as well as other artifacts, are made of this material. The source of the material is the Alibates Dolomite Lentil of the Quartermaster Formation along the Canadian River in the central Texas Panhandle (Glasscock 1955; Krieger 1946; Watson 1950). Alibates dolomite is virtually absent in the upper Purgatoire and only a single diamond-shaped knife of this material has been recovered. This artifact, together with a few sherds of Borger, or Stamper, Cordmarked ceramics (the type ceramic for the Panhandle Culture) were found in shallow, superficial deposits and have not been documented in lower cultural levels by the excavations reported here.

Lintz (1978:321) presented a provocative criticism of Campbell's (1976) model for the developmental sequence of Panhandle Culture architecture and its relationship to other cultural developments to the east of Trinidad on the Chaquaqua Plateau. Lintz cautioned that many of the Puebloan ceramics associated with Panhandle input sites are "surface finds" and as such, are of little use in dating specific architectural forms.

As is the case with the Sopris Phase sites discussed below, there is a complex diversity of structures throughout the Panhandle culture, probably due in part to specialized functions. There does not seem, however, to be any direct relationship, either ancestral or derivative, between the Sopris and Panhandle developments, with such hallmarks of certain Panhandle culture structures totally lacking (i.e., rectangular single-roomed structures lined with upright slabs, depressed floor channels and alter benches).

Carlana Phase (ca. A.D. 1525-1750)

The exact route and time of arrival in the Southern Plains of Athabascan speaking peoples from the north is not known. Our best evidence indicates that the peoples called "Apaches" were not known to the Pueblo Indians earlier than about A.D. 1525 (D. Gunnerson 1974:5). In the Purgatoire River valley, there are indications of a temporary occupation by these peoples by the presence of micaceous pottery, both of the Ocate Micaceous and Cimarron Micaceous varieties (J. Gunnerson 1969). These two types of ceramics occur late in the cultural sequence in the Park Plateau and elsewhere. Tentative dates of A.D. 1550-1750 have been proposed for Ocate Micaceous and A.D. 1750-1900 for Cimarron Micaceous.

Although sedentary Apace occupation has been described by Valverde as early as 1719 near Cimarron, New Mexico (Thomas 1935:22-33), investigations in southeastern Colorado have been unsuccessful in associating the presumed Apache ceramics with permanent dwellings. However, in the southern part of the Park Plateau along the upper Canadian River of New Mexico, J. Gunnerson (1969) has excavated adobe "Apache Pueblos."

The micaceous pottery problem is by no means settled (J. Gunnerson 1959, 1969; Ellis and Brody 1963). That is, no claim can be made for an Apache occupation on the basis of micaceous pottery alone. Wedel (1961:151) cautions that micaceous wares have been the principal ceramics of Taos and Picuris Pueblos from the time of the Pueblo Revolt of 1680. It cannot be assumed, therefore, that their presence in the Purgatoire drainage necessarily indicates Apache occupation of the area. However, without such historic Spanish wares as Casitas Red-on-Brown, Kapo Black, etc. (see Dick in Schroeder 1968) which are found at Baca Phase sites, the presence of Cimarron or Ocate Micaceous sherds in surface sites most likely indicates the presence in the area of the Jicarilla Apache. Sites such as 5LA1411 were apparent tipi rings and exclusively micaceous pottery fall into this category (Hand et al. 1977:65-67).

Montanes Phase (ca. 1750-1860)

The separation of the Montanes Phase from the Carlana is purely arbitrary. There is historical evidence that after about 1750, increasing pressure from Muache and Tabequache Utes, Comanches, and to a lesser degree, Cheyennes, Arapahoes and Kiowas, forced the Apaches (Jicarilias and Penzayes) out of southeastern Colorado, ultimately to reach their present home in northcentral New Mexico.

Several surface sites in the upper Purgatoire have produced small glass beads which were trade items during the post-1800 period. These sites usually contain projectile points, occasional grinding stones and lithic debitage.

THE RANCHERO COMPLEX

Baca Phase (A.D. 1860-1900)

In a preliminary report on the archaeological resources of the upper Purgatoire River, Dick (1963) proposed the "Ranchero Complex" to cover the period of initial Spanish settlement of the Trinidad area. Numerous sites which characterize this complex are located near Trinidad. Most of these represent small sheep ranches with evidence of both adobe and sandstone house foundations, porcelain, hand-wrought nails, late Taos or Picuris micaceous pottery, as well as other late ceramic types of "Spanish" origin such as those described by Dick (1968). Originally, Dick proposed the name "Lucero" for the single phase within this complex.

Since "Lucero Phase" has been used elsewhere (Dittert 1961:250) this phase has been redesignated the "Baca Phase" after Felipe Baca who established a ranch on the banks of the Purgatoire at the present site of Trinidad, Colorado in 1861 and was among the earliest Spanish-speaking settlers. Baca was followed by numerous other pioneers of Spanish surname who established their ranches in southeastern Colorado and gave the distinct Spanish flavor to that part of the state. So important in fact was the Spanish-speaking population, the Las Animas county commissioners enlisted the aid of surrounding counties in 1871 to translate the laws of Colorado Territory into Spanish so that written copies in that language could be distributed to county and precinct officers, only 11 out of 72 of whom could understand English (Taylor 1966:116).

The status of work on this important phase in the history of southeastern Colorado has not changed since the time of Dick's tenure at Trinidad. And yet, there are undoubtedly numerous more sites in the upper Purgatoire River drainage from this period. For example, even though the exploitation of coal in the Trinidad-Walsenburg area was not fully developed until after A.D. 1900, many of the small communities established during the Baca Phase (Taylor 1966:57) were later to become "coal camps."

Modern (post A.D. 1900):

Much the same as northeastern New Mexico, the Trinidad area remains largely Spanish-American in character today. However, with the construction of the Santa Fe Railroad in the early 1870s (Chronic and Chronic 1972:96), the economic base began to change rapidly. Small sheep ranches gave way to the larger cattle ranching operations made possible by the railroad. An ever-increasing interest in the exploitation of coal developed soon afterward. As early as 1846, Emory had noted the extensive deposits of soft, or bituminous, coal in the Trinidad-Walsenburg area, but serious mining did not begin until 1873 (Harbour and Dixon 1959:475). The period of greatest production was between 1905 and 1927 with a record of nearly 8 million short-tons mined in 1910.

With the development of the coal industry came the incorporation of Trinidad as a city in 1877, one year after Colorado statehood was granted, and the development of myriad small coal-camps in the upper Purgatoire River valley. Some of these towns (e.g. Sopris, St. Thomas, Piedmont and Viola) were removed during the construction of Trinidad Lake; others however have endured. West of Trinidad and upriver from Starkville and Janse, between Weston and Stonewall, Colorado, can be seen examples of the typical adobe architecture of the earlier Baca Phase which has continued into the present, even though the economic base has changed.

RE-EVALUATION OF DATED ARCHITECTURE

A recent re-appraisal of radiocarbon dates by Jeff Eighmy (Eighmy and Wood 1984) suggests that the pithouses and storage pits assigned to the Initial Sopris Phase may well date as early as A.D. 630 due to recalibration of the dates. All dates obtained from Sopris Phase sites are presented in Table 2.

Twelve radiocarbon dates obtained between 1966 and 1977 were

Site:	Provenience:	Radiocarbon Assay Number	$-\delta C^{14}$	Age (B.P.)	Date[1]	Archeomagnetic Date	Radiocarbon Recalibration
5LA1211	Feature 1-75 Post 9	Post I-9747	181±8	1605±60	A.D. 345	A.D. 1140±43	A.D. 425±80
	Feature 1-75 Beam	Beam I-9748	152±8	1325±80	A.D. 625		A.D. 655±80
	Feature 15 Storage Pit	----				A.D. 1085±31	
	Feature 53 Hearth	----				A.D. 1075±15	
	Feature 51 Pithouse	----				undateable[3]	
	Feature 59 Pit	I-9749	148±8	1285±80	A.D. 665	undateable[3]	A.D. 685±80
	TC:C9:9 (Breternitz)	Log W-1906		1030±250	A.D. 920		A.D. 1000±250
	TC:C9:9 (Breternitz)	Log W-1910		1000±250	A.D. 950		A.D. 1010±250
5LA1416	Feature 7 Hearth	I-9750	151±8	1315±80	A.D. 635		A.D. 670±80
	Feature 28 Hearth (Pit House)	I-9764	148±8	1285±80	A.D. 665		A.D. 685±80
	Feature 31 Fill	Post I-9753	119±12	1020±110	A.D. 930		A.D. 1000±80
	Feature 31 Floor	I-9763	145±8	1260±80	A.D. 690	A.D. 1195±13	A.D. 790±100
	Feature 77 Hearth	----				A.D. 1090±41	
	Feature 79 Pit	Charcoal I-9752	175±8	1545±80	A.D. 405	A.D. 1090±17	A.D. 525±80
	Feature 90 Hearth	I-9751	137±8	1185±80	A.D. 765	A.D. 1075±39	A.D. 785±80
	Correlation Trench #1	I-9762	161±8	1410±80	A.D. 540	undateable[3]	A.D. 630±80

[1] At 1-sigma level.
[2] At 2-sigma level.
[3] Statistical inconsistency between the specimens in the sample.

TABLE 2: Radiocarbon assay (Isotopes), archeomagnetic dates (Dubois), and recalibration (Eighmy) at 5LA1211 and 5LA1416.

perceived to be consistently too old. All seven archaeomagnetic dates fell within a 120 yr period, between A.D. 1075 and 1195, and were used along with ceramic cross-dating to develop the Sopris Phase chronology. It is felt now these should also be disregarded because the Southwest Virtual Geomagnetic Pole Path has recently been recalibrated and changed for dates between A.D. 1000 and 1300 (Sternberg 1982; McGuire and Sternberg 1982). Since the samples were reported without documentation, it is not possible to reinterpret them.

Four radiocarbon dates (I-9747, I-9748, I-9752, I-9753) were taken from unidentified portions of beams, posts or other pieces of charcoal and could date from hundreds of years earlier than actual use of the site (Table 2). Hence they also cannot be considered. However, the remaining six dates, when corrected (Struiver 1982) provide dates which fall between A.D. 630-875. These were taken from the central hearth of a pithouse and from pits and features which were the stratigraphically lowest or completely isolated. These corrected dates suggest that pithouses previously assigned to the Initial Sopris Phase (A.D. 1000-1100) might be part of an earlier, pre-A.D. 900, occupation. There was no instance where the identified radiocarbon samples came from features associated with adobe or masonry construction producing early dates. This premis is supported by the lack of consistently associated ceramics in pithouses.

Additionally, two remaining radiocarbon samples (W-1906 and W-1910), taken from log fragments at 5LA1211 (TC:C9:90, a multiroomed adobe structure), were corrected to produce dates of A.D. 1000±250 and

A.D. 1010±250. However samples were from identified portions of logs and could date earlier. These dates correlate well with associated ceramics. Finally, looking only at well dated structural remains, only pithouses have been documented in southern Colorado before A.D. 600 (for specific data, see Eighmy and Wood 1984).

Research and evaluation of other remnants of material culture will be necessary before a definitive statement concerning the origin and chronology of these earliest levels can be made. Present evidence suggests these pithouses and storage pits may represent the Woodland component that has previously eluded us.

It is suggested here that pit house architecture, storage pits and hearths were utilized between A.D. 630-875 and should be deleted from reviews of the Initial Sopris Phase.

CONCLUDING SYNTHESIS

In an attempt to integrate past research with the present study and conclude 25 years of research, it was felt that the time had come to organize and discuss hypotheses and recommendations concerning possible origins of, and external contacts with, the prehistoric inhabitants of the upper Purgatoire River valley. It was important as an attempt to synthesize knowledge concerning these sites and integrate this with research conducted in the adjacent Plains and Southwest culture areas.

Based on evidence presented only briefly here, but in detail within Part II of the Trinidad Lake Cultural Resource Study (Wood and Bair 1980) and from the research of our predecessors and colleagues, as well as from archaeological sequences on the Plains and in the northern Rio Grande, four major alternatives concerning origins have been suggested. These are:

1. Indigenous peoples have inhabited the area, perhaps from Archaic times, but at least well-established by about A.D. 1000.
2. Pioneering Rio Grande Anasazi groups migrated into the area as a reflection of the general population expansion of late Pueblo II times.
3. Newly-arrived Athabascan peoples came from the north by way of the Plains east of the Rocky Mountains.
4. Peoples were related to the generalized Plains Woodland pattern which began to express itself on the Central and Southern Plains at the beginning of the Christian Era and continued until ca. A.D. 1000.

INDIGENOUS POPULATIONS

The hypothesis that Sopris Phase populations represent indigenous peoples who inhabited the area, possibly from Archaic times, is difficult to prove or disprove on the basis of this research.

Paleoindian and Archaic components in the prehistory of southeastern Colorado have never been adequately defined. Campbell (1969, 1976), Anderson (1976) and Wood-Simpson (1976) mention some sites east of the Trinidad area affiliations and note surface finds of Paleoindian and Archaic projectile points. Ongoing research by the University of Denver at the Pinon Canyon Project along the Lower Purgatoire valley may aid in defining these components.

The most revealing information comes from Lutz and Hunt's (1979) extensive survey in 1977-1978 along the high terraces north of the Purgatoire River. They have been able to define early, middle and late components representing the Archaic from ca. 4000 B.C. to A.D. 0. Early Basketmaker-like projectile points were retrieved from sites and have been placed within the A.D. 0-400 time frame. A Woodland component follows from A.D. 400-1000. Late Prehistoric assemblages include Sopris Phase-like sites with stone structures dating post A.D. 1000. Apache sites from A.D. 1550-1900? were also identified.

Lutz and Hunt (1979) utilized a model for patterns of change based on subsistence. They note that early sites representing a total hunting and gathering subsistence base are generally located on high terraces above and away from major water sources. The onset of agriculture witnessed a trend toward locating closer to arable land.

Finally, the earlier Sopris Phase occupations are marked by the presence of what appears to be two indigenously manufactured ceramic types: Polished Plain and Sopris Plain. The former does not compare with polished wares from any other area. Sopris Plain was the preferred ceramic ware and appears to have degenerated with the introduction of Incised and B/W wares during the Late Sopris Phase which accompanies Pueblo II expansion late in that period. These early wares are suggestive of an indigenous population. However, the degree of influences from the Plains and the Southwest cannot be determined nor their importance overlooked in an analysis of culture change and origins.

RIO GRANDE ANASAZI

The similarities between the northern Rio Grande and the upper Purgatoire River valley during the Pueblo II period (A.D. 850 or 900 - 1050 or 1100) are seen in settlement patterns, architecture, ceramics and some aspects of material culture. By the end of the period, the Pueblo II culture was well established in the mountain-plains contact zone of the Canadian River in northern New Mexico (Lang 1977). Lutes (1959) has compared sites in the Philmont Scout Ranch to those in the upper Purgatoire River valley.

However, Purgatoire Complex sites with architecture appear suddenly, ca. A.D. 1000. this correlates with the expansion of Pueblo II populations into northern New Mexico. However, when comparing these two contemporaneous traditions, the absences in upper Purgatoire River sites of standard cultural traits found in Pueblo sites is notable. Although both share similar external architectural designs, i.e., pit, jacal and adobe houses with bell-shaped storage cists, no additional comparisons can be made. Ventilators, deflectors, ash pit hearth combinations, kivas, cranial deformations, bundle burials, beads, squash and domestic turkey are not present in Sopris Phase sites. Maize has been recovered in such small amounts, it is felt that horticulture did not predominate as a major subsistence pattern. Arable land is abundant in the wide floodplain of the Purgatoire River and it is postulated that environmental conditions at that time, which supported agriculture in northern New Mexico, could have supported a more intensive horticultural base here as well. Ceramic tradeware and several turquoise pendants are associated with the Late Sopris Phase.

If one accepts this hypothesis, the absence of such important cultural traits as kivas and cranial deformation as well as the lack of evidence for beans and squash, suggests that either religious and esthetic values and subsistence techniques changed drastically on arriving in the Purgatoire River valley or the northward expansion of the Puebloan peoples resulted in increased trade due to accessibility. To presume the former would seem to be unreasonable. Hence, it is believed that the latter hypothesis is the only reasonable alternative.

ATHABASCANS

The hypothesis that peoples inhabiting the Upper Purgatoire River area were Athabascans who came from the north by way of the Plains has been included because of limited evidence from physical anthropological assessments suggesting a physical type similar to that of Athabascan peoples.

Turner (in Wood and Bair 1980, Appendix I) analyzed thirteen individuals from burials at sites in the Upper Purgatoire valley. Turner reported a 23.1% incidence of three-rooted first mandibular molars, which correlates with that of the Navajo and Northwest Coast Indians, indicating Athabascan affinities. It differs from findings for Anasazi populations (4.9%). Additionally, Miller's (in Wood and Bair 1980, Appendix II) appraisal of ABO blood grouping also supports Athabascan origins, if ABO analyses are considered valid. Archaeological evidence to support an Athabascan migration into southeastern Colorado before A.D. 1500 is lacking.

Since Fremont influences between A.D. 500 and A.D. 1400 in the eastern portion of Colorado cannot be documented, it is difficult to explain Athabascan physical traits present in the Purgatoire populations. It is sufficient to say that either the earliest migrations which are evidenced by Anasazi influences in the Utah-Fremont may have produced a similar situation in eastern Colorado or that three-rooted first mandibular molars are a result of early Athabascan admixture with Plains populations.

PLAINS WOODLAND

Plains Woodland affiliations are certainly exhibited in Sopris Phase sites. However, to directly relate this in totality to any particular tradition, focus or phase in the Central and Southern Plains is not possible. Unfortunately, a vast expanse of archaeologically uncharted territory lies between the upper Purgatoire valley and areas east which exhibit known Woodland chronologies. Present research by the University of Denver at the extensive Pinon Canyon project may shed some light in this area.

Lutz and Hunt (1979) noted the presence of Woodland sites dating from A.D. 400-1000 in the previously discussed survey of the upper Purgatoire and Apishapa drainages. Whether these are direct antecedents of the Sopris Phase cannot be determined. No site identified as Woodland has ever been excavated in this immediate area.

Campbell (1976) notes the appearance of cordmarked ceramics, masonry structures and limited horticulture on the Chaquaqua Plateau during this time and places this

Woodland tradition in the Graneros Focus as defined by Withers (1954).

The presence of cordmarked ceramics at early levels in Sopris Phase sites, as well as the construction of jacal semi-subterranean houses, could suggest Plains affiliations. Additionally, the continued use of elbow pipes throughout the phase, as well as the Woodland-like projectile point from burial 1-77, would indicate contacts with the east. Cordmarked ceramics, triangular side-notched projectile points, diamond-shaped beveled knives, Alibates dolomite and masonry structures during the Late Sopris Phase can be related to the Apishapa Focus to the east and thus the Panhandle Aspect. However, Sopris Phase sites are clearly too early to postulate a direct relationship. The tremendous impact of the northern Rio Grande here as well as over the entire northeastern periphery, tends to overshadow what may be a development from a generalized Plains Woodland pattern. Present re-evaluation of radiocarbon dates and those associated architectural features may further illuminate this Woodland pattern. Additionally, the previously mentioned dearth of basic Puebloan traits gives evidence to the thesis that Sopris Phase populations entered the region from the east.

SUMMARY

A general overview of the present knowledge concerning the Sopris Phase populations in reference to culture contacts and possible origins of Sopris Phase peoples has been presented. Archaeological evidence suggests that:

1. an indigenous base, beginning at least from the Archaic is indicated;
2. possible early migration of Athabascans onto the Central Plains, combined with a generalized Plains Woodland pattern, expressed itself in this area at least by A.D. 1000; and
3. Sopris Phase peoples were not a northern extension of the Anasazi culture.

A definitive statement concerning origins would be premature because of the status of archaeology in southeastern Colorado. Efforts to distinguish between Athabascan, Plains and southwestern influences, as well as evaluating a base for possible indigenous populations may conclude this study, but is only a start in understanding these prehistoric developments. The many thousand square kilometers of uncharted territory on the Eastern Slope of Colorado may well contain the missing pieces to the puzzle of Athabascan-Plains-Puebloan contacts.

REFERENCES CITED

Anderson, J.
1976 A techno-functional analysis of the flaked lithic materials from three Woodland period sites on the High Plains, Southeastern Colorado. Ms. on file, Department of Anthropology, University of Colorado, Boulder.

Breternitz, D.A.
1966 An appraisal of tree-ring dated pottery in the Southwest. Anthropological Papers, University of Arizona 10.

Campbell, R.G.
1969 Prehistoric Panhandle culture on the Chaquaqua Plateau, Southeastern Colorado. Unpublished PhD. dissertation, Department of Anthropology, University of Colorado, Boulder.

1976 The Panhandle Aspect of the Chaquaqua Plateau. Graduate Studies, Texas Tech University, Lubbock.

Chronic, John and Halka Chronic
1972 Prairie, peak and plateau: A guide to the geology of Colorado. Colorado Geological Survey, Bulletin 32.

Dick, Herbert W.
1963 Preliminary Report: Trinidad Reservoir, Las Animas County, Colorado. Ms. on file, National Park Service, Midwest Archaeological Center, Lincoln, Nebraska.

1968 Six historic pottery types from Spanish sites in New Mexico. In Collected Papers in Honor of Lyndon Hargrave (B.H. Schroeder, ed.), Papers of the Archaeological Society of New Mexico 1.

Dittert, A.E., Jr., J.J. Hester and F.W. Eddy
1961 An archaeological survey of the Navajo Reservoir District, northwestern New Mexico. Monographs of the School of American Research and the Museum of New Mexico 23.

Eighmy, Jeff and Caryl E. Wood
1984 Dated architecture on the southern Colorado Plains. Papers of the Philmont Conference on the Archaeology of Northeastern New Mexico. New Mexico Archaeological Council Proceedings 6(1).

Ellis, Florance Hawley and J.J. Brody
1963 Ceramic stratigraphy and tribal history at Taos Pueblo. American Antiquity 29:316-327.

Fenneman, Nevin M.
1931 Physiography of the western United States. McGraw-Hill, New York.

Glasscock, Keith and Alma Glasscock
1955 A preliminary report on CR-1, an Indian campsite in Mosie County, Texas. Panhandle-Plains Historical Society, Canyon, Texas.

Gunnerson, Dolores A.
1974 The Jicarilla Apaches. Northern Illinois University Press, DeKalb, Illinois.

Gunnerson, James H.
1959 Archeological survey in northeastern New Mexico. El Palacio 66:145-154.

1969 Apache Archeology in northeastern New Mexico. American Antiquity 34: 23-39.

Hand, O.D., Carla Latuda and Gerald A. Bair
1977 Trinidad Lake cultural resource study, Part 1: An evaluative survey of historic and archeological sites within the Corps of Engineers Trin-

idad Lake Flood Control Project, Las Animas County, Colorado. Ms. on file, Laboratory of Contract Archeology, Trinidad State Junior College, Trinidad, Colorado.

Harbour, R.L. and G.H. Dixon
1959 Coal resources of the Trinidad-Aguilar area, Las Animas and Huerfano Counties, Colorado. *United States Geological Survey Bulletin* 1072G: 445G-489G.

Ireland, Stephen K.
1970 Purgatoire River Reservoir salvage archeology, 1969: Sites TC:C9:4 and TC:C9:9. Ms. on file, National Park Service, Midwest Archaeological Center, Lincoln, Nebraska.

Krieger, A.D.
1946 Culture complexes and chronology in northern Texas with extension of Puebloan datings to the Mississippi Valley. *University of Texas Publications* 4640.

Kuchler, A.W.
1964 Potential natural vegetation of the coterminous United States. *American Geographical Society, Special Publication* 36.

Lang, R.W.
1977 The prehistoric Pueblo cultural sequence in the northern Rio Grande. Paper presented at the 1977 Pecos Conference, Santa Fe, New Mexico.

Lintz, Christopher
1978 Architecture and radiocarbon dating of the Antelope Creek Focus: A test of Campbell's model. *Plains Anthropologist* 23(82):319-328.

Lutes, Eugene
1959 A marginal prehistoric culture of northeastern New Mexico. *El Palacio* 66:59-68.

Lutz, Bruce and William J. Hunt, Jr.
1979 Models for patterns and change in prehistoric settlement: Subsistence systems of the Purgatoire and Apishapa Highlands. Ms. on file, Interagency Archaeological Services, U.S. Department of the Interior, Denver.

McGuire, R.H. and R.S. Sternberg
1982 A revision of the virtual geomagnetic pole curve for the Southwest (A.D. 1100-1400) and its implications for archaeomagnetic dating. Paper presented at the 47th Annual Meeting, Society for American Archaeology, Minneapolis.

Sternberg, R.S.
1982 *Archaeomagnetic secular variation of direction and intensity in the American Southwest.* Unpublished PhD. dissertation, Department of Geosciences, University of Arizona.

Struiver, M.
1982 A high-precision cali-

bration of the AD radiocarbon time scale. Radiocarbon 24(1):1-26.

Taylor, Morris F.
1966 Trinidad, Colorado Territory. Trinidad State Junior College, Trinidad, Colorado.

Thomas, A.B.
1955 After Coronado. Spanish Exploration Northeast of New Mexico, 1696-1727. University of Oklahoma Press, Norman.

Watson, V.
1950 The Optima Focus of the Panhandle Aspect: Description and analysis. Texas Anthropological Society 21:7-68.

Wedel, Waldo
1961 Prehistoric man on the Great Plains. University of Oklahoma Press, Norman.

Wetherington, Ron
1968 Pot Creek Pueblo. Fort Burgwin Research Center, Research Paper 6.

Withers, A.M.
1954 University of Denver Archeological Fieldwork, 1952-1953. Southwestern Lore 19(4):1-3.

Wood-Simpson, Caryl
1976 Trinchera Cave: A rock shelter in southeastern Colorado. Unpublished M.A. thesis, Department of Anthropology, University of Wyoming, Laramie.

Wood, Caryl E. and Gerald A. Bair
1980 The Trinidad Lake cultural resource study, Part II: The prehistoric occupations of the upper Purgatoire River valley, southeastern Colorado. Ms. on file, Department of Anthropology, Trinidad State Junior College, Trinidad, Colorado.

Caryl Wood
851 Taylor
Craig, Colorado