Investigation into prehistoric lithic procurement in the Bearlodge Mountains, Wyoming

Tim Church

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AN INVESTIGATION INTO PREHISTORIC LITHIC PROCUREMENT
IN THE BEARLODGE MOUNTAINS, WYOMING

by

Tim Church

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This thesis presents the results of field and laboratory analysis of lithic resources found in the Bearlodge Mountains of northeastern Wyoming. It includes morphological, microscopic, and geochemical information on the stone available at prehistorically exploited lithic sources, as well as unexploited lithic sources. Also included are comments on procurement techniques, the spatial distribution of exploited lithic sources, and suggestions for future research.
PREFACE

After some five years of frequently being gone on weekends to the field, and later to the lab, of hauling around and storing boxes of dusty, dirty rocks, and spending money on equipment and supplies, my loving thanks goes to my wife who put up with it all.

My sincere thanks also goes to the following people. Mr. Lance Rom, Forest Archaeologist for the Black Hills National Forest, who thought I was a little crazy but nevertheless supported my efforts. The late Dr. Robert Alex, South Dakota State Archaeologist, who quietly encouraged the early stages of the project. and Dr. Thomas Foor, Anthropology Department, University of Montana, for his constant patience and advice.
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INTRODUCTION

Study Goals

There were two main goals of my study. My first was to assemble a documented comparative collection of stone from the Bearlodge Mountains of Wyoming. My second goal was to describe the stone in sufficient detail to provide a database on which a stone tool could be reliably assigned to at least the formation from which it came.

Stone is the most abundant, and sometimes only, artifact material found on archaeological sites in the Northern Plains. While studies of its use and tool production have been undertaken, the identification and study of the sources of these raw materials have been neglected. In part this has been because it was thought that highly technical and expensive technologies were necessary to trace the raw stone accurately. When such studies have been undertaken, most have adopted a strict reliance upon the geologic methodologies and terminology. I suggest this has inhibited the archaeological study of raw materials. Butler (1984: 299-300) in discussing the papers contributed at the first prehistoric chert exploitation conference in 1981 succinctly observes that:

What we have advocated and what is generally in evidence in these papers are archaeological chert types, that is, specific ranges of variation in cherts that are defined as meaningful by the archaeologist. These may or may not equate precisely with geological identifications, although in most cases the attempt is
made to match the "type" with a specific geological deposit or group of deposits. One should not forget that decisions on the identity and classification of geological units are sometimes as arbitrary as many traditional archaeological classifications.

The perspective taken here is that a standard terminology should lie at the base of any study relying upon lithic source data. At present such a standard terminology does not exist. What does exist is a mixture of geologic, archaeological and "rock hound" terms that are vague or rely too heavily on petrographic or chemical traits. A brief review of the literature provides several examples. For example porcellanite is a baked clay common in the Fort Union formation (Fredlund 1976) as well as a chert resulting "from the presence of disordered cristobalite or from argillaceous and calcareous impurities (Blatt 1980, p. 571)," thus the two are, by definition, totally different.

Another is the term jasperoid, within the geologic community itself there is a confusion over to what type of rock the term refers. "These include blout, flint, quartz, jasper, hornstone, chert, seczite, ozarkite, cherokite, silicified limestone, and silicified dolomite (Lovering 1972:2)."

A standard terminology should depend upon a set of observable traits that enables one to differentiate between stone types. In geology such traits are often petrological or chemical and require time consuming thin sectioning or chemical tests to determine the samples provenance. I believe that this, in part, is why archaeology has failed to adopt the geologic methodologies. Further, archaeologists fail to recognize the incompatibility with archaeology of a geologically based framework co-
opted for use in archaeology. The stone most often of interest to
archaeologists represents a very special and rare form of the stone type to
the geologist, which is usually not of economic value. To have value to
prehistoric peoples the stone must be accessible, sufficiently free from
internal defects to allow controlled reduction, and of sufficient size for
reduction. While in one sense a rock remains a rock the questions that
the geologist and the archaeologist hope to answer by the study of stones
are widely divergent.

Added to these inter-disciplinary problems are the various techniques
championed within archaeology. Luedtke discusses the sometimes
ridiculous bickering over whose technique was better. She rightly points
out that:

The truth is that they all work; each works better in some cases or
situations than in others but they are all useful in their different
ways. An optimal system of lithic source identification should
attempt to make use of as many different kinds of information
about chert types as possible, . . . (Luedtke 1987: 5).

This study's basic thrust is to construct a system for the archaeological
study of stone for the Bearlodge Mountains of Wyoming. Such a
systematic, practical method for the identification of stone material types
and their sources would enable studies of exchange systems, temporal
aspects of use, procurement strategies and techniques, and group
mobility. As Ahler has pointed out we need to know what types and the
extent of all lithic resources, exploited and non-exploited, present before
we can begin making statements about resource use (1977: 133).
Previous Research

**Resource Studies.** No detailed archaeological work has been conducted at any Bearlodge Mountains lithic procurement sites. The lithic sources in the adjacent Black Hills have also had, at most, only basic site recording, even the well-known Flint Hill and Battle Mountain quarries lack such basic pieces of documentation as site maps, or published artifact descriptions. Characterization of lithic raw materials is, at best, rudimentary. Raw material definitions are based on undocumented samples, personal knowledge, and oral tradition mixed with a large number of assumptions.

**Overviews.** The 1984 cultural resource overview completed for the Black Hills National Forest, which includes the Bearlodge Mountains, (Cassells, Miller & Miller 1984) has only three pages on lithic procurement sites. The major quarries of Spanish Diggings, Knife River Flint, porcellanite are outlined as sources of artifacts found in Black Hills sites. Black Hills sources of chipable stone are only briefly mentioned and there is no attempt to provide either a geologic distribution of the sources or meaningful geological descriptions. The lithic sources in the Bearlodge Mountains are not addressed.

**Sourcing Studies.** Most quartzite tools from the Vore site, a late prehistoric bison trap near Sundance, Wyoming were attributed to the Spanish Diggings quarries (Reher and Frison 1980). This determination was based on the gross characteristics of the stone from the site and the personal knowledge of the author.
Craig in her study of lithic sources in northeastern Wyoming and Southeastern Montana suggests that the Black Hills contains only limited quantities of good quality cherts, and that quartzites "tend to have greenish-brown and grey tones to them (Craig 1983: 42)."

Alice Tratebas has conducted the only other investigations into Black Hills lithic sources. She also did not investigate the Bearlodge Mountains lithic sources. During her tenure at the South Dakota Archaeological Research Center she documented a number of quarry sites in the Black Hills. She did not, however, collect well documented samples or publish detailed descriptions of the materials. Her dissertation hypothesis (Tratebas 1986) relied heavily on determining the source of Black Hills artifacts. Unfortunately her source descriptions are vague (for example she defines Hogback chalcedony as, "chalcedonies in light gray or brown colors, sometimes mottled, and distinguished by small circles of lighter colors (Tratebas 1986: 427)," and based on her personal knowledge. As such the descriptions contribute very little to the understanding of lithic types and procurement in the Black Hills.

**Northern Plains Overviews.** Ahler (1977) published the first regional overview of northern plains lithic resources, and it remains the basis of much of the work done on the plains. Unfortunately the study has become dated with the discovery of additional resources. The study also only broadly describes the resources based on visual characteristics. Ahler’s study formed the basis for two later studies, Nowak (1982) and Ketcherside (1983), both of which were completed as part of the Northern Border Pipeline cultural resource studies. Nowak’s research added only a
few pieces of information, while Ketcherside supplemented Ahler's study with important, albeit secondary, geologic information.

Another overview on the periphery of the northern plains was completed by Bakken (1985). This study was based on the author's own field sampling of 67 lithic sources in northwestern Minnesota. The collected materials were classified into eight broad groups and described on the basis of visual observations. While limited in scope the study is notable because it was done as an undergraduate thesis.

Specific Sources. Outside of the main study area several nearby sources have been investigated (figure 1). A number of lithic procurement areas have been recorded in the Badlands, southeast of the Black Hills, yet most have not received any detailed investigation. However, investigation at one major chert quarry, 39SH37-the West Horse Chert Quarry (Nowak and Hannus 1985), has provided an important base of information. Besides adding to our knowledge of the types of material available in the Badlands, the investigators established a temporal range of use for the quarry. Based on C-14 dates the quarry was exploited from 810 B. C. to 1230 A. D., and surface collection of Clovis points at the site hints at a much greater time depth.

The Spanish Diggings quarries, to the southwest of the Black Hills had attracted attention as early as the 1890's. The information available on the site was limited to information gathered during short visits until the 1960's. Unfortunately these visits also resulted in the collection of thousands of tools from the quarries and their subsequent loss. It was not until 1966 (Saul 1966) that something of a systematic investigation was undertaken at some of the quarries. Since then the extensive quarries
continue to attract attention (Duguid and Bedish 1968 for example) but their vastness has inhibited any substantial overall investigation. The quartzites from Spanish Diggings and the smaller Flint Hill quarry were petrographically compared by two Chadron State College (Nebraska) geologists (Witzel and Hartley 1976). Their conclusion was that the two sources could be differentiated based on grain size, color and percentage of cement.

Perhaps the best known of the northern plains sources are the Knife River Flint quarries in western North Dakota. The quarries, which extend over some 10,000 acres, have been exploited for at least 11,000 years. The material was petrographically described in 1970 (Clayton et al. 1970: 282-290). The tool manufacture, stratigraphy, and procurement techniques present at the quarries have been investigated.

The other dominant material on the northern plains is porcellanite (a metamorphosed clay) from the widely scattered sources centered in southeastern Montana. The material was first described archaeologically in 1976 (Fredlund 1976). Since then the material has been the subject of several studies including analysis of stone distribution (Clark 1981) and procurement (Clark 1982).

Other source or material specific studies on the northern plains include: Rainy Buttes silicified wood of southwest North Dakota (Loendorf 1984); the lithic resources available in quaternary deposits in the badlands of southwestern North Dakota (Kuehn 1982); the glacial till sources of the material known as Tongue River Silicified Sediment, Silica or Quartzite, found in eastern South Dakota and much of Iowa (Andersen 1971 & 1978) and Keyser and Fagan’s more detailed study of a
Figure 1. Major North Plains Lithic Sources.
Tongue River Silica procurement site in the Cave Hills of northwestern South Dakota (Keyser & Fagan 1987); the Nehawka flint of western Nebraska extensively studied just after the turn of the century (Blackman 1907); Antelope chert, a fossiliferous chert from the Custer National Forest in southwestern North Dakota (Beckes et. al. 1987); Davis' on-going studies at the Schmitt chert quarry site in western Montana (Davis 1982a & 1982b), as well as his investigation at the South Everson chert quarry in southwestern Montana (Davis 1981); and Campling's study of Swan River chert in west-central Manitoba (Campling 1980). There are, of course, other studies underway or not available in the literature.

As far as non-chipped stone the list of studies is quite short. There is Frison's study of steatite sources in the Bighorn Mountains of Wyoming (Frison 1982), Hartley's thesis on the procurement of salt on the northern plains (Hartley 1979), Sigstad's doctoral dissertation on catlinite (Sigstad 1973), and an as yet unpublished study on South Dakota pipestone resources (Gundersen 1986).

Overall the northern plains is rich in lithic material sources, many presumably exploited on a local level, and several on a regional level.

**Sourcing Studies.** Ahler's 1989 study of the lithic materials at Medicine Crow site on the Missouri River in South Dakota attempted to differentiate between local and non-local materials and suggested sources for the non-local materials. Ahler concluded that the majority of materials were local in origin, while use of such non-local materials as Knife River Flint, orthoquartzites, basalt, Tongue River quartzite and others was limited.
Francis’ 1983 dissertation on lithic procurement in the Bighorn Mountains of Wyoming focused on how the stone from the various formations was exploited (using Binford’s 1979 model) and how this is reflected in the artifact assemblage. By examining the artifacts from a sample of procurement and non-procurement sites, she was able to show that materials from certain sites appear to have been exploited for specific purposes. Her artifact sourcing was based upon visually observed characteristics only, no geochemical analyses were used. She found that secondary sources, Amsden formation (corresponding to the Black Hill’s Minnelusa formation) and Cambrian formation sources were not heavily exploited. While Morrison, Phosphoria (corresponding to the Black Hill’s Spearfish formation) and Madison formation (corresponding to the Black Hill’s Pahasapa formation) sources were heavily exploited.

Lithic artifacts from the Milliron site, a Folsom bison kill site in southwestern Montana, were visually examined and possible sources suggested. Francis (1988) suggests that the majority of lithic materials were obtained locally. These materials included porcellanite from outcrops, silicified wood and cherts from lag deposits, and lag deposits of Tongue River quartzite (a.k.a. Tongue River Silicified Sediment, Tongue River Silica, and TRSS). Two materials were considered non-local, these were an orthoquartzite and a dendritic chert. Sources of these materials were suggested as either the Hartville uplift, the Bighorn mountains, or the Black Hills.

The Wittrock Site (13OB4), in northwestern Iowa, is a fortified village site of the Mill Creek culture (A.D. 900-1300). Five pipestone specimens excavated from the site were subjected to x-ray powder diffraction
analysis. The results indicate that the pipestone originated locally from river-terrace gravels deposits (Gundersen 1986).

**Visual Approach.** A previous study (Haury 1984) provided many of the techniques adopted for this investigation. Haury investigated the chert resources of the Flint Hills in Kansas and Oklahoma. In her conclusions Haury states:

> It is posited that macroscopic and lens-aided observations reveal characteristics which can be used to distinguish the chert types of the southern Flint Hills. This proposal is based on the fact that variations in depositional and diagenetic environments resulted in different modes of occurrences and variations in the physical features of the cherts formed within them. If the means and conditions under which chert forms are sufficiently varied, then chert from different lithofacies will exhibit definitive combinations of diagnostic structures (Haury 1984: 71).

She found that the variables of color, texture, luster, fracture, inclusions, and morphology were sufficient to determine the probable source of stone artifacts in many cases. “It must be emphasized that it is a combination of features which makeup the necessary and sufficient requirements for each (chert) type (Haury 1984: 71, emphasis added).”

**Geological Approach.** Lanier and Dodd (1985) suggested a strict reliance on simple geological methods in determining basic rock types on sites in Utah. Traits such as hardness, and reaction to hydrochloride acid along with visual attributes were suggested as being sufficient for determination. The researchers did not however attempt to attribute
rock types to specific sources or even to formations. Also the study did not include chert.

A study using traditional petrological techniques (Mason & Aigner 1987) of basalt artifacts from three Aleutian sites found that a distant flow of basalt had been the preferred source for inhabitants at the three sites and that the source was exploited over a lengthy period of time.

The sources of fibrolite axes common in southwestern Pueblo sites was investigated in 1963 (Montgomery 1963). From a mineralogic comparison (the specific techniques are not stated) of the axes recovered and by comparison of the geologic literature for similar outcrops, the author concluded that the majority of the material for the axes was located in northwestern New Mexico.

Reid is unique in Plains lithic studies in his use of biostratigraphic techniques in the sourcing of late Paleozoic cherts. The technique relies upon the presence/absence of certain fusulinids with known temporal distributions. The technique was shown to be useful in determining the formation of chert artifacts.

Geochemical Approach. A number of investigators have used Instrumental Neutron Activation Analysis (INAA) to determine the trace elements of exploited stone. Ludekte (1979) was one of the first to use INAA as a base for trace element characterization of chert artifacts. She correctly points out two of the main weaknesses of visual sourcing.

*In general, visual identification alone is inadequate for any serious study of chert material types. The chance of error is great, and too much confidence must be placed on the identifier's*
expertise in chert discrimination. Furthermore, the identifier's decisions cannot readily be evaluated by other workers, since the decisions are usually not based on clearly stated, objective, quantifiable criteria (Ludekte 1974: 745-746).

Her examination of the sources of chert in the Great Lakes area centered around correct interpretation of her data as much as the usefulness of the INAA technique. She concluded that INAA was useful for chert types in the Great Lakes area (she explicitly stated that the techniques used and the results may not be valid elsewhere). Further she found that the results could vary widely dependent upon the choice of trace elements used in the discriminant analysis.
THE STUDY AREA

Geographic Location

The study area includes the majority of the Bearlodge mountains in northeastern Wyoming (figure 2). The Bearlodge Mountains offered several advantages: the area is geographically isolated, which simplified delineation, and the lithic resources have not been characterized to form an adequate database for provenance studies. Within this area occur known sources of chalcedony, quartzite and silicified wood.

Topography

Lands within the the Black Hills National Forest, which includes the majority of the Bearlodge Mountains, have been classified into six major landform regions (figure 3) based on the various ecosystems (Black Hills National Forest n.d.). In turn each region is divided into various districts, which are themselves divided into individual ecological land units (ELUs).

The six regions (based on Feneman's (1931) classification) are as follows:

Crystalline Basin: this area forms the core of the Black Hills. It consists of Precambrian granites, schists, slates and meta-quartzites forming rugged topography such as Harney Peak and the Needles.
Figure 2. Location of the Study Area, Bearlodge Mountains, Wyoming
Figure 3. Regions of the Bearlodge Mountains.
(Source: Black Hills National Forest, n.d.)
Limestone Plateau: this region surrounds the Crystalline Basin and is composed primarily of limestones, dolomites and sandstones of Cambrian to Permian age. The high plateau is cut in several places, such as Spearfish Canyon, forming narrow canyons surrounded by high, steep cliffs.

Red Valley: the Red Valley surrounds the Black Hills and is often referred to as the "race-track." It is a broad, up to 2 miles, flat area most conspicuous on the east side of the Black Hills. It is characterized by the red soil of the Spearfish formation. Other outcrops include shales, sandstones, siltstones and gypsum.

Dakota Hogback: the hogback in turn surrounds the Red Valley forming the outer rim of the Black Hills. The ridge is most pronounced along the northeast side of the Black Hills and gradually breaks into smaller ridge complexes to the south, north and west. Altitude varies from 3,800 to 4,900 feet above sea level. The Hogback is composed mainly of sandstones from the Fall River and Lakota formations.

Cuesta: the two small areas classified as Cuesta occur in southern Black Hills and are dry canyonlands of sandstone.

Volcanic Mountains: a number of volcanic intrusions occur in the northern Black Hills, 7,071 foot high Terry Peak being the highest. Others include Inyan Kara, Cement ridge, and Warren Peak in the Bearlodge Mountains (figure 4). They are composed of rhyolites, porphyries and monzonites.

This ecosystem classification system formed the basis for classifying the lithic sources investigated in this thesis. The modified system is fully discussed at the beginning of the results chapter.
Figure 4. Digital Elevation Model of Black Hills National Forest Lands, Bearlodge Mtns., Wyoming
Geology

To gain an idea of the variability, abundance, and diagenetics of the exploited stone the general geology of the area must be understood. The following discussion was compiled from the geologic literature of the Bearlodge Mountains region. A description of only those formations that outcrop within the Bearlodge Mountains is presented below. The formation descriptions were compiled from two sources, Robinson et. al. 1964 and Staatz 1983. A complete geologic column for the Black Hills/Bearlodge Mountains is presented in figure 5

The White River Group and Ogalalla formation

The Tertiary rocks of the Bearlodge Mountains and Black Hills include the White River Group consisting of claystone, siltstone, and limestone which occurs mainly on the eastern flank of the Bearlodge Mountains. The Ogalalla formation consists of sandstone, conglomerate, and siltstone with a minimum thickness of 50 feet in the southern Bearlodge Mountains.

Newcastle Sandstone

The Newcastle sandstone “... is a varied unit consisting for the most part of lenticular beds of sandstone and shale, with lesser amounts of siltstone, carbonaceous shale, coal, and bentonite (Robinson et al. 1964: 44).” Its thickness ranges from 20-100 feet. It does not outcrop within the Bearlodge Mountains but is present in the foothills. Fresh-water mollusk fossils and dinosaur bones have been reported although fossils are overall scarce in the formation.
Fall River (Dakota) Sandstone

Fall River sandstone caps the higher areas of the Bearlodge Mountains as well as the southern Black Hills. It is also the cap rock along much of the hogback ridge. "Much of the sandstone is in beds less than an inch to about a foot thick, although thicker bedded sandstone units 30 to as much as 50 feet thick generally make massive rounded ledges in the upper half of the formation (Robinson et. al. 1964: 27)." Marine fossils such as fresh-water mollusks, plesiosaurian teeth, pelecypod, as well as various plant remains have been reported.

Lakota Formation

The Lakota consists mainly of "...medium grained, light-gray to white, medium-bedded to massive sandstone (Staatz 1983: 15)." Some beds are crossbedded. The formation ranges in thickness from 3-4 meters in the southern Bearlodge to 90 meters in the northern. It contains fossil ferns, cycads, conifers, ostracodes and other plant remains. It has been correlated with the Cloverly formation of central and western Wyoming (the well-known Spanish Diggings quarries in southeast Wyoming are in the Cloverly formation).

Morrison Formation

This formation is mainly composed of greenish-gray claystone ranging in thickness from 6-37 meters. It contains such fossils as ostracodes, dinosaur bones, and silicified wood.
Figure 5. Geologic Column of the Black Hills and Bearlodge Mtns.
(Source: S.D. School of Mines and Technology, n.d.)
Sundance Formation

The Sundance formation is chiefly composed of sandstone and shale divided into five members. These are the Redwater (sandstone/shale), Lak (sandstone), Hulett (sandstone), Stockade-Beaver (shale), and Canyon Springs (sandstone). It remains a uniform thickness of about 100-120 meters through the Bearlodge. Fossils include ammonites, ostracodes, brachiopods and foraminifera.

Gypsum Springs Formation

". . .Consists of massive white gypsum, red claystone, and gray limestone. . . (Robinson et. al. 1964)," often forming ledges and cliffs. It is intermittent through northeastern Wyoming with thicknesses ranging from 125-80 ft. The only fossils reported are ostracodes from the red claystone unit in the upper part of the formation.

Spearfish Formation

Consists of shale, siltstone and fine-grained sandstone. The lower part is notable because of the abundance of white gypsum and the formation's deep red color. It ranges in thickness from 155 to 273 meters. No fossils have been reported from the formation.

Minnekahta Limestone

This thin formation is composed of gray limestone ranging in thickness from 5-10 meters. No fossils from this formation have been reported from the Bearlodge Mountains, although some have been found in the nearby Black Hills.
Opeche Shale

"The Opeche Formation consists of fine-grained, reddish-brown siltstone and some shale (Staatz 1983: 12)." Formation thickness ranges from 7 to 36 meters. No fossils have been reported from the formation.

Minnelusa Formation

The majority of the formation consists of a sandstone, although beds of tan to gray limestone do occur. The formation has been typically broken into three members, the Converse, Leo, and Fairbank. Formation thickness ranges from 175-200 meters. No fossils have been found from this formation in the Bearlodge Mountains.

Pahasapa Limestone

The Pahasapa is a thick, 150-175 meters, gray limestone. It is resistant and often forms ledges, hills, and low cliffs. It is also cavernous in the Black Hills. Fossils are rare from this formation in the Bearlodge Mountains, but common elsewhere. Brachiopods and corals have been collected in the Black Hills.

Whitewood Formation

This formation consists of thin unit of light-gray, fine-grained limestone ranging in thickness from 30-45 meters. No fossils have been reported from this formation in the Bearlodge Mountains.

Deadwood Formation

This is the oldest sedimentary formation in the Bearlodge Mountains and is chiefly composed of quartzite and shaly limestone. Thick beds of
white and brown to red quartzite occur in the southern Bearlodge (Staatz 1983: 9). Its thickness ranges from 100 to over 300 meters. Fossils consist of trilobites, fish remains, conodonts. Another feature of some of the beds are vertical, sand filled worm burrows.

The PreCambrian is represented in the Bearlodge (specially the southern portion) by granitic rocks such as those that form Warren Peak.

History

The Bearlodge Mountains and Black Hills first known white visitors were the fur-trappers in the early 1800s, although there is some evidence to suggest earlier entry by white explorers into the region. The Bearlodge Mountains as well as the Black Hills were given to the Dakota Indians in the Fort Laramie treaty of 1851. Shortly after the Civil War rumors of gold discoveries in the Black Hills attracted miners. In 1874 General George Armstrong Custer led an expedition into the Black Hills in order to evict all white trespassers. Instead of discouraging the influx of whites Custer’s exploration only served to confirm the presence of gold. Unable or unwilling to stem the tide of miners the US government sought to buy the Black Hills from the Dakota in the Black Hills agreement of 1876. By the 1880’s mining towns such as Deadwood, Lead, Keystone, Custer and numerous others contained crowds of people.

The Bearlodge Mountains, while containing mineralized deposits, did not attract the large numbers of miners as did the nearby Black Hills. Nevertheless modest mining was undertaken in the Bearlodge Mountains, particularly around the Warren Peak area. The Black Hills and Bearlodge Mountains were primarily of interest to white settlers for
their potential mineral wealth. This undoubtedly affected any remains of prehistoric mining that may have occurred in formations also exploited by historic mining.

**Archaeology**

The archaeology of the area is characterized by shallow sites primarily of lithic artifacts suggesting plains hunting activities. These hunting activities required the acquisition of stone, and thus lithic exploitation can be expected to have begun at the earliest entry into the area (probably PaleoIndian) and continued until the introduction by trade of metal which replaced stone as the primary tool material.

The cultural sequence suggested for the Northern Plains by Frison (1978) has been adopted for this discussion. Temporal use of the Black Hills/Bearlodge Mountains extends back into the Paleo-Indian period (pre-5000 BC). The Agate Basin site located on the southwestern edge of the Black Hills contains substantial late Paleo-Indian period materials. At other sites in the Black Hills there have been found Alberta, Angostura and Lovell Constricted projectile points. Cassells (Cassells, Miller and Miller 1984) notes an absence of the earlier Clovis and Folsom sites, but this may not reflect a cultural hiatus.

Evidence of use during the early Plains Archaic (5000-3500 BC) has not been well-documented. The Hawken site near the Black Hills in Wyoming dates from this period. Within the Black Hills itself there is only slight evidence of occupation during this period from the south-central and southern Hills. This lack of evidence may indicate a cultural gap during this period or may only represent insufficient data.
The Middle Plains Archaic (3500-1500 BC) period is well represented in the Bearlodge Mountains and the Black Hills. The McKean site lies in the outer fringes of the Bearlodge Mountains, and McKean Complex projectile points and sites are common throughout the area. However few of these sites have been excavated, thus much remains to be learned about the use of the Hills during this period. It has been suggested that the Black Hills would have provided a cool, watered refuge for plains hunters seeking relief from the drying climate postulated after the last ice age.

The Late Plains Archaic/Woodland (1500 BC-900 AD) period sites are moderately well represented, although Besant Phase projectile points are somewhat uncommon.

The Late Prehistoric/Plains Village (900-1700 AD) period is not well represented in the Bearlodge Mountains. The Vore site, a bison jump, situated between the Black Hills proper and the Bearlodge Mountains of northeastern Wyoming, contained substantial deposits assigned to the Late Prehistoric period (Frison 1978).

The Protohistoric period (1700-1861 AD) is the least understood and represented period in the region. Several metal arrowheads have been reported from private collections, and structures on two sites have been interpreted as Protohistoric. A single blue trade bead found on 39LA314 (Church 1985) in the northern Black Hills and C-14 dates from the Deerfield site, 39PN214 (Buechler 1984), suggest some use during this period.
METHODS

Fieldwork

**Exploited Sources.** All exploited outcrop sources visited were recorded or re-recorded using the IMACS site form and exploited source form, with a site photo and site sketch map also completed. I sampled each outcrop and tried to collect a representative cross-section of the material based on the quality, color, and structure available at the source. Generally 10-20 specimens were collected from each source. Specimens were obtained as unmodified nodules or chunks if possible. In the few cases where this was not possible a minimum number of pieces of quarry debris were selected.

Although uncommon in the study area secondary deposits, such as lag or stream deposits, presented special sampling analysis problems. Such prehistorically exploited sources commonly consist of large areas with a diffuse, simple artifact assemblage. Because of this they have generally been something of a headache for archaeologists. This fact has resulted in very little work being done (or thought necessary) on these sites. Deaver attempted to determine relative material availability in the glacial tills at sites and how these materials were exploited (Deaver 1983). She found that such secondary deposits were a valuable resource because of easy exploitation from the surface and the wide range of materials present (a supermarket quarry as she calls them). Various rocks from tills
were exploited for ring and cairn rocks, hearth and boiling stones, and for tool manufacture.

**Unexploited Sources.** Unexploited sources have, for the most part, been investigated even less investigation than exploited sources. One of the few such efforts to date involves a transect strategy to sample the availability of chert in the Lower Illinois Valley by George Odell (Odell 1984). He observes that; "It is clear that a cogent interpretation of the regularities of human behavior concerning the exploitation of lithic materials requires knowledge of the relative parameters of those materials natural occurrences in the region under study (Odell 1984: 46)."

With similar conviction I decided to include as many unexploited sources as possible in this study. But because of limitations in time and money, sampling of these sources was limited to those outcrops found in the course of other work, or reported by others.

Samples were taken and a special Unexploited Source form was filled out for each unexploited outcrop or secondary deposit.

*Laboratory Work*

**Analysis.** In researching various techniques that might prove useful in the analysis of the resulting collections I kept several factors in mind. Specifically, these were the cost and availability of the techniques. Most of the techniques adopted for Phase I & III required a minimum of equipment and training. Phase II required a bit more sophisticated equipment and a basic background in geology. Phase IV, geochemical analysis, took advantage of the accuracy of XRF.
Preparation. Laboratory methods were designed to eliminate the possibility of specimen loss, confusion, or introduction of error.

- All samples were washed.
- Close-up photos were taken of individual samples to illustrate patina, cortex, structure or attributes (35mm color film).

Morphological Description. A large part of the lab work was aimed at recording the gross morphology of each specimen using standardized terms and techniques. The weight of each specimen was measured to the nearest tenth of a gram using a OHAUS lume-o-gram digital balance for specimens under 2000 g and a OHAUS triple beam balance for specimens over 2000 g. The length and circumference was measured to the nearest millimeter. Density was measured using the water immersion technique (Kempe and Templeman 1983: 28-29). Colors were determined by comparison to the Geologic Society of America's Rock Color Chart. Once its description was complete, each specimen was broken via hard hammer percussion using a suitable river cobble. The degree of control a flintknapper could exert over the material was subjectively categorized (poor, fair, good, excellent) based on this reduction.

Specimen Description. Each specimen had its weight, physical size, form, grain size, specific density noted; the cortex color(s), thickness, texture, type, presence of bioclasts noted; the color(s), texture, structure, translucency, luster, fracture, attributes and quality of primary material noted; and the presence of patination and its color, thickness, amount and luster noted.

Microscopic Examination. When Phase I was completed a sub-sample of small chips from each source was selected for microscopic
examination. The equipment included a binocular Bausch & Lomb microscope with 1X-7X, illuminated by a American Optical high intensity light.

The traits sphericity, roundness and sorting were determined by visual comparison to standard charts. Specifically these were Longiaru’s sorting comparators (figure 6) (Longiaru 1987), Power’s roundness comparator (figure 7) (Powers 1958), and Rittenhouse’s sphericity comparator (figure 8) (Rittenhouse 1943).

Several traits observable only in orthoquartzites (at these levels of magnification) were included in the study. Microscopic textures were adopted from reports on the results of work on eastern North American orthoquartzite quarries (Ebright 1987). Ebright has constructed a continuum (based on geologic studies) of quartzite textures (Figure 9) that are easily observable under low power magnification.

The traits to be noted included the presence or absence of any bioclasts or inclusions. For orthoquartzites the additional traits, grain sphericity, roundness, sorting, size, and microscopic texture were determined.

**Fluorescence.** Fluorescence occurs when certain minerals are irradiated with ultraviolet light. It is a highly variable trait, and no other geoarchaeological sourcing projects have investigated the technique. For this study all the specimens from all the sources were laid on a table and examined with a hand-held UV light. The strength of the fluorescence (weak, moderate, strong) and amount of fluorescence (spotty, patchy and wide-spread) were noted. Spotty fluorescence was observed in the cortex of a number of specimens but is not reported in the results section as cortex does not remain on the vast majority of archaeological artifacts.
Only fluorescence in the primary material is reported in the results section. The majority of specimens exhibiting fluorescence were chalcedonies, whereas none of the orthoquartzite specimens exhibited fluorescence.
Figure 6. Sorting Comparators (from Longiaru 1987: 793).
Figure 7. Images for Estimating Visual Roundness (after Powers 1958).
Figure 8. Images for Estimating Visual Sphericity
(after Rittenhouse 1943).
Type I - Orthoquartzite with individual grains bonded by concretionary opal and/or chalcedony.

Type II - Secondary overgrowths on individual grains which remain isolated in silica cement.

Type III - Secondary overgrowths on individual grains which form an interlocking aggregate.

Type IV - Presolved orthoquartzite with sutured boundaries along grain to grain contacts form an interlocking aggregate.

Figure 9. Microscopic Quartzite Texture Continuum.
(modified from Ebright 1987: 31)
Heat Alteration. The heat alteration studies mentioned below were not designed for investigating prehistoric heat alteration in itself. Rather, the reaction of the stone was recorded to reduce possible errors in Phase I. Specifically, an artifact found at a site that is reddish in color may or may not have been heat altered. To compare accurately that artifact with a possible source one should know the source stone’s reaction to heat must be known. Ideally all reddish stone should be suspect, but at the same time all artifacts of reddish stone cannot be ignored. Therefore a modest program of thermal alteration was used. Specimen fragments from each source were divided into several batches and with each batch subjected to a different temperature. All specimens were heated for two hours. Only gross changes such as color and crazing (hairline fractures) were noted.

Geochemical Analysis. While a major goal of this study was to provide a series of inexpensive and convenient methods for provenance studies I realized that to find the source of some stone more advanced techniques were required.

Due to the kind cooperation of Ed Keller of Chemistry Stores at the University of Montana I was able to use a fluorescence analyzer. A subsample of several of the sources collected were selected for analysis. X-ray fluorescence analysis is a semi-quantitative technique which

\[ \ldots \text{involves excitation of elements in a sample by primary x-rays which cause the displacement of inner electrons. The vacant lower energy levels are filled by higher energy electrons and the loss of energy is expressed as secondary or fluorescent x-rays,} \]
which have a characteristic wavelength. Each element emits x-rays of a specific wavelength which is directly related to the atomic number of the element. In this way, the presence of particular elements in a sample can be determined. The amount of an element present is determined by the intensity of the peak at the wavelength characteristic of an element (Katzenberg 1984: 58).

The equipment used was a EG & G Ortec Tefa III Tube Excited Fluorescence Analyzer, model 6110 with a EG & G Ortec Eeds II Energy Dispersive Spectrometer linked to ORACLE computer software for analysis. The samples consisted of small rock chips (samples may be small pieces or ground samples). Care was taken to select the chips from the interior of specimens in order to avoid variations that might be present in the cortex or weathered surface of the rock. A 0-20 Kev energy range was selected with a dead time of around 50% as recommended by Mr. Keller. All samples were run to a 4k resolution unless otherwise noted. Several samples were run to a 32k resolution in order to test variation due to resolution differences, but the results did not significantly alter the accuracy of the results. Up to ten elements may be selected for statistical analysis with the ORACLE software. A standard suite of eight elements was selected based on similar studies (Roepke personal communication). These were CA (calcium), FE (iron), SR (strontium), MN (manganese), CO (cobalt), and SI (silicon), TI (titanium) and CU (copper).

The results were then normalized, giving a percent figure based on the number of peaks detected during the analysis. These figures represent
the relative abundance of the element within the element suite. The figures were then entered into a scientific spreadsheet program and averages and standard deviations calculated. The sample data and average were then graphed in a line chart to visually compare the results. A summary rose diagram and base data for each source was then constructed and these are presented in the results chapter.

Definitions

The following are the working definitions for the study.

Procurement Strategies

Embedded Procurement—where raw materials are obtained incidentally to the execution of basic subsistence tasks (Binford 1979: 259-260).

Encounter Procurement—consumers move around the landscape so as to take advantage of resources which are not uniformly distributed (Haury 1986: 2, modified).

Indirect Procurement—obtain needed material through exchange (Earle & Ericson 1977).

Logistical Procurement: a small special work force moves to a specific location for the express purpose of obtaining the raw material. Collected material is then taken back for storage or distribution (Binford 1980: 10).

Procurement Techniques

Expedient—obtain raw materials from secondary surface deposits such as upland residuals or stream deposits (Haury 1986: 5).

Extraction—the retrieval of raw material from exposed sources as opposed to using excavation to reach desirable material (Haury 1986: 4).
Quarrying-pits (vertical excavation) or tunnels (horizontal excavation) are excavated in bedrock or in deposits of upland residuals in order to obtain raw material (Haury 1986: 3-4, modified).

Characteristics of Quarrying Techniques (figure 10)

Vertical Techniques

Pitting-a circular excavation extending vertically from the ground surface down to the material bearing strata. Pits generally measure 1-3 meters in diameter and are often in-filled with quarry debris or wind brown detritus.

Trenching-a linear excavation extending vertically from the ground surface down to the material bearing strata and then following this strata by linear enlargement of the excavation.

Gophering-a branching excavation extending vertically underground from the ground surface following a material bearing strata. Associated with tilted exposures.

Horizontal Techniques

Tunnelling-a deep linear, horizontal underground excavation into a material bearing outcrop.

Extraction Techniques

Undermining-a shallow horizontal excavation into the material bearing strata leaving a roof of overlying strata.

Levering-the fracturing of a surface and slope exposed material bearing strata by leverage applied into cracks and fissures forcing chunks of material off the parent outcrop with subsequent reduction of these chunks.
Material Types. These definitions are intended primarily for field use. They are not based on geologic criteria but rather on traits that are easily observable in the field.

- Chert-opaque cryptocrystalline material
- Chalcedony-translucent cryptocrystalline material
- Quartzite-opaque micro/macrocrystalline material
Figure 10. Examples of Quarrying Techniques
Cryptocrystalline-individual grains are not visible under microscope (AGI 1976: 102).

Microcrystalline-individual grains are visible under microscope but not to naked eye (AGI 1976: 279), typically these fall into the silt (.1/16mm) and very fine sand (1/16-1/8mm) grain size categories.

Macrocrystalline-individual grains are visible to naked eye (AGI 1976: 264), typically these fall into the fine sand (1/8-1/4) and larger grain size categories.

**Deposit Types**

Primary-original deposits. Those most often exploited prehistorically outcrop above the surface thus providing access.

Secondary-deposits that have eroded from a primary deposit. These can be of the following three types. Colluvium, which are tabular or nodular pieces that have broken off an outcrop but which remain scattered nearby. Stream or alluvial deposits are those that have been transported, some to great distances, by water. These occur in the form of river cobbles, some characterized by a surface Hertzian fractures.

**Traits**

Cortex-The outer coating or crust of the siliceous material, most often of the parent matrix, often limestone.

Color-Color(s) of the specimens as compared to the Geological Society of America's standard Rock Color Chart.

Condition-The completeness of the specimen (incomplete, complete). Most appropriate to nodules and cobbles.

Form-the overall shape of the specimen.

Nodule (ellipsoidal, spherical, irregular).
Cobble—a rock fragment between 64 and 256 mm in diameter (larger than a pebble and smaller than a boulder), rounded or otherwise abraded in the course of aqueous, eolian or glacial transport (AGI 1976: 81).

Pebble-smooth rounded stones ranging in diameter from 2 to 64 mm (AGI 1976: 319).

Tabular piece-stone with angular edges broken from a primary, bedded outcrop and at most transported only a short distance.

Fracture Characteristics

- Blocky—breaks into angular squarish chunks.
- Sub-conchoidal—breaks into rough, irregular flakes.
- Conchoidal—breaks into regular, smooth curved flakes.

Luster - The amount of light reflected from the surface of a stone. In terms of this study this was determined from a freshly fractured surface. Granular luster has a 'sparkling' appearance. Glassy luster is shiny with a high degree of reflectance. Semi-mat luster is waxy with moderate light reflectance. And a mat luster is dull with minimal light reflectance.

Patina-The chemical or mechanical alteration of the outer surface of the stone. Can take the form of bleaching, induration, staining, varnishing, or the formation of a crust (Goodwin 1960: 302-311).

Quality-A subjective assessment of the knapping characteristics of the stone. Mostly related to the fracture type and presence or absence of internal bedding planes.

Specific Density-The density of the material as determined by weighing a specimen in air divided into its volume displacement.
Texture-The coarseness of the material. Related to the size and irregularity of the grains.

Translucency-Transparent-able to allow light transmission through more than 3 mm of stone thickness. Translucent-able to allow light transmission through more than 1 mm of stone thickness. Opaque-not able to allow light transmission through more than 1 mm of stone thickness.

Structure. Internal deposition characteristics as revealed by either color, textual, or bedding planes (figure 11).

Parallel Color/Textual Banding
A layer of color or textual variation within the stone, most often in bedded stone. Each layer or band maintains its own thickness and remains nearly parallel, although thickness may vary between bands. Can be multiple colors. Layers are not circular (see concentric banding below).

Concentric Color/Textual Banding
A layer or layers of color or textual variation within the stone, most often nodular in form. Each layer or band maintains its thickness and remains nearly parallel, although thickness may vary between bands. Can be multiple colors. Layers or bands form a circular pattern starting from the outside of the nodule and becoming smaller toward the center of the nodule.

Marly
Wavy patterns of differing color within the rock.

Color/Textual Mottling
Irregular marked with spots of different color (AGI 1976: 289).
Concentric Color or Textual Banding

Horizontal Color or Textual Banding

Marling

Mottling

Figure 11. Examples of the various Structure types.
**Attributes.** Various inclusions or chemically produced changes in the rock. Sometimes related to the stones genesis (figure 12).

**Dendrites**
Moss-like inclusions within the stone, these are not actual fossils but rather consist of the crystals of a foreign mineral, often an oxide of manganese (AGI 1976: 115). Most often in chert and chalcedony.

**Vesicles**
Small bubbles of air within the stone formed by the expansion of gas or steam during solidification (AGI 1976: 453). Most often associated with igneous or metamorphic processes. Obsidian, vitreous porcellanite, and others can have vesicles.

**Veins**
Linear or branching streaks of a secondary mineral deposited on internal joints.

**Vugs**
Small cavities within the rock, often filled with crystals, often druze quartz (AGI 1976: 458). Associated with sedimentary rocks such as cherts and chalcedonies.

**Oolites**
Small spheres (from 0.25 to 2.00 mm in diameter) of foreign stone, usually calcareous, within the rock (AGI 1976: 305). Often the oolites are of limestone or hematite. Associated with sedimentary rocks such as cherts and chalcedonies.

**Crystal Casts**
Small square or rectangular cavities caused by crystals that have subsequently eroded (AGI 1976: 65).
Figure 12. Examples of Attributes.
RESULTS

Sources of Error

Field Sampling. Criteria for choosing the various sites were somewhat arbitrary in nature (see Methods for a complete discussion of the criteria), and some sampling errors could be expected. However because 19 (57%) of the 33 previously recorded lithic procurement sites were visited any sampling errors are probably minimal.

The sampling of the lithic deposits themselves posed larger problems. First there were the standard concerns of obtaining a representative cross-section of the rock present on both a visual level well as a microscopic and geochemical level. In normal geologic sampling a scheme would be employed to randomize the collection. But the lithic outcrops at these sites are not only geologic but also cultural, having been modified by man. Because of this and concerns over the level of impacts that random sampling of primary outcrops would cause I decided not to employ that strategy. The specimens collected almost exclusively represent either colluvium from the main outcrop, debris, and in the case of secondary deposits unmodified cobbles. The result is that not only are there concerns about sampling on the geologic level, but also concerns that the materials collected do not accurately represent what was attractive to the prehistoric inhabitants.

Laboratory. Determination of the colors exhibited by the specimens was done using a standard set of color chips (The Rock Color Chart). Conditions for viewing were substantially the same for all specimens, i.e.
a mix of available daylight and indoor fluorescent lighting. Different viewing conditions can, of course, result in different color assignments. However a variable more likely to impact color assignment is individual color perception differences. What is blue to me may not be the same to another person. Such biological based differences cannot be addressed without very sophisticated instruments.

Quantitative XRF requires standard rock samples from the United States Geologic Survey to insure a high degree of accurate (defined as as "the difference between the results obtained and the correct result (Peck 1964: 54)") and precision ("the results obtained on several analyses of the same rock (Hughes 1986: 30)"). The UM facility does not have USGS standard samples. In order to gauge accuracy between analytical runs a standard internal to this study was selected. This was a single piece of Knife River Flint. At the beginning of each work session the KRF was analyzed and the results compared from previous work sessions. This proved valuable as a contaminated specimen container was detected and changed during one work session. Several other possible sources of error need to be mentioned. The first is masking of one element by another. Typically this involves elements that lie close together on the periodic table. The results of the first work session on the XRF analyzer had to be discarded because of false readings due to masking. Subsequently a different suite of elements, ones which were spaced apart from each other on the periodic table were selected, eliminating the problem.

Size and shape of the specimen can also cause variability. To achieve the highest accuracy and precision specimens should be powdered and packed in the sample container to form a flat surface. In my own
analysis flakes taken off of larger specimens were used because archaeologists attempting to use the XRF results to identify the source of the artifacts will probably not be able to powder their artifacts. However Hughes (1986: 35-37) has found that the effects of variations in shape were negligible for lenticular and biconvex specimens but might be more of a problem for very irregular shaped specimens. Hughes also found that size was more of an impact on the results. But as long as the specimen covers the majority of the target variations should also be minimal.

For this study specimens were selected that had flat surfaces and would cover the majority of the target. Where a single specimen large enough to cover the target was not available several specimens were arranged on the target to present a flat surface and to increase target coverage.

*Characteristics Summary for Exploited Formations*

The following is a summary of the stone characteristics based on the results of this study that occur in each formation. Those items suggested to be of diagnostic value in determining the source formation or specific source within a formation of artifacts are in bold.

**Fall River Formation.** Nine of the exploited sources were determined to occur within the Fall River formation.

**Morphological Summary**

Orthoquartzite from the Fall River formation occurs in beds 5-15 feet thick and often forms erosion resistant cap rock. The rock is a macrocrystalline quartzite, opaque with a granular luster and poor to
excellent conchoidal fracture. None of the the specimens contained any identifiable bioclasts and no specimens fluoresced under UV light.

Weathered Colors: reds, grays, browns are most common with purple reported from two sources and green from only one source (48CK290) (figure 13).

Fresh Colors: the same as those for weathered surfaces.

Minor Colors: browns, reds most common with purple reported from two sources.

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Table 1. Colors from Fall River Formation Sites

Cortex Colors: browns, reds, oranges most common with grays reported from one source.

Heat Alteration: browns were darkened, reddened or grayed. Grays were lightened, browned or reddened. Speckling became more pronounced.
Structure: uniform or with color/textual mottling or color/textual parallel banding common.

Attributes: open, sand or quartz filled vugs common, as was brown or red speckling. Calcareous patches and chalcedony filled veins were rare.

Specific Density: ranged from 1.86 to 2.45 with an average of 2.12 (figure 14).

**Microscopic Summary**

All sources were a Type II orthoquartzite with average sphericity values from .65 to .85 (figure 15), a roundness value of .4 to .5 (figure 16), an estimated grain size in the medium sand category (1/4-1/2 mm), and a sorting value almost uniformly of .35 (very well to well sorted) (figure 17).

**Geochemical Summary**

Only one source was subjected to XRF analysis and this showed a typical geochemical makeup for orthoquartzites. The dominant element being iron (76%) of the eight element analyzed.
Weathered Colors

Green  Gray  Brown  Red  Purple
48CK264
48CK274
48CK287
48CK288
48CK289
48CK530
48CK598

Fresh Colors

Green  Gray  Brown  Red  Purple
48CK284
48CK274
48CK287
48CK288
48CK289
48CK530
48CK598

Figure 13. Fall River Orthoquartzite Color Ranges
Figure 14. Specific Density Values for Fall River Formations Sites
Figure 15. Sphericity of Fall River Formation Sources.
Figure 16. Range of Variation for Roundness in Fall River Formation Sources
Figure 17. Sorting Values for Fall River Formation Sources
Lakota. Only one source, 48CK1204, was determined to occur within the Lakota formation.

Morphological Summary

Orthoquartzite from the Lakota formation occurs in beds 5-15 feet thick. The rock is a macrocrystalline quartzite, opaque with a granular luster and poor to excellent conchoidal fracture. None of the the specimens contained any identifiable bioclasts and no specimens fluoresced under UV light.

Weathered Colors: browns are most common with purple, grays and blacks reported.

Fresh Colors: mirror those for weathered surfaces.

Minor Colors: browns, grays and oranges.

Cortex Colors: browns.

Heat Alteration: browns were lightened and reddened.

Structure: uniform or with color/textual mottling or color/textual parallel banding common.

Attributes: dark brown speckling and areas of coarser grained material.

Specific Density: 2.05.

Microscopic Summary

The source is a Type I orthoquartzite with an average sphericity value of .75, a roundness value of .4, an estimated grain size in the medium sand category (1/4-1/2 mm), and a sorting value of .35 (very well to well sorted).

Geochemical Summary

The orthoquartzite showed a typical geochemical make-up, with the dominant element being iron (83%) of the eight elements analyzed.
Morrison. A total of three exploited sources and three non-exploited sources were determined to occur in the Morrison formation. Both orthoquartzite and chalcedony occur in the formation, each of which occur in two different types.

Morphological Summary-Orthoquartzite

The classic orthoquartzite from the Morrison formation occurs in beds 5-10 feet thick. The rock is a microcrystalline quartzite, opaque with a mat to granular luster and poor to excellent conchoidal fracture. None of the specimens contained any identifiable bioclasts and no specimens fluoresced under UV light.

Weathered Colors: grays are most common with browns rare.

Fresh Colors: mirror those for weathered surfaces.

Minor Colors: browns and grays.

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</table>

Table 2. Colors from Morrison Orthoquartzite Formation Sites

Cortex Colors: browns, reds, oranges, grays.

Heat Alteration: grays darkened, browns greyed.

Structure: uniform or with color mottling, marling or color/textual parallel banding common.

Attributes: empty or sand filled vugs. Areas of very large sand grains.

Specific Density: 2.27 (range from 1.98 to 2.62) (figure 18).
Microscopic Summary

The source is a Type II orthoquartzite with average sphericity values from .63 to .87 (figure 19), a roundness value of .4 (figure 20), an estimated grain size in the **very fine sand category (1/8-1/16 mm)**, and a sorting value of .35 (very well to well sorted) (figure 21).

Geochemical Summary

The orthoquartzite (with the exception of 48CK1139 which will be discussed later) showed a untypical geochemical make-up, exhibiting **twin peaks of iron-33.96% (with range from 23.59-48.93%) and titanium-28.60% (with a range of 22.14-34.77%)** of the eight elements analyzed.

A second variety of orthoquartzite from the Morrison formation was collected from 3Mr48Ck. The rock is a macrocrystalline quartzite, opaque with a granular luster and poor conchoidal fracture. The single specimen did not contain any identifiable bioclasts and did not fluoresced under UV light.

**Weathered Colors:** gray (lighter than the classic Morrison quartzite).

**Fresh Colors:** mirror those for weathered surfaces.

**Minor Colors:** none.

**Cortex Colors:** none.

**Heat Alteration:** none altered.

**Structure:** uniform.

**Attributes:** scattered dark grains giving a speckled appearance.

**Specific Density:** 2.13.
Microscopic Summary

The source is a Type II orthoquartzite with a sphericity value of from .75, a roundness value of .3, an estimated grain size in the medium sand category (1/4-1/2 mm), and a sorting value of 0.0 (very well sorted).

Geochemical Summary

The specimen was not subjected to XRF analysis.
Figure 18. Specific Density Values for Orthoquartzite from Morrison Formation Sites
Figure 19. Morrison Formation Orthoquartzite Sphericity
Figure 20. Morrison Formation Orthoquartzite Roundness Values
Figure 21. Morrison Formation Orthoquartzite Sorting Values
Morphological Summary-Chalcedony

Chalcedony occurs in two forms, one as nodules and the other as tabular pieces. Both are cryptocrystalline, translucent with a semi-mat to mat luster and poor to good conchoidal fracture. None of the the specimens contained any identifiable bioclasts. Those specimens of the nodular variety exhibited weak to strong, patchy brown fluorescence, while those of the tabular variety exhibited moderate, patchy brown fluorescence under UV light. The characteristics of the nodular chalcedony are as follows.

- Circumference: from 5 cm to 19.5 cm.
- Weathered Colors: browns and grays.
- Fresh Colors: mirror those for weathered surfaces.
- Minor Colors: browns and reds.
- Cortex Colors: browns.
- Heat Alteration: stone reddened.
- Structure: color mottling or color parallel banding.
- Attributes: spherical dark grains and white quartz crystals.
- Specific Density: 2.15 (range from 1.90 to 2.40).
- Patination: none.

Geochemical Summary

The single nodular chalcedony specimen (from 2Mr48CK) subjected to XRF showed four main elements, these were; silicon (31.85%), manganese (22.60%), cobalt (21.80%), and iron (10.62%).

The characteristics of the tabular chalcedony are as follows.

- Thickness: up to 13.5 cm.
Weathered Colors: browns and grays.

Fresh Colors: mirror those for weathered surfaces.

Minor Colors: browns, reds, grays and orange.

Cortex Colors: browns and orange.

Heat Alteration: none subjected to heat alteration.

Structure: color mottling, marling or color/textual parallel banding.

Attributes: sand filled vugs, hematite veins.

Specific Density: 2.20 (range from 2.03 to 2.36).

Patination: none.

**Geochemical Summary**

The single tabular chalcedony specimen (from 2Mr48CK) subjected to XRF showed iron as the dominant element (59.54%), with manganese (10.62%) and cobalt (12.53%) as the next most abundant element of the eight counted.

One exploited source and two non-exploited sources were determined to be secondary deposits. These are not summarized as their parent formations cannot be identified. Based on published geologic literature it is suggested that the orthoquartzite present at 48CK1137 originated from the Fall River formation with the Lakota formation another possibility. The single specimen of silicified wood from 3Sc48Ck is probably from the White River formation. And finally the stone from 5Sc48Ck is probably from the Morrison formation.

Figures 22, 23, 24, & 25 present the average values for microscopic characteristics from each formation for comparison.
Figure 22. Average Specific Density Values for Fall River, Lakota and Morrison Formations.
Figure 23. Average Sphericity Values for Fall River, Lakota and Morrison Formation Orthoquartzites.
Figure 24. Average Roundness Values for Fall River, Lakota and Morrison Formation Orthoquartzites.
Figure 25 Average Sorting Values for Fall River, Lakota and Morrison Formation Orthoquartzites.
A key guide (figure 26) was developed based on the diagnostic traits found during this study. I must stress that the guide should be viewed as dynamic, as more analysis are done on the samples collected for this study and as other sources are added to the database this chart will be revised.
This key is based upon the currently known lithic resources of the Bearlodge and on the analysis done in this study. It does not include look alikes such as Tongue River Silica (similar to Morrison orthoquartzite), or Bijou Hills quartzite (visually similar to the green quartzite from 48CK290).

Figure 26. Key guide to Known Bearlodge Lithic Sources.
Potentially Exploited Formations. Other formations present in the Bearlodge Mountains likely to contain useable lithic resources, but from which no sources can be linked at present, are the Spearfish, Minnelusa, and PreCambrian formations. Both the Spearfish and Minnelusa formations contain high quality cherts. The PreCambrian formations in the Bearlodge Mountains, located predominantly around Warren Peak, contain deposits of rare earths that may have been of value to the prehistoric inhabitants of the area as pigments. Specifically these include manganese oxides, limonite, and hematite producing black, red, brown and green colors (Staatz 1983: 33). Aboriginal use of all of these minerals has been documented elsewhere in North America (Heizer 1944: 309-311)
CONCLUSIONS

Lithic Procurement Patterning in the Bearlodge Mountains

Spatial. Of course lithic procurement sites are not randomly distributed across the landscape, they are tied to certain geologic formations, and these in turn are limited in their spatial distribution. Evaluation of the spatial characteristics of the lithic procurement sites in the Bearlodge Mountains reveal that patterns in both their surface and vertical distribution exist (figure 27).

Distribution of known or reported lithic procurement sites across the landscape is limited to only ELU units 53, 54, 55, and 56 (figure 28, oversize). Ecological Land Units 55 & 56 contain the majority of sites with ELU 56 having the highest site density of one site for every 634 acres (counting only BHNF sites and lands). However eleven sites of the 23 sites in ELUs 55 and 56 occur within a small area centered around Cliff and Lost Springs. This area was undoubtedly attractive to the prehistoric inhabitants not only because of the excellent and relatively accessible lithic resources but also because of the abundance of high-mountain springs in the area. I would suggest that exploitation of the Bearlodge Mountains lithic resources was an embedded task (Binford 1979: 259-260) performed either prior to bison hunting on the nearby plains or during periods of drought when the Bearlodge Mountains food and water resources became of critical value. Frison (1978: 242-243), discussing the
Figure 27. Source Distribution (sites & non-exploited sources) by Ecological Land Unit and Geologic Formation.
Vore site (located between the Black Hills and the Bearlodge Mountains), states that, with only one exception, the bison kills occurred in the Fall, but not on a yearly basis, and usually after a period of high precipitation.

Because of the high site density in the Cliff/Lost Spring area I have labeled the area the Northern Bearlodge Lithic Procurement District (figure 29).

The lithic procurement sites also cluster at particular elevations (figure 30). This should be no surprise as the geologic formations are vertically distributed.

**Temporal.** Only two sites in this study contained time diagnostic material. The first is 48CK264 with a corner notched projectile point assigned to the Late Archaic, and 48CK289 with a narrow corner-notched point assigned to the Late Prehistoric. No statements as to variations in lithic procurement through time can be made based on this minimal information.

**Procurement Techniques.** Of those sites sampled two were expediently exploited, nine were extractively exploited, and two were quarried. Of those extractively exploited eight were limited to surface extraction while outcrops at two sites were undermined. Both of those sites quarried were mined via vertical pitting into the bedrock. One of the two quarry sites is from the Fall River Formation (48CK530) and the other from the Lakota formation (48CK1204).
Figure 30. Elevation of Sources by Formation


General Conclusions

Two issues plagued this study from the beginning, these were a lack of adequate and accurate information on previously recorded sites.

Accurate Information. Thirty-two percent (6 out of 19) of those sites chosen for field visitation either could not be located or were determined not to be lithic procurement sites. From the original site descriptions at least one of those sites not relocated appears to be a large, heavily exploited lithic source. The remainder of the six sites were either natural outcrops that fractured into flake-like pieces leading to mis-identification, or were lithic scatters that were wrongly assumed to indicate exploitation of a nearby rock outcrop.

Thirty-two percent should not be considered an acceptable level of field error and I would strongly recommend that the basis for site type classification be more precisely defined. Lithic procurement sites should be defined as those containing direct evidence, in the form of quarrying or extractive features.

Lack of information. Another problem was the lack of adequate information in the cultural resource reports and on the site forms. Wyoming adopted the IMACS site form in the 1980's and this will insure that more information will be consistently recorded. However the IMACS guidelines do not specifically address many of the types of information found important during this study. Adequate information for lithic procurement sites should include the formation being exploited (often easily obtainable from geologic maps), the type of rock, the type of procurement, and the type and size of any features present.
Without this minimal level of information any later research, such as this study, will be forced to make sampling decisions (among others) on the basis of guess-work.

**Laboratory Methods.** Phase I analysis was the most time consuming and labor intensive of the analytical phases. But is also very important. However based on the results of this study the process can be streamlined. Several unproductive items were deleted from the study early. These were streak plate color for the primary material and cortex, specific gravity (so closely tied to specific weight that only one was deemed necessary), and hardness. In reviewing this study several other items were judged to have contributed little to the summary description of the sources. These are length, circumference, weight, cortex thickness and texture.

Specific weight has been used in studies in Europe and so was included in this study. However the method used in this study, determining the difference in volume of a narrow, water filled, cylinder, was prone to inaccurate results because of problems with water tension. The technique might still prove of value given a more accurate method (such as Kushelevsky 1975: 99-101).

Phase II turned out to be of considerable value in describing orthoquartzites. The techniques used are easily completed with a minimum of equipment and experience. I would suggest that petrological examination and SEM examination might also add a considerable amount of information.

The techniques of Phase III appear to be of limited value. Heat alteration is a necessary procedure in order to determine any color shifts
that may occur and thus may influence determination of color during Phase I. Ultra-violet fluorescence may be of some value in the characterization of chalcedonies, it is of no value for the orthoquartzites present in the Bearlodge Mountains.

Phase IV was, as expected, the one that required sophisticated equipment and a certain amount of experience and knowledge in order to establish a proper and precise methodology and to make some sense of the resulting data. Based on my experience during this study I suggest that geochemical analysis be employed in attempts at determining specific sources within a formation, rather than attempting to determine both formation and specific source. By adding the results of geochemical analysis to microscopic examination some of the confusion and error can be eliminated.

**Future Research**

**Exploitation of Precambrian deposits.** Evidence is mounting that such rocks contain unique minerals that were exploited by prehistoric miners. These minerals include mica, biotite, clays, hematite, quartz, and various metals. Unfortunately these are exactly the types of minerals that have also attracted historic and modern day mining operations. It can only be assumed that direct evidence of prehistoric exploitation of these minerals has largely been destroyed by such activity. Having said this I would suggest that it is of extreme importance that any remaining evidence of prehistoric use of these deposits be identified, protected and studied.
Also the geologic complexity of the PreCambrian rocks of the Bearlodge Mountains (and of the nearby Black Hills) presents considerable difficulties in systematic investigation.

**Exploitation of areas surrounding the Bearlodge Mountains.** The area surrounding the Bearlodge Mountains has only been minimally investigated for cultural resources. Almost nothing is known of lithic procurement sites on the periphery of the Bearlodge Mountains. Substantial amounts of silicified wood occur to the northwest near Keyhole Reservoir and outcrops of lower formations such as the Spearfish, Minnelusa (which contains high quality cherts) undoubtedly exist.

The archaeological records for these areas should be examined as a preliminary step in determining the true scope of the lithic resources in northeastern Wyoming.

**Procurement Methods and Techniques.** In her study on lithic resource use patterns in the Bighorn Mountains of Wyoming Francis (1983) concluded that secondary sources were most likely used in casual procurement, while Morrison formation quartzite sources were more concentrated and valued which resulted in local curation (the Fall River and Lakota formations were not addressed in her study). It appears that a similar pattern is present in the Bearlodge Mountains; however, more detailed studies of the procurement techniques used, curation, and fall-off rates for each of the formations should be undertaken.

Detailed analysis of the procurement techniques used at these sites would provide information to test the assumptions under which most plains archaeologists now labor.
Temporal Variations in Procurement Patterns/Trends. If there is one glaring gap in our knowledge of lithic procurement on the Northern Plains then it is how these may have varied through time. Such variations have long been suspected, but because lithic procurement sites often lack readily dated features or artifacts they have yet to be systematically investigated.

Concluding Remarks

Value of Comparative Collections. It has been the experience of this writer that documented, comparative, lithic collections are almost non-existent. And yet such collections are of significant value. With such a collection the lithic analyst can address such issues as regional exchange, mobility patterns, reduction variations due to stone type or formation.

Value of Standardized Terminology and Methodology. Of those few comparative collections that do exist for Northern Plains materials, none used a standardized terminology and methodology that would allow cross-collection comparisons. Without the ability to coherently discuss and describe materials from different collections we cannot use such materials in regional studies.
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APPENDIX A

Because of the complexity of data considered in this study some thought was given to organizing the results into a meaningful system. A four part, spatially based, hierarchical system was devised for New Mexico obsidian sources (Baugh & Nelson 1987). In their system the “Source System” was a geographically region, the “Source Subsystem” was a geologic formation, the “Locality Complex” was a relatively small area within the region, and the “Collection Locality” was the specific outcrop sampled. The use of such a system enabled the data to be tied into geologic and geographic frameworks.

A similar system exists for the Black Hills National Forest, namely the Ecological Land Unit Study. This study classified the lands of the Black Hills National Forest on the basis of geomorphology, geology, flora and fauna into a three tiered system, “Region” corresponding to major landforms with the Hills, “District” corresponding to sub-landforms, and “Ecological Land Units,” small groupings of similar vegetative areas. To these pre-existing categories three more were added to accommodate this study. These were “System,” borrowed from Baugh & Nelson’s study and meaning a geographic region, “Formation,” corresponding to the geological stratigraphy, and “Source,” corresponding to Baugh & Nelson’s “Collection Locality.”

The resulting classification for the various sources examined in this study are presented in Figure 31 (folded).
Red Valley Region (figure 32), Sundance Uplands District,

ELU 48, Morrison Formation, Non-Exploited Sources

2Mr48Ck (T53N, R63W, Section 28)

Environmental Setting: Two pieces of a excellent appearing chalcedony were collected from this source in the Bearlodge Mountains, Wyoming. Their morphology indicates that they are from a primary deposit. The deposit was not located but probably occurs up slope from the spot.

Geology: this is a primary outcrop of the Morrison formation based upon published geologic maps and descriptions of the area (Darton 1905) and upon field observations by the author.

Characterization Summary-Phase I

Morphology: the stone is a nodular chalcedony.

Average circumference=19.5 cm (range 14.0-25.0 cm).

Color(s): Weathered surfaces=medium light gray-N6.

Fresh surfaces=medium light gray-N6.

Minor colors=pale red-5R 6/2.

Structure: uniform.

Attributes: noted inclusions were white quartz crystals.

Traits:

Average specific density=1.9 (range 1.7-2.1).

Translucency=translucent. Luster=semi-mat.

Fracture=good conchoidal fracture.
Figure 32. Red Valley Region, Bearlodge Mountains.
(Source: Black Hills National Forest, n.d.)
Overall knapping quality=good to excellent (one specimen broke into moderately blocky pieces which were large enough for further reduction).

Patination=none.

Cortex: consists of the parent sandstone. Color is pale red-10R 6/2 on weathered surfaces and pale red-10R 6/2 and grayish orange-10YR 7/4 on fresh surfaces.

Phase II

Fossils: none.

Inclusions: white amphorous areas.

Phase III

Fluorescence: weak, wide-spread, brownish fluorescence.

Heat Alteration: no specimens heated.

Phase IV

Results of the XRF analysis are presented in figure 33.
Figure 33. XRF Results for 2Mr48Ck.
Dakota Hogback Region (figure 34), Gently Dipping Hogback District, ELU 53, Morrison Formation, Reported Sites (unsampled).

48CK472 (T52N, R65W, Section 32)
The site was recorded in 1982 and described as a “... utilized outcropping of Morrison quartzite (Larson et. al. 1983).” Exploitation of the outcrop appeared to be limited to expedient procurement and no features were observed. The site lies on a west facing slope above a small meadow at an elevation of 4280 ft. A geologic map of the area (Mapel et. al. 1959) confirms that the outcrop is of the Morrison formation.

48CK474 (T52N, R65W, Section 32)
This site was also recorded in 1982 and was described as similar to 48CK472, i.e. an outcropping of Morrison quartzite expediently exploited. “The site is located on a moderately steep, south facing slope west of an ephemeral drainage (Larson et. al. 1983).” Elevation is 4320.

48CK475 (T52N, R65W, Section 32)
Recorded along with 48CK472 and 48CK474 above, this site is also described as an outcropping of Morrison quartzite casually exploited. “The site is located on a narrow flat below a hill to the northeast which has outcrops of Morrison quartzite and an unnamed side drainage of Huett canyon (Larson et. al. 1983).” Elevation is 4360.

ELU 54, Morrison Formation, Reported Sites (unsampled).
48CK478 (T53N, R64W, Section 29).
This site was recorded in 1982 and described as a Morrison quartzite quarry with two possible quarry pits observed. The material described,
Figure 34. Dakota Hogback Region, Bearlodge Mountains.
(Source: Black Hills National Forest, n.d.)
light tan with occasional burgundy bands, differs from typical Morrison quartzite. The site is located atop a knoll along a ridgeline at an elevation of 4880 (Larson et al. 1983). A geologic map of the area (Mapel et al. 1959) confirms that this area is from the Morrison formation.

ELU 55, Fall River Formation, Exploited Sources

48CK274 (T55N, R63W, Section 35)

Background: Originally recorded by a USFS para-professional in 1979 during a inventory for the South Top Timber Sale. The site was described as "Approximately 4 acres in size along the top of the mesa and on the edge to the southwest. Large amounts of the metamorphic layers have been moved in search of a particular band or lens, leaving waste flakes by the ton scattered on the top and side slopes below." (Niles 1980).

The site was relocated without difficulty in 1986. An outcropping of quartzite with quantities of associated flakes, cores and hammerstones were present. The layer with the best quality quartzite has been mined resulting in shallow overhangs.

The site was later recommended as eligible to the National Register of Historic Places (Cassells 1989).

Environmental Setting: the site lies on a cliff edge at an elevation of 4790 feet.

Geology: this is a primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an quarry site of about 750 square meters with a dense artifact distribution (a maximum of 100+ artifacts per square
meter) consisting mainly of debitage with a single hammerstone observed. No features other than the exploited outcrops themselves were noted. The site's use has not been dated at this time.

Characterization Summary-Phase I

Morphology: The extracted stone is tabular orthoquartzite.

Average thickness=4.6 cm (range 3.0-6.0 cm).

Color(s): Weathered surfaces=reds (moderate red-5R 5/4, dusky red-5R 3/4), grays (very light gray-N8, light gray-N7, grayish red-10R 4/2, grayish pink-5R 8/2), and browns (pale yellow brown-10YR 6/2, dark yellow brown-10YR 6/6).

Fresh surfaces=reds (moderate red 5R 5/4, dusky red 5R 3/4), grays (very light gray-N8, light gray-N7, grayish pink-5R 8/2), browns (moderate red brown-10R 4/6, dark yellow brown-10YR 6/6).

Minor colors=moderate yellow brown-10YR 5/4, grayish red-5R 4/2.

Structure: the majority of the specimens exhibited uniform structure. One specimen exhibited color mottling and one specimen exhibited textual mottling.

Attributes: empty vugs and chalcedony filled veins noted in two specimens.

Traits:

Average specific density=2.11 (range 1.98-2.3)

Translucency=opaque. Luster=granular.

Fracture=poor to excellent conchoidal fracture.

Overall knapping quality=good.

Patination=none.
Cortex: consists of the parent sandstone. Colors are predominantly browns (pale brown-5YR 5/2, moderate brown-5YR 4/4, pale yellow brown-10YR 6/2, grayish brown-5YR 3/2. Minor colors=pinkish gray-5YR 8/1, light brown 5YR 6/4, grayish orange-10YR 7/4, moderate reddish orange-10R 6/6, very pale orange-10YR 8/2.

Phase II
Grain Morphology: macrocrystalline with a microscopic type II texture.
Average sphericity=.85 (range .79-.87).
Average roundness=.4 (range .4-.5)
Average sorting=.35 (very well to well sorted).
Fossils: none.

Phase III
Fluorescence: none.
Heat Alteration: no change in the single specimen heated.

48CK275 (T55N, R63W, Section 35)
Background: Also recorded by a USGS para-professional in the 1979 survey for the South Top Timber Sale. The site lies across the drainage from 48CK274. The site description was given as follows; "A great amount of effort has been expended here in what looks like a mining effort by the aboriginals. Material is scattered below the rim in a talus (sic) below the activity at the rims exposed sides." (Niles 1980).

The site was revisited in 1986. The quartzite is of a better quality than at 48CK274 and has been more extensively exploited. The same mining technique was employed as at 48CK274 at five spots along the rim. A possible pit was observed away from the rim also. Large quantities of
flakes, cores and shatter are present. Several quartzite river cobble hammerstones were noted (Church 1987: 6).

Environmental Setting: the site at the edge of a steep cliff at an elevation of 4791 feet.

Geology: this is a primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an a quarry site of about 2000 square meters with a dense artifact distribution (a maximum of 100+ artifacts per square meter) consisting mainly of debitage, quarry debris, and two cobble hammerstones of quartzite. The exposed quartzite outcrops have been horizontally mined at three locations along the cliff rim. A shallow, round pit is also present just back from the edge a short distance. Temporal use of the site is undetermined at this time.

Characterization Summary-Phase I

Morphology: The stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=browns (moderate brown-5YR 4/4, moderate yellowish brown-10YR 5/4, light brown-5YR 5/6, pale reddish brown-10R 5/4), reds (very dark red-5R 2/6, moderate red-5R 4/6), and grayish orange-10YR 7/4.

Fresh surfaces=the same as above.

Minor colors=grayish orange pink-10R 8/2, pinkish gray-5YR 8/1, moderate pink-5R 7/4, dark reddish brown-10R 3/4.

Structure: the majority of the specimens were uniform, several displayed color and textual mottling or parallel color banding.
Attributes: open or quartz filled vugs were noted in two specimens, and a third displayed red speckling.

Traits:

Average specific density=2.23 (range 1.63-3.08).

Translucency=opaque. Luster=granular.

Fracture=poor to good conchoidal fracture.

Overall knapping quality=excellent.

Patination=none.


Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.

Average sphericity=.78 (range .73-.83).

Average roundness=.5 (range .3-.7).

Average sorting=.35 (very well to well sorted).

Inclusions: all of the specimens contain red to brown speckling.

Fossils: none.

Phase III

Fluorescence: none.

Heat Alteration: color shift in one out of three specimens heated.

Pale yellow brown (10YR 6/2) to pale red (10YR 6/2).
Dark speckling more pronounced in one specimen after heating.

48CK289 (T54N, R63W, Section 12)

Background: This site was recorded by a USFS para-professional during a 1979 inventory of the South Top Timber Sale. It was described as a large lithic scatter (Niles 1980).

The site was revisited several times during 1986. The first visit revealed a utilized outcrop of quartzite along the rim edge. The site was subsequently tested by USFS archaeologists. This testing indicated that the cultural deposits are relatively shallow (above 10 cm). Continual cattle grazing has disturbed large areas of the site which is mostly loose sandy soil. Surface collection of the site revealed large quantities of primary, secondary, tertiary flakes and cores of quartzite with lesser amounts of cherts. A small narrow corner notched point was also recovered from the surface. It appears that some surface procurement was taking place on site at the small outcropping of quartzite. But the primary activity was lithic reduction of the quartzite that was procured at the numerous quartzite outcrops nearby.

Environmental Setting: the site lies at an elevation of 4740 near the edge of a sandstone cliff.

Geology: this is primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an extractive lithic procurement site and campsite about 1,000 square meters in size with a moderately dense artifact distribution of debitage and tools. A narrow corner notched point
attributed to the late prehistoric period was uncovered during inspection of the site by USFS personnel.

Characterization Summary-Phase I

Morphology: The extracted stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=pale pink-5RP 8/2 and browns (pale reddish brown-10R 5/4, moderate yellowish brown-10YR 5/4, pale yellowish brown-10YR 6/2).

Fresh surfaces=pale red purple-5P 6/2, dusky red-5R 3/4, and browns (dark yellowish brown-10YR 4/2, pale yellowish brown-10YR 6/2).

Minor colors=pale purple-5P 6/2, blackish red-5R 2/2, dark yellowish brown-10YR 4/2, and moderate yellowish brown-10YR 5/4.

Structure: all specimens exhibited either color mottling or parallel color and textual banding.

Attributes: one specimen contained sand filled vugs.

Traits:

Average specific density=2.22 (range 2.08-2.43).

Translucency=opaque. Luster=granular.

Fracture=blocky to sub-conchoidal fracture.

Overall knapping quality=good.

Patination: none.

Cortex: consists of the parent sandstone. Colors are predominantly brown on both weathered and fresh surfaces (dark yellowish brown-10YR 4/2 and dusky brown-5YR 2/2).

Phase II

Grain Morphology: macrocrystalline with a microscopic type I to II texture.
Average sphericity=.71.
Average roundness=.4.
Average sorting=.35 (very well to well sorted).
Fossils: none.

Phase III

Fluorescence: none.
Heat Alteration: no specimens heated.

48CK530 (T54N, R63W, Sections 21 & 28)

Background: This quarry was located by a USFS para-professional during a timber sale survey in 1978. He noted that "There are 3 trenches or pits which appear to have had material removed near the edge of the west rim." (Niles 1978). A small surface collection was made.

The site was revisited by USFS archaeologists (including this author) in 1986 during an inventory for a fence line (Miller 1986). At that time the existence of the quarry pits and massive amounts of debitage were confirmed, although the site area was reduced. Several biface blanks were collected at this time. Subsequently the site was visited again to gather samples for this study. Five shallow quarry pits were located along the canyon rim. The quartzite is of excellent quality with the majority being tan in color. The mounds of debitage partially hidden under forest litter leaves no doubt that this was an important lithic procurement site.

Environmental Setting: the site lies on the edge of a narrow drainage at an elevation of 4700 feet.
Geology: this is a primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: site is an quarry site of about 7,500 square meters with a dense artifact distribution (a maximum of 500 artifacts per square meter) consisting mainly of debitage with several large, broken biface and one hammerstone noted. Five shallow round quarry pits are present in the bedrock.

Characterization Summary-Phase I

Morphology: The extracted stone is a tabular orthoquartzite.

Average thickness=5.85 (range 3.5-7.5 cm).


Structure: two of the specimens were uniform, the remainder display either color or textual mottling.

Attributes: none.

Traits:

Average specific density=2.02 (range 1.65-2.33).

Translucency=opaque. Luster=granular.

Fracture=sub-conchoidal to excellent conchoidal.
Overall knapping quality=good.
Patination=none.

Cortex: consists of the parent sandstone. Colors on weathered surfaces are browns (moderate brown-5YR 3/4, pale brown-5YR 5/2, dark yellowish brown-10YR 4/2) and reds (blackish red-5R 2/2 and moderate red-5R 5/4). Fresh surfaces displayed oranges (grayish orange-10YR 7/4, dark yellowish orange-10YR 6/6), pale brown-5YR 5/2, moderate red-5R 5/4.

Phase II
Grain Morphology: macrocrystalline with a microscopic type II texture.
Average sphericity=.76 (range .63-.87).
Average roundness=.5 (range .2-.7).
Average sorting=.35 (very well to well sorted) (range 0.0-.50).
Fossils: none.

Phase III
Fluorescence: none.
Heat Alteration: isolated color shifts from grayish brown (5YR 3/2) to moderate brown (5YR 4/4) in the single specimen heated.

Phase IV
The results of the XRF analysis are presented in figure 35.

48CK598 (T54N, R63W, Section 12)

Background: A quarry site located during the South Top Timber Sale inventory by a USFS para-professional in 1980. No information other than its location and label as a quarry was available (Niles 1980).
**Source:** 48CK530  
**Material:** Quartzites  
**Formation:** Fall River  
**ELU:** 55  
**District:** Gently Dipping Hogback  
**Region:** Dakota Hogback  
**System:** Bearlodge Mtns.

**X-Ray Fluorescence Results**

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**N:** 2/7

Figure 35. XRF Results for 48CK530.
The site was revisited in 1986 and found to consist of small pocket of exploited white quartzite along the rimrock. A moderate amount of debitage was present. Procurement was confined to the surface (Church 1987a: 7).

Environmental Setting: the site lies on the edge of a high cliff at an elevation of 4400 feet. Geology: this is a primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Darton 1905) and upon field observations by the author.

Cultural Materials: the site is an extractive lithic procurement site of about 100 square meters with a moderately dense artifact distribution (a maximum of 50 artifacts per square meter) consisting of debitage. No features other than the outcrop itself was evident. Temporal use of the site is undetermined at this time.

Characterization Summary-Phase I

Morphology: the stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=grays (yellowish gray-5Y 7/2, very light gray-N8) and pale yellowish brown 10YR 6/2.

Fresh surfaces=grays (yellowish gray-5Y 7/2, light gray-N7, pinkish gray-5YR 8/1.

Minor colors=pale yellowish brown 10YR 6/2, dusky yellowish brown-10YR 2/2, pale olive-10Y 6/2.

Structure: the specimens were either uniform, exhibited color mottling or parallel textual banding.

Attributes: none.

Traits:
Average specific density=2.45 (range 2.0-3.3).

Translucency=opaque. Luster=granular.

Fracture=sub-conchoidal to poor conchoidal.

Overall knapping quality=poor.

Patination=none.

Cortex: consist of the parent sandstone. Weathered surface colors are dark yellowish brown-10YR 4/2 and moderate reddish brown-10R 4/6.

Fresh surfaces are very pale orange-10YR 8/2 or pinkish gray-5YR 8/1.

Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.

Average sphericity=.70 (range .63-.79).

Average roundness=.4 (range .4-.5).

Average sorting=.35 (very well to well sorted).

Fossils: none.

Phase III

Fluorescence: none.

Heat Alteration: color shift from light olive gray (5Y 6/1) to light brownish gray (5YR 6/1) in the single specimen heated.

Reported Sites (unsampled)

48CK241 (T55N, R63W, Section 2)

This site was recorded in 1979 by a USFS para-professional and later evaluated in 1989. It is described as "... extensive quartzite quarry located below the Lakota sandstone rimrock overlooking Harding Gulch near the north end of the Bearlodge Mountains (Cassells 1989: 12)." A geologic map of the area (Mapel et. al. 1959) however indicates that the site is
from the Fall River formation, not the Lakota as Cassells indicates. No features are reported. Elevation is 4380 ft.

**48CK531 (T54N, R63W, Section 21)**

This small site was recorded by USFS personnel (including the author) in 1986 (Miller 1986). It is a small outcropping of Fall River quartzite of a light gray color on the slope of a ridgeline. No features were observed and exploitation appears limited to expedient procurement. Elevation is 4700 ft.

**48CK1121 (T53N, R63W, Section 10)**

This site was located by a USFS archaeologist in 1986 (Miller 1986). The site is a small outcropping of Fall River quartzite (confirmed by a geologic map of the area (Darton 1905) that was casually exploited. The site is located on a slight slope at an elevation of 5060 ft.

**48CK1261 (T53N, R62W, Section 2)**

This site was located in 1989 by a USFS archaeologist (Zettel 1989). It is described as a large, sparse lithic reduction site. “On the southern end of the site sandstone and quartzite rock outcrops are present above a steep slope down into a dry gully. The site function appears to be mostly lithic reduction with limited lithic procurement or testing (ibid: 4).” Elevation is 4880 ft. A geologic map of the area indicated the site is located on the Fall River formation (Mapel et. al. 1959).
ELU 55, Lakota Formation, Exploited Sources

48CK1204-Source Area A  (T53N, R63W, Section 14)

Background: This site was accidentally discovered by the author in 1987 during a nearby project. The quarry consists of an area covering the upper slopes and top of a large hill. The cultural remains can be divided into four areas. The first area (Source A) is the actual quarry consisting of extensive amounts of large primary flakes, cores, and shatter. At least one debris filled pit is present on the hillslope. Unfortunately most of this area has been severely disturbed by the construction of an old road no longer in use. A large quarry blank was located exposed in this roadbed. The second area is characterized by a several discreet, undisturbed workshop areas containing cores and debitage. The third area (Source B) is another outcropping of sandstone/quartzite. The quartzite in this area is a grey in color and occurs as thin bands in the sandstone. Although very fine-grained the material contains internal fracture planes that make it almost impossible to knap. This outcrop was only minimally utilized. The fourth area, comprising the remainder of the site, consists of scattered debitage (Church 1988).

Environmental Setting: the site occupies the top and sides of a small hill at an elevation of 5060 feet.

Geology: this is a primary outcrop of the Lakota formation, based upon published geologic maps and descriptions of the area (Darton 1095) and upon field observations by the author.

Cultural Materials: the site is a quarry and lithic reduction site with a dense artifact distribution (a maximum of 50 artifacts per square meter)
consisting mainly of debitage with one very large biface noted. An extraction pit is located in Source area A and others may be present under the vegetation. Temporal use of the site is undetermined at this time.

Characterization Summary-Phase I

Morphology: The extracted stone is tabular orthoquartzite.


Fresh surfaces=browns (pale yellowish brown-10YR 6/2, moderate yellowish brown-10YR 5/2, moderate brown-5YR 4/4, grayish brown-5YR 3/2, dark yellowish brown-10YR 4/2), very dark red-5R 2/6, medium dark gray-N4, grayish black-N2.


Structure: the specimens exhibited color and/or textual mottling, parallel color banding, marling, or were uniform.

Attributes: two specimens displayed dark brown speckles and contained areas of coarser grained material.

Traits:

Average specific density=2.05 (range 1.91-2.20).
Translucency=opaque. Luster=granular.
Fracture=poor to excellent conchoidal fracture.
Overall knapping quality=excellent.
Patination=none.

Phase II

Grain Morphology: macrocrystalline with a microscopic type I texture. 
   Average sphericity=.75 (range .63-.83).
   Average roundness=.4 (range .4-.6)
   Average sorting=.35 (very well to well sorted) (range .35-.50).

Phase III

Fluorescence: none.

Heat Alteration: color shift from dark yellow brown (10YR 4/2) to grayish red (5R 4/2) in one specimen and isolated reddened areas noted in the other heated specimen.

Phase IV

The results of XRF analysis are presented in figure 36.

ELU 55, Morrison Formation, Exploited Sources

48CK1139 (T53N, R63W, Section 22)

Background: This site was located during an inventory for the Ellsbury Timber Sale by this author in 1986 (Church 1986). The site consists of an outcropping of grayish quartzite with some reddish chalcedony. The outcrop has been minimally exploited and limited to expedient surface procurement. A small number of flakes and debitage were observed. The
Source: 48CK1204
Material: Quartzite
Formation: Lakota
ELU: 55
District: Gentyl Dipping Hogback
Region: Dakota Hogback
System: Bearlodge Mtns.

X-Ray Fluorescence Results

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<td>CU</td>
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N= 5/12

Figure 36. XRF Results for 48CK1204, Area A.
edge of the outcropping has been severely disturbed by construction of a road.

Environmental Setting: the site lies on the slope and base of a low ridge finger at an elevation of 5000 feet.

Geology: this is a primary outcrop of the Morrison formation based upon published geologic maps and descriptions of the area (Darton 1905) and upon field observations by the author.

Cultural Materials: the site is an extractive lithic procurement site of about 1500 square meters with a sparse artifact distribution consisting mainly of debitage and shatter. No features are present. Temporal use of the site is undetermined at this time.

Characterization Summary-Phase I

Morphology: there are three types of stone outcropping at the site. Type A is a tabular orthoquartzite, type B is a nodular chalcedony, and type C is a tabular chalcedony.

Color(s):

Type A, weathered surfaces=grays (light olive gray-5Y 5/2, medium gray-N5, greenish gray-5GY 6/1, olive gray-5Y 4/1), browns (dark yellowish brown-10YR 4/2, moderate yellowish brown-10YR 5/4, light brown-5YR 5/6, pale yellowish brown-10YR 6/2), and grayish black-N2.

Fresh surfaces=grays (light olive gray-5Y 5/2, medium dark gray-N4, medium gray-N5, olive gray-5Y 4/1), brown (light brown-5YR 5/6, dark yellowish brown-10YR 5/4, moderate yellowish brown-10YR 5/4, pale yellowish brown-10YR 6/2), grayish red-5R 4/2, and grayish black-N2.

Minor colors=olive gray-5Y 4/1, grayish orange-10YR 7/4, moderate red-5R 5/4, moderate yellowish brown-10YR 5/4, moderate brown-5YR
3/4, dark gray-N3, moderate reddish brown-10R 4/6, pale yellowish brown-10YR 6/2, medium dark gray-N4, dark yellowish orange-10YR 6/6, grayish black-N2.


Structure:
Type A-the majority of the specimens were either uniform or had parallel color banding. A few specimens contained color mottling or marling.

Type B-contained either color mottling or parallel color banding.

Type C-contained parallel color/textural banding, marling, or color mottling.

Attributes:
Type A-a number of specimens contained large sand grains, or vugs (empty or filled with large sand grains).

Type B-one specimen contains spherical dark grains.

Type C-one specimen contains vugs filled with large sand grains, and another contained veins of red hematite.
Traits:

Type A
Average specific density=2.62 (range 2.25-3.15)
Translucency=opaque. Luster=mat.
Fracture=poor to good conchoidal fracture.
Overall knapping quality=fair.
Patination=none.

Type B
Average specific density=4.8 (range 3.8-5.8).
Translucency=translucent. Luster=mat.
Fracture=poor to good conchoidal fracture.
Overall knapping quality=poor.
Patination=none.

Type C
Average specific density=4.72 (range 4.3-4.9).
Translucency=translucent. Luster=semi-mat.
Fracture=blocky to good conchoidal fracture.
Overall knapping quality=poor.
Patination=none.

Cortex:

Type A, consists of parent sandstone. Weathered surfaces displayed oranges (pale yellowish orange-10YR 8/6, very pale orange-10YR 8/2, grayish orange-10YR 4/4, moderate pinkish orange-10R 7/4), moderate yellowish brown-10YR 5/4, light gray-N7. Fresh surfaces=oranges (very pale orange-10YR 8/2, pale yellowish orange-10YR 8/6), medium light

Type B, consists of parent sandstone. Weathered and fresh surfaces= light brown-5YR 5/6.


Phase II

Grain Morphology:
Type A-microcrystalline with a microscopic type II texture.
  Average sphericity=.75 (range .67-.87).
  Average roundness=.4 (range .3-.6).
  Average sorting=.50 (moderately well sorted) (range .35-1.00).
Fossils: all specimens of all types contained no fossils.
Inclusions: Type A only, veins, reddish inclusions, reddish marling and streaks, very large quartz grains.

Phase III

Fluorescence: moderately strong, patchy, with orange to brown fluorescence in five specimens of Type B.

Heat Alteration: Color shifts were noted in two out of six Type A specimens.
  Light olive gray (5Y 5/2) to medium gray (N5)
  Dark yellow brown (10YR 4/2) to dusky red (5R 3/4)
Phase IV

The results of XRF analysis are presented in figure 37.

**48CK1204-Source Area B** (T53N, R63W, Section 14)

Background: this area lies within the site area of 48CK1204 but these specific outcrops were only minimally exploited and are from a different formation than those exploited. The quartzite in this area is a grey in color and occurs as thin bands in the sandstone. Although very fine-grained the material contains internal fracture planes that make it almost impossible to knap. This outcrop was only minimally utilized. The fourth area, comprising the remainder of the site, consists of scattered debitage (Church 1988).

Cultural Material: only a few scattered pieces of shatter, probably resulting from testing of the outcrop were observed.

Environmental Setting: the site occupies the side of a small hill at an elevation of 5060 feet.

Geology: this is a primary outcrop of the Morrison formation, based upon published geologic maps and descriptions of the area (Darton 1095) and upon field observations by the author.

**Characterization Summary-Phase I**

The stone is a tabular orthoquartzite.

Color(s): weathered surfaces=yellowish gray-5Y 8/1 and pale yellowish brown-10YR 6/2.

Fresh surfaces=yellowish gray 5Y 8/1 and pale yellowish brown-10YR 6/2.

Minor colors=dark yellow brown-10YR 4/2.
Source: 48CK1139
Material: Quartzite
Formation: Morrison
ELU: 55
District: Gently Dipping Hogback
Region: Dakota Hogback
System: Bearlodge Mtns.

X-Ray Fluorescence Results

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N= 1/22

Figure 37. XRF Results for 48CK1139.
Structure: the specimens were either uniform or exhibited marling.

Attributes: no attributes.

Traits:

Average specific density=1.98 (range 1.92-2.04).
Translucency=opaque. Luster=granular.
Fracture=good to excellent conchoidal fracture.
Overall knapping quality=poor (the material contains numerous internal fractures causes uncontrolled blocky reduction).
Patination=none.


Phase II

Grain Morphology: microcrystalline with a microscopic type II texture.
Average sphericity=.87.
Average roundness=.7.
Average sorting=.35 (very well to well sorted).
Fossils: none.

Phase III

Fluorescence: none.
Heat Alteration: no specimens were subjected to heat alteration.

Phase IV

The results of XRF analysis are presented in figure 38.
**Source:** 48CK1204  
**Material:** Quartzite  
**Formation:** Morrison  
**ELU:** 55  
**District:** Gentyl Dipping Hogback  
**Region:** Dakota Hogback  
**System:** Bearlodge Mtns.

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**N= 1/2**

Figure 38. XRF Results for 48CK1204, Area B.
Non-Exploited Sources

1Mr48Ck (T53N, R63W, Section 23)

Environmental Setting: This is a small outcrop of brown chalcedony exposed in an old logging trail.

Geology: this is a primary outcrop of the Morrison formation based upon published geologic maps and descriptions of the area (Darton 1905) and upon field observations by the author.

Characterization Summary-Phase I

Morphology: The stone is a tabular chalcedony.

Average thickness=13.5 (range 10.0-17.0 cm).

Color(s): Weathered surfaces=uniformly Dusky yellowish brown-10YR 2/2.

Fresh surfaces=are brown (dark yellowish brown-10YR 4/2, dusky yellowish brown-10YR 2/2.

Minor colors=dark yellowish orange-10YR 6/6, very pale orange-10YR 8/2.

Structure: parallel color and textual banding observed on all three specimens.

Attributes: none.

Traits:

Average specific density=2.03 (range 1.9-2.10).

Translucency=translucent. Luster=semi-mat.

Fracture=good to excellent conchoidal fracture.

Overall knapping quality=good (one specimen contained internal fracture planes making controlled reduction impossible).

Patination=none.
Cortex: consists of the parent sandstone. Colors are predominantly orange (very pale orange-10YR 8/2) or brown (moderate yellowish brown-10YR 5/4). Minor colors=none.

Phase II

Fossils: none.

Inclusions: scattered red spots, amphorous light brown areas.

Phase III

Fluorescence: weak, sparse, red/brown fluorescence noted in four specimens.

Heat Alteration: no change in the single specimen heated.

Phase IV

Results of the XRF analysis are presented in figure 39.

Reported Sites (unsampled)

48CK1265 (T53N, R63W, Section 18)

This site was also recorded in 1989 and described as “... a small workshop and quarry on and just below a saddle on the west side of Slaybaugh Creek (Cassells 1989: 40).” No features were observed and exploitation appears limited to expedient procurement. A geologic map of the area (Darton 1905) indicates that the outcropping quartzite is either from the Lakota or Morrison formations. Based on the description of the materials at the site, “gray quartzite,” the outcrop was attributed to the Morrison formation. Elevation is 5000 ft.
Source: 1Mr48Ck
Material: Chalcedony
Formation: Morrison
ELU: 55
District: Gently Dipping
Hogback
Region: Dakota
Hogback
System: Bearlodge Mtns.

X-Ray Fluorescence Results

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N= 1/3

Figure 39. XRF Results for 1Mr48Ck.
Secondary Deposits, Exploited Sources

48CK1137 (T53N, R63W, Section 22)

Background: This site was located during an inventory for the Ellsbury Timber Sale by this author (Church 1986). The site is defined by surface a large lithic scatter if chipped stone materials on a high terrace overlooking a permanent stream at the end of a valley. The site lies partially on Forest land and on private land. The use, if any, of this source would have been limited to expedient surface procurement. Environmental Setting: the site lies in a moderately sized valley at an elevation of 5000 feet.

Geology: this is a secondary deposit of orthoquartzite probably originating from either the Fall River or Lakota formations.

Cultural Materials: the site is mainly a campsite based on recovered materials with expedient use of the sparse secondary orthoquartzite deposits present. The area is defined by a sparse artifact scatter of lithic debitage and a few tools on the surface. In addition one feature, a lithic cache, was uncovered during testing. The cache contained 343 pieces of debitage, two large biface fragments, and a broken sharpening stone of sandstone.

Characterization Summary-Phase I

Morphology: The stone is a cobble or tabular orthoquartzite.

Average circumference=28.6 cm (range 20.0-34.0 cm).

Color(s): Weathered surfaces=browns (grayish brown-5YR 3/2, moderate yellowish brown-10YR 5/4, light brown-5YR 5/6), and grays (medium light gray-N5, yellowish gray-5Y 8/1).
Fresh surfaces=browns (grayish brown-5YR 3/2, light brown-5YR 5/6),
grays (light gray-N7, medium gray-N5), grayish orange-10YR 7/4.
Structure: the specimens are either uniform or exhibit color mottling.
Attributes: one specimen contained chalcedony filled veins and
another exhibited black speckles.

Traits:
  Average specific density=2.45 (range 2.42-2.55).
  Translucency=opaque. Luster=granular.
  Fracture=poor to excellent conchoidal fracture.
  Overall knapping quality=good/excellent.
Cortex: consists of a thin layer of the parent sandstone. Weathered
surfaces are dark yellowish orange-10YR 6/6, grayish orange-10YR 7/4,
and light brownish gray-5YR 6/1. Fresh surfaces=dark yellowish orange-
10YR 6/6, grayish orange-10YR 7/4.

Phase II
Grain Morphology: macrocrystalline with a microscopic type II texture.
  Average sphericity=.82 (range .71-.87).
  Average roundness=.6.
  Average sorting=0.0 (very well sorted) (range 0.0-.35).
Fossils: none.

Phase III
Fluorescence: none.
Heat Alteration: partial color shift in the single specimen heated from
moderate brown (5YR 3/4) to pale brown (5YR 5/2).
Non-Exploited Sources

3Sc48Ck (T55N, R63W, Section 7)

Environmental Setting: A single piece of silicified wood was collected from secondary gravel deposits. Chert pebbles are abundant in the gravels but are too small for efficient utilization.

Geology: this is a secondary deposit from the White River formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Characterization Summary-Phase I

Morphology: The stone is a silicified piece of wood.

Color(s): Weathered surface=dusky yellowish brown-5Y 6/4.

Fresh surface=moderate brown-5YR 3/4.

Minor colors=None.

Structure: the specimen exhibits textual mottling.

Attributes: none.

Traits:

Average specific density=1.93.

Translucency=translucent. Luster=semi-mat.

Fracture=poor.

Overall knapping quality=poor. The layering of the original wood causes uncontrolled fractures.

Cortex: none.

Phase II

Fossils: the entire specimen is a fossil. Cell structure is apparent.
Phase III

Fluorescence: none.

Heat Alteration: no specimens heated.

5Sc48Ck (T53N, R63W, Section 14)

Environmental Setting: This is a source adjacent to 48CK1204, a large quartzite quarry in the Bearlodge Mountains of Wyoming. The material here takes several forms. Type A are polished cobbles of a tan, red and gray homogeneous quartzite. Type B are small, mostly pebble sized, nodules of a reddish chalcedony. Type C is white to light gray chert in angular chunks. All of these are exposed in a limited area and are secondary in nature. Reconnaissance of the general area failed to located any other sources of like materials.

Geology: this is a secondary deposit, probably of the Morrison formation based upon published geologic maps and descriptions of the area (Darton 1905) and field observations by the author.

Characterization Summary-Phase I

Morphology: Type A, cobbles (ranging in circumference from 23.5 to 34 cm) of orthoquartzite, type B are tabular pieces of chert, and type C are are pebbles of chalcedony.

Type B, weathered and fresh surfaces are yellowish gray-5Y 8/1. Minor colors include pale yellowish brown-10YR 6/2, and very pale orange-10YR 8/2.

Type C, weathered surfaces are either very dark red-5R 2/6 or moderate brown-5YR 4/4. Fresh surfaces are either very dark red-5R 2/6 or brownish gray-5YR 4/1. Minor colors include pinkish gray-5YR 8/1.

Structure:
Type A-the majority are uniform, one specimen each exhibited color mottling or parallel color banding.
Type B-both specimens exhibited marling.
Type C-both specimens exhibited color mottling.

Attributes:
Type A-none.
Type B-dendritic, oolitic, chalcedony filled veins.
Type C-inclusions of crystals or dark and light spherical areas (1 mm in diameter).

Traits:
Type A
Average specific density=2.16 (range 1.63-2.49).
Translucency=opaque. Luster=granular.
Fracture=poor conchoidal fracture.
Overall knapping quality=poor.
Patination=none.

Type B
Average specific density=2.06 (range 1.98-2.14).
Translucency=translucent to opaque. Luster=semi-mat.
Fracture=good conchoidal fracture.
Overall knapping quality=good.
Patination=none.

Type C
Average specific density=2.36 (range 2.29-2.44).
Translucency=transparent to translucent.
Luster=mat to semi-mat.
Fracture=good to poor conchoidal fracture.
Overall knapping quality=fair.
Patination=none.

Cortex:
Type A-has no cortex.
Type B-consists of parent limestone, white-N9, in color.
Type C-has no cortex.

Phase II

Grain Morphology:
Type A-microcrystalline with a microscopic with a silicified sandstone or type II texture.

Average sphericity=.73 (range .65-.83).
Average roundness=.45 (range .3-.6).
Average sorting=.75 (range .50-1.00).

Type B-cryptocrystalline.
Type C-cryptocrystalline.

Fossils: none of the specimens from any type contained fossils.
Phase III

Fluorescence: Type C specimens exhibited strong, wide-spread or confined to certain bands, orange/brown fluorescence in three of the chalcedony specimens.

Heat Alteration: color shifts in two out of the three Type A specimens.

Very pale orange (10YR 8/2) to pinkish gray (5YR 8/1).

Grayish yellow (5Y 8/4) to yellowish gray (5Y 7/2).

Phase IV

Results of the XRF analysis are presented in figure 40.

Reported Sites (unsampled)

48CK1179 (T53N, R63W, Section 7)

This site was recorded in 1989 and described as "... a large quarry and workshop located on an below a ridge just west of Slaybaugh Creek ... (Cassells 1989: 38)." No features were observed and it appears that prehistoric use was limited to expedient procurement. A geologic map of the area (Darton 1905) indicates that the quartzite outcrops would be from the Morrison formation. Elevation is 4860.

ELU 56, Fall River Formation, Exploited Sources

48CK264 (T55N, R63W, Section 26)

Background: This site was originally recorded in 1980 by a USFS para-professional during the North Top Timber Sale inventory. The site was described as having an extensive quarry with small areas of lithic waste along the rimrock (Niles 1980). A corner notched point was collected nearby at this time.
Source: 5Sc48Ck
Material: Quartzites,
Chalcedonies and
Cherts
Formation: Secondary
ELU: 56
District: Gently Dipping
Hogback
Region: Dakota
Hogback
System: Bearlodge Mtns.

X-Ray Fluorescence Results

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Figure 40. XRF Results for 5Sc48Ck.
The site area was relocated on July 19, 1986. The site is somewhat unusual as the outcropping quartzite is of poor quality and consequently was not used. But a deposit of better quality colluvium quartzite was extensively exploited. No tools or features were observed.

Environmental Setting: the site lies on the moderate slope of low ridge at an elevation of 4640 feet.

Geology: this is primary outcrop of orthoquartzite with associated colluvium of the Fall River formation, based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an expedient lithic procurement area with a dense artifact distribution consisting mainly of debitage and tested chunks of colluvium. The primary orthoquartzite outcrops, located a short distance uphill, do not appear to have been exploited. No features were observed. The presence of a corner-notched chert projectile point found by the original investigator in the vicinity would suggest use during the Archaic.

Characterization Summary-Phase I

Morphology: the exploited stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=browns (dusky yellow brown-10YR 2/2, moderate yellowish brown-10YR 5/4, grayish brown-5YR 3/2, dark yellowish brown-10YR 4/2), grays (light gray-N6, pinkish gray-5YR 8/1), and reds (very dusky red-10R 2/2, dusky red-5R 3/4, pale red-10R 6/2).

Fresh surfaces=browns (dusky yellow brown-10YR 2/2, moderate yellowish brown-10YR 5/4, pale yellowish brown-10YR 6/2, dark
yellowish brown-10YR 4/2), grays (light gray-N6, pinkish gray-5YR 8/1), and reds (very dusky red-10R 2/2, dusky red-5R 3/4, pale red-10R 6/2).

Minor colors=moderate brown-5YR 4/4, white-N9, pale purple-5P 6/2, pale yellowish brown-10YR 6/2, dusky yellowish brown-10YR 2/2, moderate reddish brown-10R 4/6, black red-5R 2/2, and pale reddish brown-10R 5/4.

Structure: the majority of the specimens exhibited either a uniform structure, or color and/or textual parallel banding. One specimen contained color mottling and another marling.

Attributes: two specimens contain vugs, one empty the other crystal filled, and one specimen has small deposits of a yellow powder.

Traits:

Average specific density=2.11 (range 1.6-2.73).

Translucency=opaque. Luster=granular.

Fracture=poor to good conchoidal fracture.

Overall knapping quality=good.

Patination=none.

Cortex: consists of the parent sandstone. The color of weathered surfaces ranged from browns (dark reddish brown-10R 3/4, pale yellowish brown-10YR 6/2, light brown=5YR 5/6, moderate brown-5YR 4/4) to grayish orange-10YR 7/4, and pale red-5R 6/2. Fresh surfaces were browns (moderate brown-5YR 4/4, pale yellowish brown-10YR 6/2, dark reddish brown-10R 3/4), orange (dark yellowish orange-10YR 6/6, grayish orange-10YR 7/4), and moderate red-5R 4/6.

Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.
Average sphericity=.76 (range .59-.85).
Average roundness=.4 (range .2-.6).
Average sorting=.35 (very well to well sorted) (range .35-.50).
Fossils: none.
Inclusions: thin reddish flecks.

Phase III

Fluorescence: none.
Heat Alteration: color shifts in two out of the three specimens heated.
Very light gray (N8) to pinkish gray (5YR 8/1).
Moderate yellowish brown (10YR 5/4) to moderate brown (5YR 4/4)

48CK287 (T54N, R63W, Section 10)

Background: The site was recorded in 1979 by a USFS para-professional during the South Top Timber Sale inventory. His description of the site is as follows. "The quarry is located at the upper edge of the precipice and northward clockwise to large blocks and overhang with hearth. The slope has heavy concentration of wast (sic) flakes and cores and are evident at edge of rim and talus slope below." (Niles 1980).

The site was relocated in 1986 and found to be a pocket of good quality light grey quartzite situated on a steep slope above a cliff. Numerous pieces of debitage are scattered on the slope and two rubble piles at the cliff's edge were noted (Church 1987a: 6).

Environmental Setting: the site lies on the edge of a steep sandstone cliff at an elevation of 4700 feet.
Geology: this is primary outcrop of orthoquartzite of the Fall River formation, based on published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an extractive lithic procurement area with moderately dense artifact distribution mainly of debitage and cores. Two mounds of rubble lie a short distance downslope from the outcrop and probably represent debris from extraction activities. The time of use for the site is undetermined.

Characterization Summary-Phase I

Morphology: the exploited stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=pale yellowish brown-10YR 6/2, light olive gray-5Y 6/1, and grayish red purple-5RP 4/2.

Fresh surfaces=pale yellowish brown-10YR 6/2, light olive gray-5Y 6/1, very light gray-N8, and grayish red purple-5RP 4/2.


Structure: All but one specimen, with parallel color banding, are uniform in structure.

Attributes: two specimens contained calcareous patches and spots.

Traits:

Average specific density=2.17 (range 2.03-2.51).

Translucency=opaque. Luster=granular.

Fracture=good to excellent conchoidal fracture.

Overall knapping quality=good.

Patination=none.

Cortex: consists of the parent sandstone. The color of weathered surfaces ranged from grayish orange-10YR 7/4, to grayish red-10R 4/2,
and pale yellowish brown-10YR 6/2. Fresh surfaces were white-N9, pale yellowish brown-10YR 6/2, pale reddish brown-10R 5/4, and grayish orange-10YR 7/4.

Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.

Average sphericity = .80 (range .77-.83).
Average roundness = .5 (range .4-.5).
Average sorting = 0.0 (very well sorted) (range 0.0-.35).
Fossils: none.

Phase III

Fluorescence: none.
Heat Alteration: color shifts in two out of three specimens heated.

Greenish gray (5GY 6/1) to light olive gray (5Y 6/1).
Light gray (N7) to very light gray (N8).

48CK288 (T54N, R63W, Section 12)

Background: This site was located during a 1979 inventory of the South Top Timber Sale by a USFS para-professional. He described the site as "A heavy concentration of quartzite flakes and cores cover an area of about 20 X 50'. So numerous as to have a depth of about 6"...." (Niles 1980).

The site was revisited in 1986 and found to have be an outcrop of fine to medium grained quartzite on a slope just below the ridgeline. Procurement was limited to the surface and numerous pieces of debitage are scattered about.
Environmental Setting: the site lies on a slight slope above a steep cliff at an elevation of 4700 feet.

Geology: this is primary outcrop of orthoquartzite with associated colluvium of the Fall River formation, based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an lithic procurement area with moderately dense artifact distribution consisting mainly of debitage, shatter, and cores. Extractive procurement techniques were used. No features were located. The time of use for the site is undetermined.

Characterization Summary-Phase I

Morphology: the exploited stone is a tabular orthoquartzite.

Color(s): Weathered surfaces=moderate yellowish brown-10YR 5/4, moderate red-5R 4/6, white-N9.

Fresh surfaces mirror those above.

Minor colors=moderate yellowish brown-10YR 5/4.

Structure: all but one specimen, with color mottling, were uniform in structure.

Attributes: none.

Traits:

Average specific density=1.89 (range 1.78-2.0).

Translucency=opaque. Luster=granular.

Fracture=poor to excellent conchoidal fracture.

Overall knapping quality=good.

Patination=none.
Cortex: consists of the parent sandstone. The color of weathered surfaces ranged from pale brown-5YR 5/2 to grayish orange-10YR 7/4. Fresh surfaces mirrored the weathered surfaces.

Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.

Average sphericity=.79 (range .75-.83).
Average roundness=.5 (range .4-.6).
Average sorting=.35 (very well to well sorted).

Fossils: none.
Inclusions: a few areas of loosely cemented sand grains in one specimen.

Phase III

Fluorescence: none.

Heat Alteration: color shifts in three out three specimens heated.

Pale yellowish brown (10YR 6/2) to light gray (N7).

Dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4).

Moderate yellowish brown (10YR 5/4) partially reddened to moderate red (5R 5/4).

48CK290 (T54N, R63W, Section 12)

Background: This site was located during the South Top Timber Sale inventory by a USFS para-professional in 1980. He described the outcropping quartzite as having "a distinctive green color". Quantities of debitage were also reported (Niles 1980).
The site was relocated in 1986 and is defined as a small pocket of exploited quartzite along the rimrock. The primary difference is the green color in the material, a color not noted at any of the other outcrops. The material could be mistaken for Bijou Hills quartzite which is common along the Missouri River. Several hundred pieces of debitage are present (Church 1987a: 6).

Environmental Setting: the site lies in sparse ponderosa pine at an elevation of 4800 on the edge of the cliff surrounding the northern Bearlodge Mountains.

Geology: this is a primary outcrop of the Fall River formation based upon published geologic maps and descriptions of the area (Mapel 1959), and on field observations by the author.

Cultural Materials: the site is an expedient lithic procurement site of about 200 square meters with a light artifact distribution (a maximum of 20 artifacts per square meter) consisting mainly of debitage and shatter. No features other than the exploited outcrop itself was noted. Temporal use of the site is undetermined at this time.

Characterization Summary-Phase I

Morphology: The exploited stone is a tabular orthoquartzite.

Average thickness=2.66 (range 2.0-4.0 cm).

Color(s): Weathered surfaces=gray (pinkish gray-5YR 8/1), greens (pale olive-10Y 6/2, dusky yellowish green-5GY 5/2), and browns (moderate yellowish brown 10YR 5/4, moderate brown-5YR 4/4).

Fresh surfaces=gray (light gray-N7), greens (grayish green-10GY 5/2, grayish olive green-5GY 3/2), browns (moderate yellow brown-10YR 5/4, moderate brown-5YR 4/4).
Minor colors=none.

Structure: all the specimens have a uniform structure.

Attributes: none.

Traits:

Average specific density=1.86 (range 1.72-2.11)
Translucency=opaque. Luster=granular.
Fracture=poor to good conchoidal fracture.
Overall knapping quality=good.

Cortex: consists of the parent sandstone on three specimens. Colors are browns (moderate yellowish brown-10YR 5/4, yellowish gray-5Y 7/2).

Minor colors=none.

Phase II

Grain Morphology: macrocrystalline with a microscopic type II texture.

Average sphericity=.70 (range .63-.73)
Average roundness=.5
Average sorting=.35 (very well to well sorted).

Fossils: none.

Phase III

Fluorescence: none.

Heat Alteration: no specimens heated.

Reported Sites (unsampled)

48CK262 (T55N, R63W, Section 26)

This site was originally located by a USFS para-professional in 1980 and later evaluated in 1989. It is described as "... an aboriginal quarry and workshop where local quartzites were probably reduced to blanks and
other transportable forms of artifacts (Cassells 1989: 17).” It is located on a high “mesa” at an elevation of 4730. A geologic map of the area (Mapel et. al. 1959) indicates that the quartzite would originate from the Fall River formation.

48CK273 (T55N, R63W, Section 34)

This site was recorded by a USFS para-professional in 1980 and later evaluated in 1989. The site is described as “... a very small quarry located among quartzite talus boulders on a gradually descending westward slope below the high mesa top... (Cassells 1989: 19).” No features were located and the quartzite appears to have been expediently gathered. A geologic map of the area (Mapel et. al. 1959) indicates that the quartzite would originate from the Fall River formation. Elevation is 4420 ft.

Lakota Formation, Reported Sites (unsampled)

48CK269 (T55N, R63W, Section 27)

This site was recorded by a USFS para-professional in 1980 and later evaluated in 1989. The site is described as “... a small quarry and shop site located where knappers exploited large quartzite talus boulders that lie across the terminus of a gradual slope... (Cassells 1989: 19).” No features were located and the quartzite appears to have been expediently procured. A geologic map of the area (Mapel et. al. 1959) indicates that the quartzite would originate from the Lakota formation. Elevation is 4300 ft.
Morrison Formation, Exploited Sources

48CK248 (T55N, R63W, Section 11)

Background: This site was located during the inventory for the East Creek Timber Sale in 1979 by a USFS para-professional. The site was described as a scatter of large flakes of a white coarse quartzite, possibly representing quarry activity (Niles 1980).

This site was relocated and evaluated by this author in 1987. It consists of a scattering of large flakes and chunks of a fine-grained grey quartzite. No outcrop was observed and procurement appeared limited to surface collection of eroding colluvium. The entire site area has been severely disturbed by natural erosion of the unstable sandy soil and by logging activity on the slopes (Church 1987b). This material is of special interest as it corresponds to what has been labeled as Morrison quartzite in Wyoming, and the grey variety of Tongue River Silicified Sediment in South Dakota. There appears to be a conflict in terms and usage that should be clarified.

Environmental Setting: the site lies on a steep side slope at an elevation of 4700 feet.

Geology: this is primary outcrop of orthoquartzite of the Morrison formation, based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Cultural Materials: the site is an expedient lithic procurement area with a sparse artifact distribution consisting of debitage and shatter. No features were located. Temporal use of the site is undetermined at this time.
Characterization Summary-Phase I

Morphology: the exploited stone is a tabular orthoquartzite.


Structure: the specimens were either uniform, exhibited color mottling, and parallel color banding.

Attributes: one specimen contained veins of an unidentified material and another specimen contained small pockets of reddish material.

Traits:

   Average specific density=2.16 (range 1.73-2.3).

   Translucency=opaque. Luster=granular.

   Fracture=poor to good conchoidal fracture.

   Overall knapping quality=good.

   Patination=none.

Cortex: consists of the parent sandstone. The color of weathered ranged from light brown-5YR 5/6 to medium light gray-N6. Fresh surfaces=pinkish gray=5YR 8/1.

Phase II

Grain Morphology: microcrystalline with a microscopic type I fracture.

   Average sphericity=.65 (range .63-.67).

   Average roundness=2.5 (range .2-.3).

   Average sorting=.50 (well to moderately well sorted).

Fossils: none.

Inclusions: veins, or reddish stained areas.
Phase III

Fluorescence: none.

Heat Alteration: no change in the single specimen heated.

Phase IV

Results of the XRF analysis are presented in figure 41.

Non-Exploited Sources

3Mr48Ck (T55N, R63W, Section 11)

Environmental Setting: This is a source located by the author in the northern Bearlodge Mountains of Wyoming. The outcrop had been exposed by road construction. There are two types of quartzite exposed. The lower is a massive coarse to medium grained quartzite, while the upper is a fine-grained grey quartzite known as Morrison quartzite. This upper material occurs in elliptical pockets in the sandstone, which has vertical burrows present. This source is fairly close to 48CK249, a Morrison quartzite procurement site.

Geology: this is a primary outcrop of the Morrison formation based upon published geologic maps and descriptions of the area (Mapel 1959) and upon field observations by the author.

Characterization Summary-Phase I

Morphology: The stone is a tabular orthoquartzite. Two types of orthoquartzite are present; a fine-grained gray (type A), and a coarser grained, lighter gray stone (type B).

Color(s): Weathered surfaces, type A=grays (light olive gray-5Y 6/1, yellowish gray-5Y 8/1). Type B= light gray-N7.
Source: 48CK248
Material: Quartzite
Formation: Morrison
ELU: 56
District: Gently Dipping
Hogback
Region: Dakota
Hogback
System: Bearlodge Mtns.

**X-Ray Fluorescence Results**

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N= 1/5

Figure 41. XRF Results for 48CK248.
Fresh surfaces, type A=grays (light olive gray-5Y 6/1, yellowish gray-5Y 8/1, light gray-N7). Type B=very light gray-N8.

Minor colors, type A=light gray-N7, medium light gray-N5, yellowish gray-5GY 8/1. Type B=none.

Structure: all of the type A specimens exhibited some color mottling. Type B structure was uniform.

Attributes: none.

Traits:

Average specific density=type A: 2.31 (range 1.73-2.67), type B: 2.13.

Translucency=opaque. Luster=granular.

Fracture=type A, good to excellent conchoidal fracture. Type B, poor conchoidal fracture.

Overall knapping quality=type A, excellent; type B, poor.

Patination=none.

Cortex: Type A consists of the parent sandstone. Colors on weathered surfaces are yellowish gray-5Y 8/1, grayish orange-10YR 7/4, and very pale orange-10YR 8/2. Type B had no cortex.

Colors on fresh surfaces are pinkish gray-5YR 8/1 and very light gray-N8.

Phase II

Grain Morphology: microcrystalline with a microscopic type II texture.

Average sphericity=type A, .79; type B, .75.

Average roundness=type A, 4; type B, .3.

Average sorting=type A & B, 0.0 (very well sorted).

Fossils: none.
Structure: type A, very small grains. Type B has scattered dark grains giving a speckled appearance.

Phase III

Fluorescence: none.

Heat Alteration: type A, color shift in one out of three heated specimens.

Yellowish gray (5Y 8/1) to very light gray (N8).

Phase IV

Results of the XRF analysis are presented in figure 42.

Reported Sites (unsampled)

48CK270 (T55N, R63W, Section 27)

This site was recorded by a USFS para-professional in 1980. It was described as a lithic scatter with a small outcropping of chalcedony. No features were present and it appears that the chalcedony outcrop was only expediently exploited. A geologic map of the area (Mapel et. al. 1959) indicates that the outcrop is probably from the Morrison formation.
Source: 3Mr48Ck
Material: Quartzite
Formation: Morrison
ELU: 56
District: Gently Dipping Hogback
Region: Dakota Hogback
System: Bearlodge Mtns.

X-Ray Fluorescence Results

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N = 4/5

Figure 42. XRF Results for 3Mr48Ck.