Thesis

High Altitude Occupation and Raw Material Procurement: Dollar Mountain, a Northwestern Wyoming Example

Submitted by

William Thomas Reitze

Department of Anthropology

In partial fulfillment of the requirements

For the Degree Master of Arts

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WE HERBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY WILLIAM THOMAS REITZE ENTITLED HIGH ALTITUDE OCCUPATION AND RAW MATERIAL PROCURMENT: DOLLAR MOUNTAIN, A NORTHWEST WYOMING EXAMPLE BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE MASTER OF ARTS.

Committee on Graduate Work

Jeffrey Eighmy

Sara Rathburn

Adviser: Lawrence Todd

Departmental Head/Director

Abstract of the Thesis

High Altitude Occupation and Raw Material Procurement: Dollar Mountain, a Northwestern Wyoming Example

Studying past human behavior is best addressed by the study of the remains of human activity through the use of archaeological methods. But the study of these remains of past human behavior must take into account their context, and human behavior must be explained as a landscape based phenomena. This thesis explores the incorporation of geoarchaeological, geomorphological, and archaeological principles into a system of landscape analysis. Through the study of the changing nature of the landscape, a better understanding of human behavioral responses to a dynamic landscape can be gained. The research was conducted as part of the Greybull River Impact Zone Project in the Upper Wood River watershed on the eastern slope of the Absaroka Range of northwestern Wyoming, during the 2003 field season. At present no published data of prehistoric occupation are available from the high altitude regions of the Absaroka Mountains. Dollar Mountain frames the western edge of a cirque basin and contains a unique deposit of fine-grained cryptocrystalline chert that has not been reported in any archaeological literature as potential material for chipped stone tools. This thesis addresses the following questions: Were the high altitude cirques of the Absarokas utilized by prehistoric peoples? Was Dollar Mountain chert utilized by prehistoric peoples? What types of geological analysis can be incorporated into archaeological interpretation to develop a relative landscape age? By understanding landscape, can more informed hypotheses of prehistoric occupation be generated? Understanding of these research questions can lead to models of how human behavior has transformed to accommodate landscape change. Human behavior does not operate only on a site-specific scale; behavior is an interaction with the environment at a variety of levels. To build the most accurate models of past human behavior, human interaction with the environment must be considered at multiple scales.

William Thomas Reitze
Anthropology Department
Colorado State University
Fort Collins, CO 80523
Fall 2004

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Chapter One: An Introduction

"An archaeologist studies and tries to reconstitute the process that has created the human world in which we live"

V. Gordon Childe (1962:9)

Understanding prehistory is a complex and extensive process. Archaeology is in the unique position to observe long term trends and to formulate and test theories with respect to human behavior (Harris 1971:156). As archaeologists, our concern should be with the interpretation of human behavior, yet human behavior must be understood in terms of the surviving archaeological record that remains as an indicator of this past behavior. However, the archaeological record is modified over time. Renfrew and Bahn (1996:46) state that all archaeological interpretation must be conducted through the analysis of context. Schiffer provides three parts to this context, 1) the spatial relationships of the material, 2) how the material was output from a cultural system, and 3) how the material has been subjected to noncultural processes (1976:13). Material without context cannot be analyzed, or at least not on at an individual scale. The examination of context requires the collection of many different types of data. Analysis must be conducted through interplay between these multiple data sets. As Mortimer

Wheeler says “Archaeology is increasingly dependent on a multitude of sciences and is itself increasingly adopting the methodology of a natural science. It draws today upon physics, chemistry, geology, biology, economics, political science, sociology, climatology, botany” (cited in Rapp & Hill 1998:3).

The dynamic nature of archaeological sites and materials is driven by the surrounding environmental events and processes. Willey (1953) began a period of analysis in archaeology where the entire landscape forms an important analytical unit. His work in the Virú Valley addressed the archaeological record on a regional level. Individual sites were no longer the only archaeological units of measure, now the interaction of sites with other sites and their environment could be analyzed. Julian Steward’s cultural ecology provided a way to analyze human populations in terms of their environment. Cultural ecology is the study of the processes by which a society adapts to its environment (Steward 1977:43). Willey and Steward’s approaches led to the analysis of archaeology in an environmental context. The development of environmental archaeology by Karl Butzer (1980) allowed analysis of archaeological assemblages to be conducted with respect to their interactions with the physical world. Butzer (1980:417) argues that the environment is not a static variable and the variation in environmental factors must be incorporated into any archaeological analysis.

The archaeological record is not uniform across the landscape, but has areas of better preservation and/or denser occupation. These concentrations are archaeological sites. To understand an archaeological site, the physical properties that led to its creation must be understood. The taphonomic processes of burial, modification, chemical alteration and subsequent exposure modify archaeological assemblages (Lyman

1994:40). To begin to say anything about human behavior from archaeological materials, these physical alterations must be separated and understood (Schiffer 1987:5). One aspect of the study of taphonomy has been to understand the physical processes that affect the distribution and condition of bone found in archaeological assemblages (Frison & Todd 1986, 1987; Rapson 1990). The modification of the bone involves the complex interaction of human activity (both by the depositors and later groups) and a suite of physical and biological processes. This concept has been applied directly to the landscape in order to understand archaeological site formation and separate prehistoric human behavior from the processes of the physical environment. The notion of *landscape taphonomy* has been suggested to address these interactions in archaeological contexts (Burger 2002; Todd et al. 2004). These interactions occur at different scales; archaeology/environmental interaction can range from distribution of material on the landscape to microstratigraphy and the minute alteration of archaeological material. To address the complexity of this interaction multiple data sets must be collected to link the variation in the physical, natural, and cultural processes. Geoarchaeology allows the incorporation of these data sets. Rapp and Hill (1998:2) suggest that geoarchaeology draws in other disciplines and sub-disciplines (e.g., archaeometry, environmental archaeology, Quaternary geology, geomorphology, taphonomy, and geography) forcing the collection, analysis, and integration of many different data sets, and offering the ideal vehicle for archaeological analysis.

The concept of applying geologic analysis to archaeological material has been present in North American archaeology almost since its inception, particularly in association with 'lithic cultures' of archaeological assemblages consisting primarily of lithic and bone. Forefathers of geoarchaeology, such as Bryan and Antevs, saw the importance of understanding the sequence of landscape development and the formation of archaeological sites through accretion of sediment (see discussion in Haynes 1990). Rapp and Hill (1998:1) describe the geologic analysis of archaeological sites as playing a "pivotal role in interpreting this record in both method and theory." Some suggest that archaeological sites are geological sites with some material of interest to archaeologists (Thorson 1990) implying that the processes that are recorded are geological. The creation of a unified framework for combining archaeology and geology is vital, as geological principles cannot be separated from archaeological analysis. Geological interpretations and principles are vital in all archaeological contexts, time periods, and landscapes. It is through the sites' physical context (the geology) that the archaeological material is given meaning (Thorson 1990). As Gladfelter (1977:520) states, "temporal and spatial contexts may be preserved with the artifacts." It is through the multidisciplinary nature of geoarchaeological principles that archaeologists are able to date sites (both through radiometric means and stratigraphic association), reconstruct past climates, understand raw material use and procurement, and create a sequence of events that begins with the discard of cultural material by a past group and culminates with the recovery of that same material, however modified, by archaeologists.

In addition to the taphonomic analysis, geologic analysis of lithic raw material is vital to the reconstruction of past human behavior. Lithic raw material economies have been used to explain hunter-gatherer behavior from measures of technological efficiency and organization. The work of Andrefsky (1994, 2001), Bamforth (1986), Binford (1979), Ingbar (1994), Parry & Kelly (1987) and others have used raw materials to model past activities through the differing kinds of tools and their raw material sources. The structure of raw material procurement (as seen through archaeological assemblages) has been used to interpret past strategies to deal with different environments and subsistence problems. This provides another data set in archaeological interpretation that helps to establish context of human behavior within the framework of geological space and time.

This thesis addresses the occupation of a cirque basin in northwestern Wyoming following the last glacial maximum (LGM), using a geoarchaeological approach. It will analyze the physical dynamics of an area driven by glacial and other geomorphic action and to analyze raw material procurement and its use by prehistoric peoples. No archaeology has previously been reported from Dollar Cirque (Dollar Cirque is in the Absaroka Mountains of northwestern Wyoming and will be the focus of this research). Framing the western margin of the cirque basin is Dollar Mountain, a unique geological feature. Dollar Mountain is an uplifted block of sedimentary rock (Rouse 1940; Wilson 1964) that has the potential to provide lithic raw materials that could be used in the production of chipped stone tools. The Dollar Mountain project was conducted as part of the larger Greybull River Impact Zone project (GRIZ) (Figure 1.1) that is assessing human land use in the Greybull River watershed.

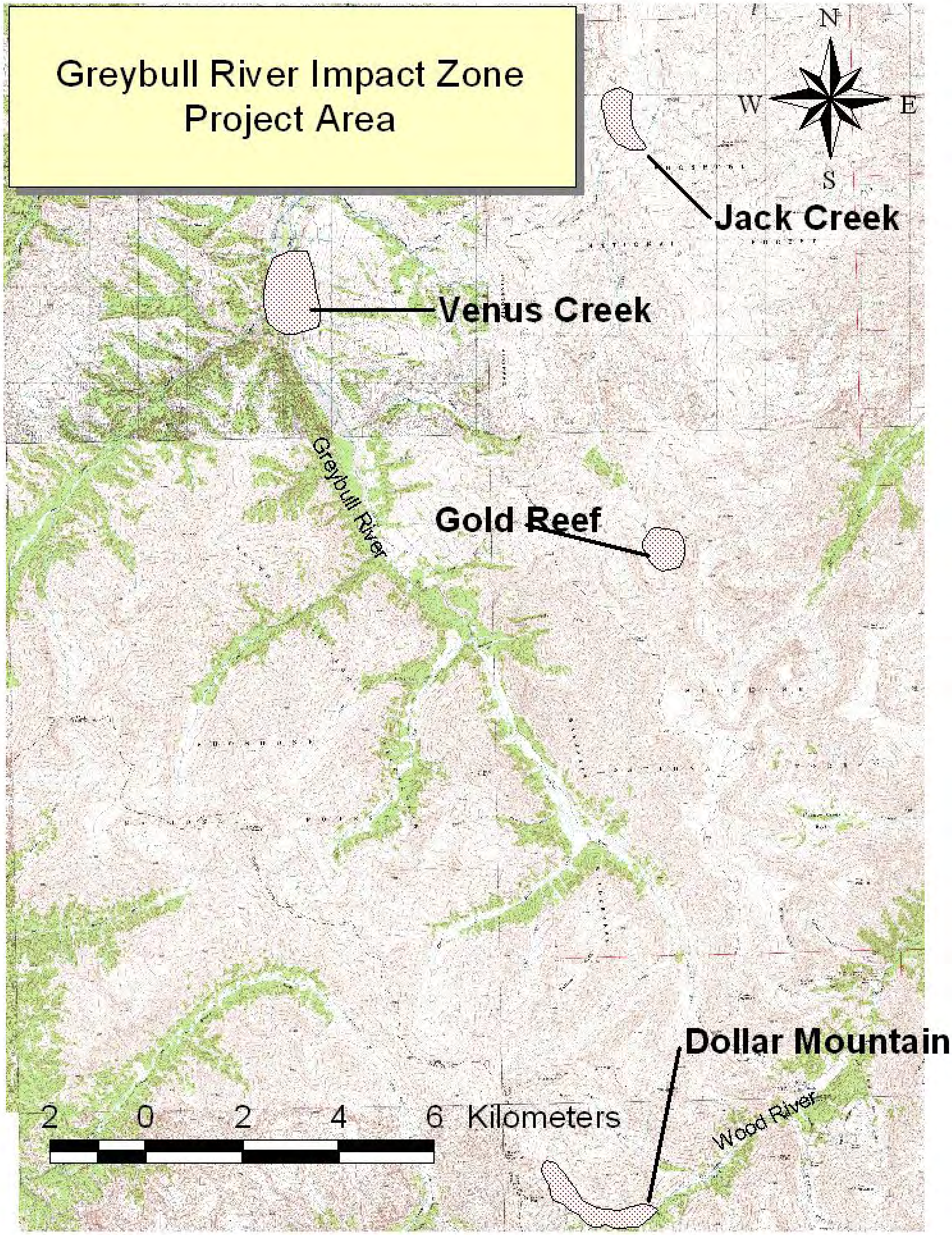


Figure 1.1- Map of the Greybull River Impact Zone project in 2003 field season. Base map: Burwell, Dunrud, Francs, Irish Rock, Phelps, and Wiggins USGS 7.5 minute topo quads.

The first goal of the Dollar Mountain project is to begin documentation of the archaeological record in Dollar Cirque (Chapter Two and Four). After the presence or absence of prehistoric occupation has been determined, then work can be done to infer past human behavioral patterns. The second goal is to understand the archaeological record in terms of the geomorphic processes that have shaped the landscape (Chapter Three). The geology and geomorphology in this high altitude cirque basin is exceedingly variable. Knowledge of the landscape, landscape age, and the processes of formation is crucial for understanding the archaeological record. The third goal is to report, describe and analyze the lithic raw material at Dollar Mountain (Chapter Four). Knowledge of the fine-grained cryptocrystalline chert within the Dollar Mountain bedrock is necessary to build regional models of human mobility, land use strategy, and raw material economies. Before questions of past human behavior can be asked, the nature of the interaction between the physical and biological worlds, and the archaeological record, must be developed.

Research Questions

This study will address the four following questions:

- Were the high altitude cirques of the Absarokas utilized by prehistoric peoples?
- Was Dollar Mountain chert utilized by Prehistoric peoples?
- What types of geological analysis can be incorporated into archaeological interpretation to develop a relative landscape age?
- By understanding landscape can more informed hypotheses of prehistoric occupation of Dollar Cirque and other high elevation portions of the Absaroka Mountains be generated?

The first chapter will address the background and history of Dollar Mountain. The following questions will be addressed. 1) What geological forces created and shaped the environment? 2) What forces have altered it through time? 3) What is the environment like today? 4) What is the climate (past and present)? 5) What governs the vegetation? 6) What resources (floral, faunal, and mineral) are present? This information can then be used to build a framework, a starting point in time, through which human behavior can be inferred.

The second chapter presents the methodology used to collect data during the project. This includes the field methodology: the survey strategy and mapping program. Second, this chapter addresses the data recording methods, which includes what variables and why different variables were recorded. This is followed by a description of the laboratory methodology and how the lithic raw material was analyzed. The chapter concludes with a description of the material that was recorded during the course of the project listed by individual site (or artifact cluster).

The third chapter begins the discussion of how the present landscape has been altered through time. This relies on analysis of the geomorphology and geology of the region. Site taphonomy is driven by a set of glacial and periglacial processes that have shaped the sites as we see them today. The complex way that the landscape has formed gives us insight into what has occurred to the material remains deposited by prehistoric peoples.

Chapter four addresses the raw material analysis of the Dollar Mountain chipped stone resources. It begins with a discussion of the formation and structure of Dollar Mountain. Next, it describes the lithic raw material in terms that can be used in macroscopic analysis with other raw material sources in the Plains and Rocky Mountains. It concludes with a description of the archaeological assemblage.

The fifth chapter synthesizes the archaeology with the raw materials and the environment. This allows for the reconstruction of potential human behavioral patterns. Knowledge of human behavioral patterns can create an understanding of the prehistoric occupations at high altitude in the Absarokas in terms of the human land use.

The final chapter provides a direction for future research. As this thesis presents a very brief look into the archaeology in Dollar Cirque, and an even more abbreviated analysis of high altitude archaeology of Northwestern Wyoming, significant potential exists for future research in both prehistoric human land use and the effects of highly dynamic glacial/periglacial environments on the formation of archaeological sites. The

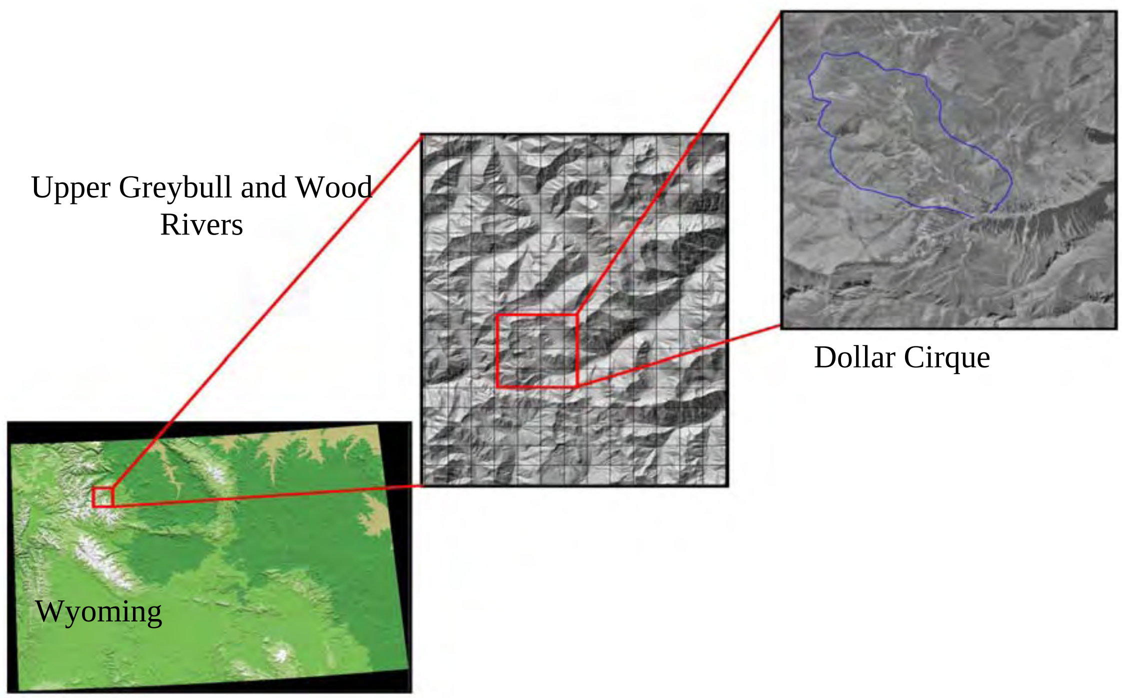


Figure 1.2 The Project's location in relation to the state of Wyoming, a 10 m digital elevation model based off of the USGS Dunrud 7.5 minute topo quad, and a digital ortho quarter quad (DOQQ), with Dollar Cirque outlined in blue. DEM and DOQQ were taken from the Wyoming Spatial Data Clearing House.

final goal of this chapter, and the entire thesis, is to generate possible research questions that can be explored in greater detail in the future.

Location

The project site is located in Northwestern Wyoming and within the Greater Yellowstone Ecotone (Figure 1.2). The Dollar Mountain project area is in a high cirque basin and neighboring sections of valley floor in the Absaroka Mountains. The Absaroka Mountains lie to the east of the Yellowstone Plateau and to the west of the Big Horn Basin. Dollar Cirque is in the Wood River Basin, a tributary of the Greybull River (the confluence is approximately 8 km west of Meeteetse, Wyoming). The Greybull River is one of the principle tributaries of the Big Horn River that drains the Big Horn Basin. The Big Horn Basin is itself framed by the Absaroka Mountains to the west, the Big Horn Mountains to the east, the Owl Creek Mountains to the south, and the Pryor Mountains to the north. The Wood River watershed is approximately 45 km long and 23 km wide, and has a total area of about 570 km^2. The highest water flow recorded at the mouth of the Wood River (as of 1973) was 143.85 m^3/sec and the lowest recorded flow 0.079 m^3/sec (KES v. 8 1973:33). The Wood River watershed ranges in elevation from approximately 3,660 meters above sea level (masl) at its highest point to 1,830 masl at it confluence with the Greybull River. Dollar Cirque is on the western slopes of Dollar and Dunrud Peaks, approximately 10 km from Franc's Peak, the highest point in the Absaroka Range (4,009 masl). The elevation of the project area ranges between 2900 masl and 3400 masl and Universal Trans Mercator (UTM) 632510 to 635360 m east to 4858400 to 4858000 m north (WGS 84 datum). Dollar Cirque has a total area of approximately 3 km^2.

Access to the site

Dollar Cirque is about 48 km west of Meeteetse and 58 km south of Cody. Start from Meeteetse and drive west on state highway 290 for approximately 8 km. Turn south on Wood River Road (county road 4DT) and continue to drive 50 km to the ghost town of Kirwin. The road is a well maintained gravel road to the Brown Mountain campground, 30 km from state highway 290. Beyond the Brown Mountain Campground the road requires four-wheel-drive and crosses the Wood River several times. Drive to the parking area at Kirwin and hike west up the Wood River. Dollar Cirque is 7 km from the Kirwin parking area, and is the second major creek on the north side of the drainage. After passing Horse Creek, cross Dollar Creek, and hike north up the slope into the hanging valley of Dollar Cirque.

Access to the site is limited by snow depth, but access to the area is possible in early summer, though much of the archaeology (particularly at higher elevations) may be covered by snow fields and drifts. At the end June during the 2003 and 2004 field sessions most of the snow fields had retreated to the head of the cirque and north facing slopes.

Geologic History

The geologic history of northwestern Wyoming is extremely complex. This history is best summarized by the work of Love (1939) in his description of the Southern Absarokas, Tetons, and Gros Ventres. The lithologic series of rock in the project area can be described by the events leading to their deposition or erosion. The depositional/erosional history can be divided into three significant events. The first is the deposition of extensive sequences of shallow marine deposits, the second is the initial uplift and erosion of the area, and third is the deposition and later dissection of the volcanic rock sequences that characterize the Absarokas today (see Figure 1.3).

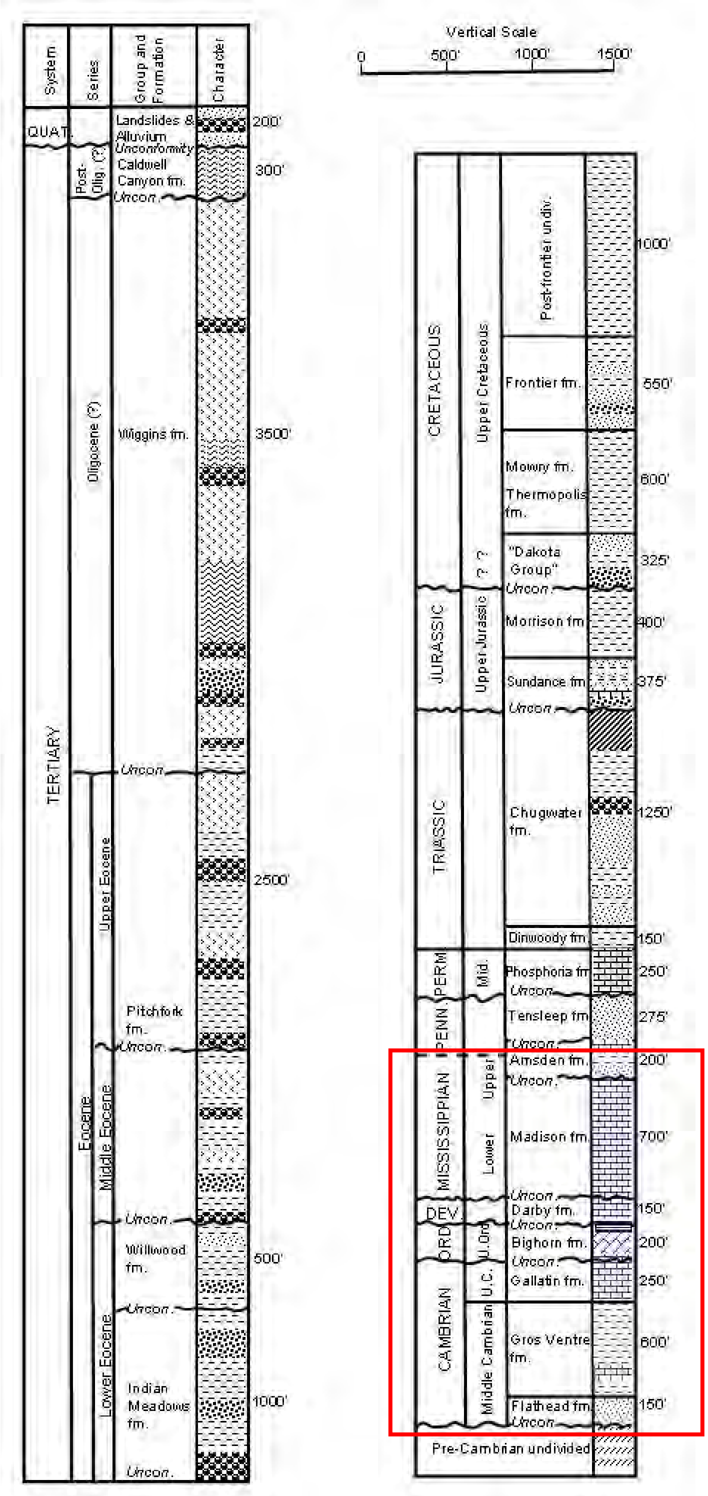


Figure 1.3- is a Stratigraphic column through the Absaroka Mountains, modified from Love 1939. The Dollar Mountain deposits range from Flathead through Amsden Formations (red box).

During the Precambrian, Wyoming was a flat featureless plain. The plain was slowly inundated by a shallow sea. From Precambrian through Cretaceous times, northwestern Wyoming was covered by several different shallow seas. This created a long series of shallow marine deposits of sandstones, shales, limestones, and mudstones all dating to the Paleozoic period. These deposits are quite extensive in both area and depth. The seas themselves covered the majority of central and northern Wyoming, retreating and advancing through 900 million years of geologic time (Love 1939). Some of these marine deposits contain fossils; others produced quantities of chert, silicified sediment, and quartzites. These marine deposits make up the sedimentary sequence at Dollar Mountain and will be discussed in greater detail in Chapter Three.

At the end of the Cretaceous, these sedimentary rocks were uplifted by the Laramide Orogeny. This orogenic episode began to uplift the region (as expressed in the uplift of the Washakie Range and the Owl Creek Mountains). The uplift was rapid, but its beginning, end, and severity varied across Wyoming. As Love (1939:104) states, "the beginning, the climax, and end of the revolution must be arbitrarily chosen and may differ greatly in time, even in localities only 100 miles apart." This intense folding and faulting of the massive deposits of sedimentary rock formed many of the principle mountain ranges of Wyoming. Erosion immediately began to rework these new ranges. By the Early Eocene, this uplift had become heavily eroded, and rivers carrying this sediment began a basin-filling period illustrated through the sedimentary sequences of the Bighorn Basin (Brown 1982; Love 1939; Pierce 1997).

Beginning at the end of the Early Eocene, and continuing through the Oligocene, massive amounts of volcanic rock were deposited on top of the marine sedimentary sequence creating the Absaroka Mountains, leading to the description of the Absarokas as a "volcanic pile" (Breckenridge 1974a:6). The present landscape is a heavily dissected plateau of volcanic and secondarily deposited volcanic rocks (Wilson 1964:60). The origin of the igneous rock is a field of composite stratovolcanoes depositing andesitic and basaltic volcanics in the form of laharic breccias, lava flows, flow breccias, tuffs, dikes, and intrusive bodies (Nelson et al. 1980:7). There are two principle volcanic formations in the region: Pitchfork and Wiggins (Love 1939; Rouse 1940; Wilson 1963, 1964; Nelson et al. 1980; Brown 1982), which overlay the early Eocene sedimentary Willwood Formation, but only the latter (Wiggins) is found within Dollar Cirque (Wilson 1963, 1964) (Figure 1.4).

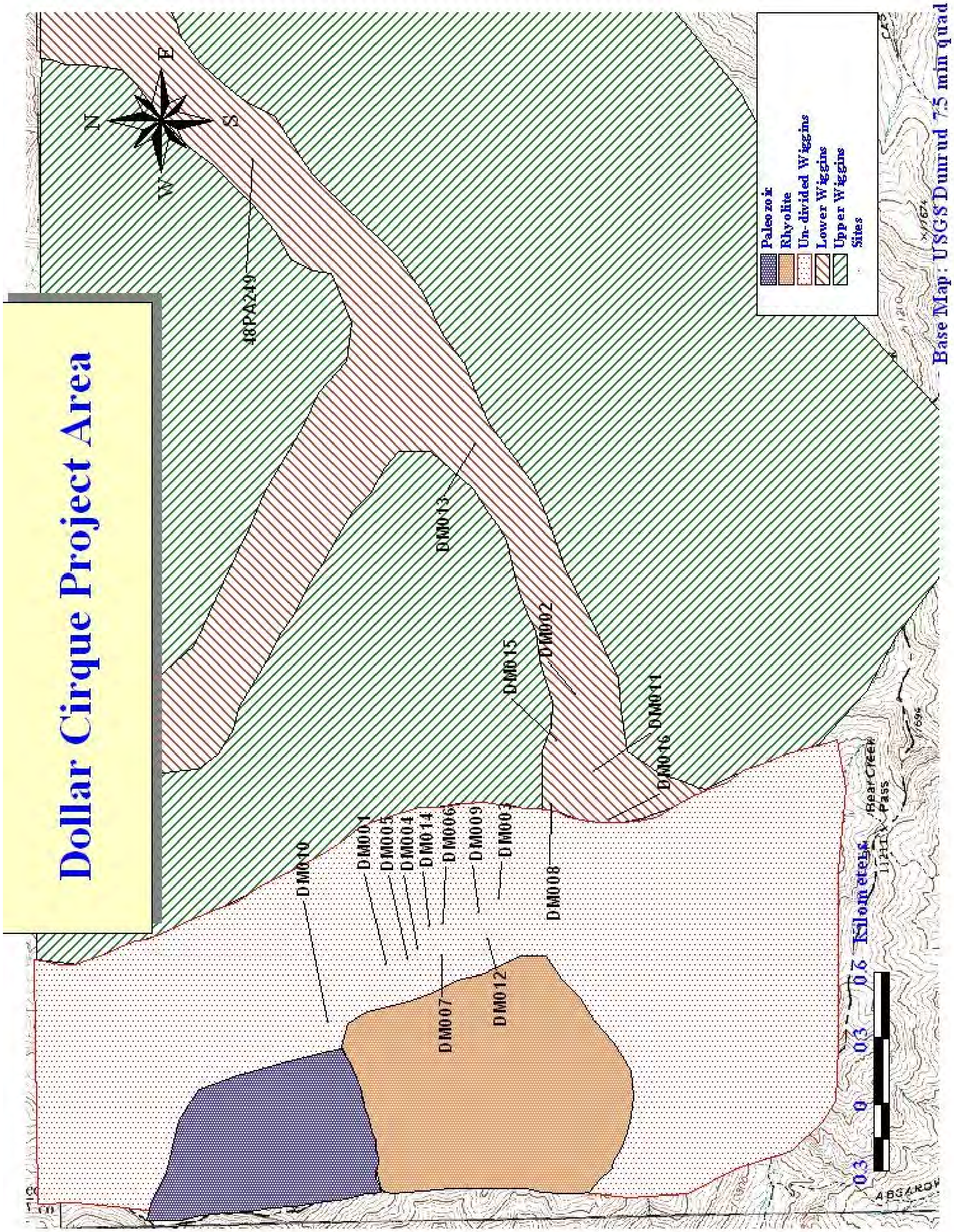


Figure 1.4- Generalized geological map of the Upper Wood River modified from Wilson 1964.

The names of the geological formations have some degree of variation across the Absarokas. Some of the formation names have been changed. For this study I will use the older nomenclature past researchers have applied to the formations within the region. This will allow a direct link to the regional geology.

Willwood

The Willwood Formation is not in Dollar Cirque but has been recorded to the northeast (Breckenridge 1974a:8). The Willwood Formation consists of approximately 180 m of shales, sandstones, and clays. It is underlain by a conglomerate approximately 10 - 14 m thick (Wilson 1964). These deposits are interbedded and often poorly sorted. The nearest exposure of this formation is downstream of Dollar Cirque, between Deer Creek and Dick Creek on the Wood River.

Pitchfork

The Pitchfork Formation is a group of volcanic detritus. It is composed of interbedded sandstones, siltstones, and conglomerates (Wilson 1964). This formation is probably of similar age to the basalt flows found in the Greybull River; Wilson (1964) includes the basalt flows at the top of his Pitchfork unit. The nearest outcrop of this formation is on the Wood River just below the Double D Ranch.

Wiggins

The only Eocene volcanic rock found in Dollar Cirque is the Wiggins Formation. The formation, as described by Love (1939:79), included the light colored volcanics that make up the high divides and ridges in the Absaroka Range. Wilson (1964) has divided this formation into two units: a lower unit (the Crosby breccia) and an upper unit. The lower unit is composed of clay beds, conglomerates, breccias, and sandstones (Wilson 1964:63-64). These all appear to be of reworked igneous origin and are difficult to separate in the field. The Crosby breccia is a distinctive unit of light greenish-gray rhyolite and andesite fragments cemented in a thick breccia deposit (Wilson 1964:64). The upper unit is poorly bedded and consists of a mix of flow and breccia deposits (Wilson 1964:65). Dollar Cirque is carved out of this rock unit.

There is also a high degree of intrusive volcanic activity in the Upper Wood River associated with volcanic vents and other bodies that have cross-cut the bedded volcanic rocks. They are composed of andesite, rhyolite, granodiorite, dactite, and basalt. Often these intrusive events have caused alteration, as is the case in the Kirwin and Gold Reef areas, providing the potential for mineral exploitation. These intrusive bodies have also created areas of contact metamorphism. This results in small pockets of silicified sediment, meta-quartzite, and isolated blocks of marble (Rouse 1940).

The intrusion of volcanic rock into the region also had the unique effect of uplifting portions of the sedimentary sequence and elevating erosion rates. This is best represented by the uplifted sequence of Paleozoic rocks that cap Dollar Mountain (Figures 1.5 and 1.6). While the details of this process will be described in greater detail later (see chapter 4), basically a stratified Paleozoic block of marine sedimentary rock was uplifted by an igneous intrusion, forcing it through the Absaroka volcanic sequence to a position within and above the Wiggins Formation. This created a unique deposit of sandstones, limestones, and shales in the center of the Absaroka volcanic field, an island of sedimentary rock in a sea of volcanics. As Rouse (1940:1425) states, "*this is the only place in the Absaroka Range where Paleozoic* [sedimentary] *rocks are found in the* *central part of the volcanic field*" [emphasis added]. These sedimentary formations include beds of fine-grained cryptocrystalline chert, quartzite, silicified sediment and mudstones all of which are potential sources of prehistoric toolstone.

The rugged characteristics of the Absarokas today are the products of intense and relatively short term (58 million years) erosion. The Absaroka volcanic field acted to form an expansive flat surface, or large plateau. This volcanic plateau was heavily dissected by fluvial and glacial action. The highest surfaces of the Absaroka Range retain the original topography of this plateau, creating high altitude flat surfaces that have been stable since the Tertiary period. These surfaces correspond with the original topography of the volcano-clastic layers and not the modern drainage divides, and may have been deformed by later geological processes (Breckenridge 1974a:18).

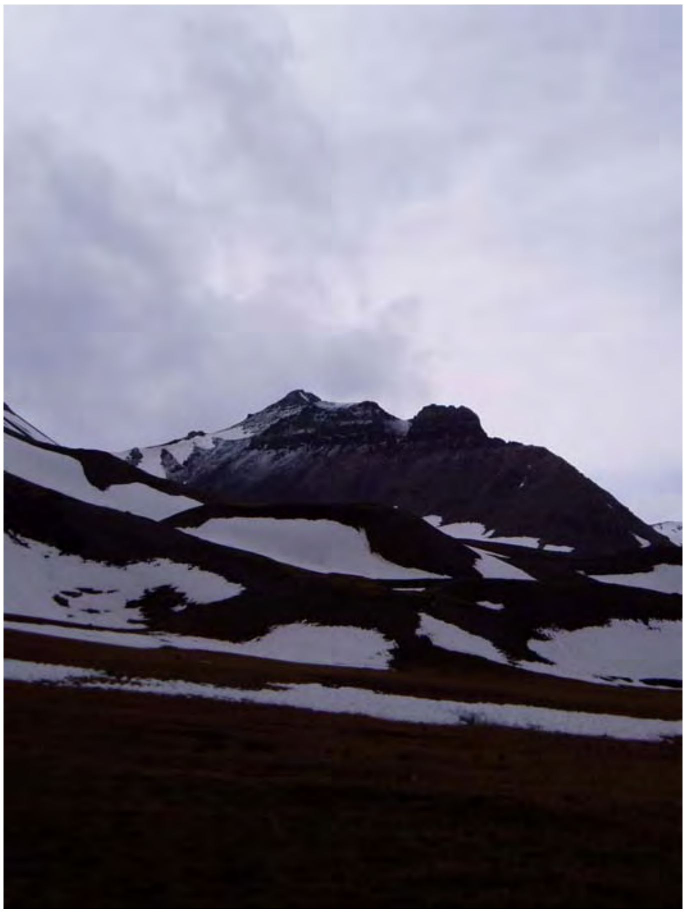


Figure 1.5- Dollar Mountain taken from Dollar Flats to the southeast of the peak.

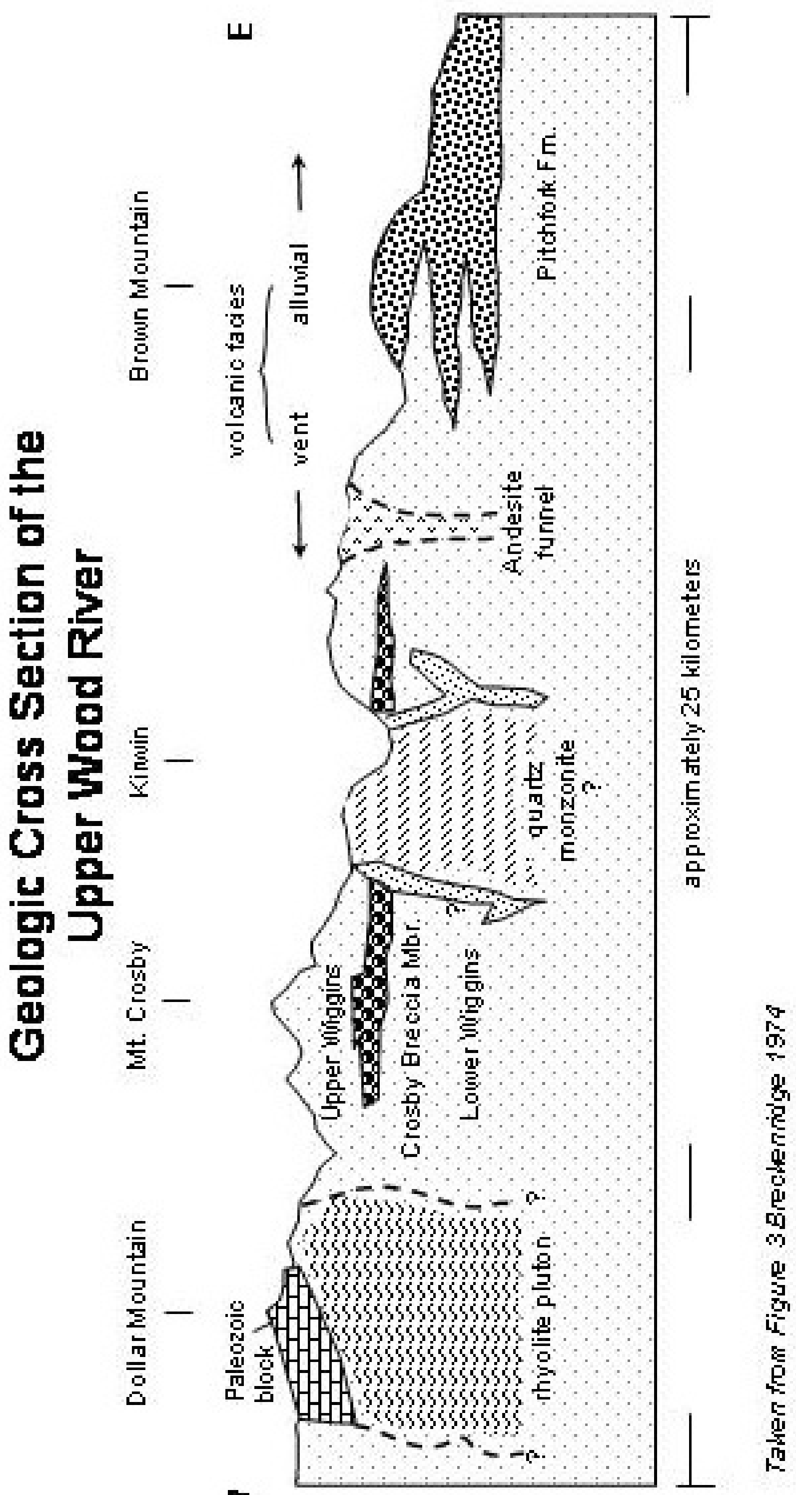


Figure 1.6- Geological cross section of the Upper Wood River

During the Pleistocene, the region underwent multiple periods of intense glacial erosion, but depositional features only remain from the early Bull Lake Glacial period, and the later Pinedale period, which is represented in two stadia (Breckenridge 1974a). This glacial action created the large U-shaped valleys, hanging valleys, numerous cirques, horns, moraines and talus and protalus deposits (Ritter et al. 2001; Martini et al. 2001). The Upper Wood River has undergone Holocene glaciation. This is represented by two advances in the Neoglacial period: the Temple Lake and the Gannett Peak stadia. These periods are named after type locations in the Wind River Range (Holmes & Moss 1955). The Temple Lake (use of the Temple Lake period has changed a lot since its original inception see Richmond 1965, 1976; Dahms 2002) stade is represented by a moraine sequence at the heads of the Pleistocene cirques. This includes a massive moraine 61 m in height just below Dollar Mountain (Breckenridge 1974a:66). The Gannett Peak stade is represented by moraines and rock glaciers in the upper reaches of the cirques (within 1 km of the head wall). Many of these rock glaciers are still active. Outwash from these glacial periods has left extensive terrace and outwash deposits in the Bighorn Basin (Pierce 1997).

In addition to this glacial action, major down cutting has occurred through fluvial action, creating a sequence of terrace deposits along the channels of the Upper Wood River. A terrace created during the Temple Lake period occurs at 0.6 to 1.5 meters above the present stream course (Breckenridge 1974a:72). Fluvial action has removed and redeposited the glacial material and created channels through the glacial deposits. There is also the possibility of periodic damming of the Wood river to create lakes at different intervals (Breckenridge 1974a: Figure 2). Some post-glacial soil development has occurred in the Upper Wood River, and Breckenridge (1974a:72) has found evidence of two periods of interstadial soil development in addition to the present soil. The soil is generally thinner and less developed on the moraine crests and the newer moraines than it is on the stable surfaces between moraine crests and on the fluvially deposited substrate.

Present Climate of the Upper Wood River

The climate of the Upper Wood River is driven by several factors. The first and most dominant is the Absaroka Mountains themselves controlling temperature and wind. Temperatures have a generally inverse relationship with elevation, as colder temperatures are found at greater elevations (Knight 1994:153). The slope aspects along the valley walls also differ in effective precipitation and amount of sunlight received (Knight 1994:155). All of these factors govern periods of freezing and snow-free areas. The mountains also create a rain shadow, making the mountain climate much wetter than the nearby Bighorn Basin [approximately 102-152 cm of mean annual precipitation and 15-25 cm for the mountains and Bighorn Basin respectively (Knight 1994:27)]. Other factors include the amounts of precipitation brought in by the prevailing westerly winds, rates of evapotranspiration, and strong seasonal climate changes (Knight 1994).

The Upper Wood River climate is typical of high mountain valleys. The average precipitation is near 50 cm, but increases substantially with increasing altitudes. Most of this precipitation falls as spring snow and early summer rain with approximately 60% of the precipitation received between May and July. Temperature averages range from January lows of -34º C to July highs of 30º C. The relative humidity averages 65-75% at night and drops during the day (KES v.8 1973). Also see the detailed temperature records collected in the Upper Greybull River later in the field session (Derr et al. 2004).

During our field session in Dollar Cirque, the field crew encountered snow storms, thunder storms (with lightning and rain), intense hail, strong winds, and beautiful days filled with warmth and sunshine. At higher altitudes, weather and temperature could change rapidly. During the field session (June 10 – June 19, 2003) we experienced a general warming, as witnessed by the retreat of snow banks and snow fields in the cirque. This melting episode raised water levels in both Dollar Creek and the Wood River. Permanent and semi-permanent snowfields are present at the head of Dollar Cirque.

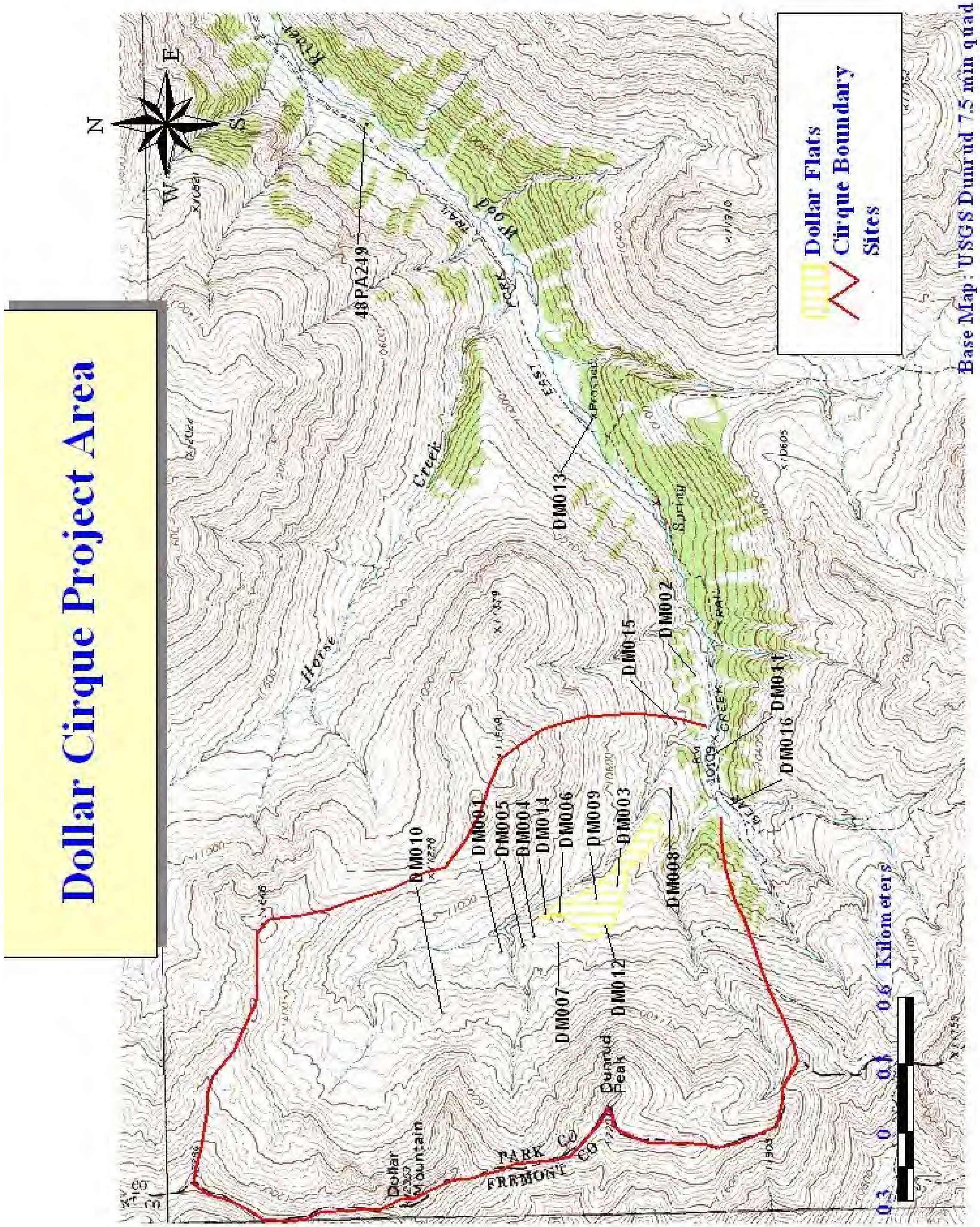


Figure 1.7- Map of the Dollar Mountain Project area. Base map is USGS Dunrud 7.5 minute topo quad

Vegetation

The project area has several different vegetation communities. The differences between these communities are governed by several factors: soils, amounts of water, aspect, and elevation. Differences in elevation and aspect are the controlling variables in the Upper Wood River. The lower reaches of the project area are within a forest environment and cultural materials were found to extend upwards into snow glade areas, through the tree-line and into the high alpine meadow environments of the Absarokas (Knight 1994; also see discussion of observed vegetation in next chapter)

The sites in the project area with the lowest elevations (48PA249 and DM002) were located in the environment that Knight (1994:174) calls the Mountain Forests. In this part of the Upper Wood River, spruce-fir stands are the predominate vegetation. The ability of Engelmann spruce and subalpine fir to tolerate the low temperature just below timberline allows them to dominate at this elevation (Knight 1994:168). The presence of open space in the forest appears to be the result of topography. The flat valley floors are devoid of tree cover, due to active geomorphic processes such as periodic flooding and colluvial accumulation. Smaller trees can be seen growing on the river terraces and in gravel colluvium, and as the age and stability of the surface increases the tree size and apparent stand age increase as well. Also, periodic avalanches act to uproot trees, scour avalanche chutes, and create associated alluvial cones. The tree cover is also controlled by aspect, with heavier cover on the northern facing slopes. This is probably driven by snow-free areas and differences in apparent precipitation (Knight 1994). Differential tree cover can be seen at DM002 (Figure 1.7) where a small open meadow is ringed with forest. This represents what Knight (1994:193) refers to as a snowglade. While the exact cause of the absence of trees is unknown, it is thought that differential snow accumulation affects the soil development and the amount of water available for seedlings (Knight 1994:194). Herbivore disturbance has also be suggested as a cause for the development of meadows (Knight 1994:198), however this seems unlikely in the Upper Wood River as only the south facing slopes seem to have open meadows.

A riparian vegetation community is also present along the Wood River. A riparian landscape is defined by Knight (1994) as being controlled by flowing water. A historic cabin (DM011) is found within this environment as well as one adit (a horizontal passage into a mine) (DM013). Also, an open lithic scatter (DM016) was discovered along the transition between riparian and forest environments (Figure 1.7). The riparian environment is characterized by water-loving plants dominated by species of willows (*Salix sp.*). The substrates in this environment are characterized by high rates of bed-load transport of gravel. Minimal soil accumulation, high degrees of flooding, and the cold climate, adversely affect the plant species found (Knight 1994:47) including those along the Wood River.

The final environment in the project area is the Upper Treeline and Alpine tundra. Photosynthesis is a temperature dependent process; the temperature is too low for too much of the growing season to sustain plants above a specific elevation. This temperature worldwide is where the July mean temperature is below 10º C (Knight 1994:201). DM008 is located at tree line and the upper margin of today's forest (Table 2). The plant species here are the same as those in the lower forests, but the height of the trees is decreased. Above DM008 is the large flat Pleistocene aged surface, referred to as Dollar Flats and is the floor of Dollar Cirque (Figure 1.7). The alpine tundra vegetation in this environment is driven by short growing seasons, high temperature variation, wind, amounts of water, and snow-free areas (Knight 1994). Soil accumulation is deepest on Dollar Flats when compared to any other portion of the cirque, with erosional channels that cut into 30-40 cm of material. The vegetation of Dollar Flats is composed of grasses and sedges. Above Dollar Flats, the sediment accumulation is much patchier. Some moraines have more fine-grained sediment accumulation than others, but these differences appear to be driven by aspect and age of the moraine deposit. The vegetation on the protalus deposits is primarily grasses and sedges with wildflowers, mosses and lichens on the exposed rocks.

Fauna of the Upper Wood River

The location within the Greater Yellowstone Ecosystem, the proximity of the Washakie Wilderness Area, and its inclusion within the Shoshone National Forest, all contribute to the diversity of species in and around the project area. A detailed study of fauna in the Upper Wood River was conducted as part of the Kirwin Environmental Study in 1971 (KES v.7 1973; KES v.8 1973).

Historical records of fauna in the Wood River are limited. Historic accounts describe numerous large ungulate species (KES v.7 1973). Bighorn sheep (*Ovis canadensis*) were common in herds of thousands at high elevations; there were also herds of elk (*Cervus canadensis*) along the Wood River and into the tributary basins (KES v.7 1973:7). Mule deer (*Odocoileus hemionus*) were present as well, but in smaller numbers than observed today (KES v.7 1973:7). Coyotes (*Canis latrans*) were common, in addition to numerous grey wolves (*Canis lupus*) (KES v.7 1973:7). Black bear (*Ursus americanus*) and grizzly bear (*Ursus horribilis*) were fairly common, while mountain lions (*Felis concolor*) were present but thinly scattered (KES v.7 1973:7). Moose (*Alces*

alces) also reestablished themselves circa 1940 from the increasing stocking of moose in Yellowstone National Park (KES v.7 1973:7).

Very little is known about the prehistoric fauna of the Upper Wood River. Bighorn sheep traps and drivelines have been reported in the Absarokas, indicating the prehistoric presence of these animals (Frison 1991, 1986). At the Helen Lookingbill Site in the Southern Absarokas, prehistoric layers contained bighorn sheep (*Ovis canadensis*), deer (*Odocoileus hemionus*), bison (*Bison bison*), porcupine (*Erethizon dorsatum*) and other mammals (Kornfeld et al. 2001). But remains of prehistoric fauna have not been found within the project area. Subsurface testing will probably be required to locate any preserved prehistoric bone within the project area.

During the course of the field work, many different types of animals were observed in the project area. Elk and deer were seen grazing in the lower portions of the Wood River in April. Micro-mammals including squirrels, ground squirrels, and chipmunks were observed. A few solitary moose were seen on the Wood River downstream of the project area. No large predators or signs of them were observed in the Upper Wood River during the 2003 field season, but the next drainage to the north (the Upper Greybull) appears to support a pack of wolves as well as grizzly bears, signs of which were encountered during fieldwork in July.

Historical Use of the Area

There have been three distinct historical uses of the region: mineral exploitation, grazing, and tourism. Seven kilometers down the valley from the project area is the historic mining district of Kirwin. In 1898 gold and silver ore was discovered by Will Kirwin along the Wood River, leading to a period of enthusiastic mineral exploration (Dunrud 1998). The district never became a significant producer of either silver or galena (the most common ore of lead) and never reached production status (Hewett 1912). Kirwin was reassessed for mineral potential after initial abandonment, and if a cost effective way was developed to move the ore out of the district it would be profitable to reopen the mines (Chapman 1917; Woods 1997). However, this never happened. In the 1960's and 1970's mineral exploration in the area was renewed, this time to test the potential of copper and molybdenum in the mineralized area (KES 1973). This exploration also never reached production status. The mineral exploration has left a significant historical mark on the landscape. The town of Kirwin, though mostly destroyed by a snow slide in 1907 (Dunrud 1998:91), still has many standing buildings and mining machinery. Efforts are being made to preserve the remaining buildings (Warren 1999). Placer claims extend into the project area, accounting for some of the historic material found during the Dollar Mountain Project. This will be discussed in detail later in this text (Appendix 1).

Cattle ranching, sheep grazing, and some farming activities are found along the rivers of the Bighorn Basin (Woods 1997). The Bighorn Basin has a long history of cattle and sheep grazing, in the basin and mountains (see discussion in Woods 1997). In 1879 Otto Franc founded the Pitchfork Ranch in the Greybull River Valley with 1,200 head of cattle (Woods 1997:86). The Pitchfork has continued to run cattle in the mountain valleys and high drainages of the Greybull River since that time. Sheep were also grazed in the high mountain valleys (Dunrud 2003). Traditionally during the summers, sheep were grazed above timberline, and cattle in the high mountain valleys (Dunrud 2003). Evidence of grazing is also attested to by the numerous cattle camps and sheepherder cabins near the Wood River and Upper Greybull River.

The nearest inhabited town to the project area is Meeteetse, Wyoming which was founded in the 1890’s. Butch Cassidy lived in Meeteetse and was arrested in front of the Cowboy Bar in 1886 (Woods 1997). The ghost town of Arland, north of Meeteetse, was founded in 1884, making it one of the earliest towns in the Bighorn Basin (Woods 1997).

The start of organized tourism in the Upper Wood River begins with the construction of the Double D Dude Ranch by Carl Dunrud in the 1930s (Dunrud 1998). The ranch was built downriver from the town of Kirwin, after Dunrud purchased the town in 1931 (Dunrud 1998:90). Some of Dunrud’s first guests were Amelia Earhart and her husband George Putnam. Before Earhart left the ranch, she filed a mineral claim and contracted with Dunrud to develop her claim and build her a cabin (Dunrud 1998:95). The cabin was never finished due to her disappearance in 1937. The Wyoming State Archaeologists office has assigned the cabin site the Smithsonian number 48PA249. The ranch was eventually closed and American Metals Climax (AMAX) bought its holdings for their mineral exploration at Kirwin in 1962. The USDA Forest Service now owns and maintains the property and the area is still a tourist destination. The Meeteetse museum leads tours to the historic sites of Kirwin and Arland. During hunting season, backcountry guides lead trips into the Absaroka Mountains. The Forest Service is also developing the Upper Wood River for recreational activities including hiking, backpacking, horse packing, and fishing. Impacts to the area from tourism are likely to increase in the future.

Archaeological Background

A basic prehistoric cultural chronology was suggested by Frison in the first edition of *Prehistoric Hunters of the High Plains* (1978) and carried on into later editions of the book (1991). This chronology defined five periods of occupation in North

America. This is the basic chronology used throughout this thesis. The first of these is the Paleoindian period. The Paleoindian period begins at the end of the Pleistocene (~12,000 B.P.) and continues through about 6,000 B.P. (Frison 1991:20). This is followed by the Archaic which is divided into three periods, Early Plains Archaic 6,000 to 3,500 B.P., Middle Plains Archaic 3,500-2,000 B.P., and Late Plains Archaic 2,000-1,500 B.P. (Frison 1991:20). The period between the end of the Archaic and historic times is referred to as the Late Prehistoric (Frison 1991:20). This basic chronology is not immutable. Increasing archaeological data plus more and better dates, have revised this basic chronology (Frison 1978, 1991; Metcalf 1987).

Little archaeological work has been conducted in the Absaroka Mountains. The entire range is almost devoid of reported archaeology, presenting a large blank spot on the map of prehistoric Wyoming. What little research that has been conducted is primarily from four principle sites: Mummy Cave (Husted et al. 2002), Dead Indian Creek (Frison et al. 1984), Bugas-Holding (Rapson 1990), and Helen Lookingbill (Kornfeld et al. 2001). In addition to these four occupation sites, Frison (1986, 1991) has reported many specialized hunting sites. These are mostly in the form of sheep traps (high altitude game drive sites), but he has also reported the recovery of a fiber net made for trapping ungulates (Frison et al. 1986). This present body of knowledge has been augmented by Breckenridge (1974a) through his study of the geomorphology of the Upper Wood River during which he located and reported several archaeological sites in the watershed. Most recently the Greybull River Impact Zone project has collected archaeological data and conducted pilot studies of historic and prehistoric archaeology at Gold Reef, Jack Creek, Haymaker Flats (near Venus Creek on the Upper Greybull), and this research at Dollar Mountain (Figure 1.1). In contrast, the archaeological record of the neighboring Bighorn Basin has received much more attention and has a much more developed history of archaeological documentation (Francis 1983; Frison 1977, Frison 1991; Frison & Todd 1986, 1987; Husted 1969).

The Mummy Cave site lies on the Shoshone River 55 km west of Cody, Wyoming at an elevation of approximately 1922 masl. The cave is located on a bend of the Shoshone River carved out of a Tertiary volcanic substrate that comprises the Yellowstone Plateau (Husted & Edgar 2001:7). The cave contains an 8.5 m deep deposit of sediments containing prehistoric material (Wedel et al. 1968). The archaeological deposit has been dated through radiocarbon methods and represents 9,000 years of intermittent occupation (Wedel et al. 1968). Due to the dryness of the cave, preservation is quite good and a wide variety of artifacts were recovered during excavations from 1963-1966. Wedel et al. (1968; Husted & Edgar 2001:35-94) describe bone pipes, basketry, pottery, fiber cordage, netting, animal bone, animal skin, leather, wood, ground stone, steatite, and the desiccated remains of an adult male dressed in mountain sheep skin (providing the cave's name). In addition to these artifacts, chipped stone debitage, tools, and an impressive sequence of projectile points was also recovered (see description in Husted & Edgar 200:951; Wedel et al. 1968). Change in projectile point patterns can be seen through this 9,000 year chronology. Cultural groups from the Paleoindian through the Archaic and into the Late Prehistoric have been associated with the Mummy Cave material (Husted & Edgar 2001). This provides a unique opportunity to understand the sequence of diagnostic projectile points on the Great Plains and into the front ranges of the Rocky Mountains.

A prehistoric net used for trapping game was discovered on Sheep Mountain (Frison et al. 1986). Sheep Mountain lies between the North and South Forks of the Shoshone River, 50 km north of the Dollar Mountain project area. The net itself was preserved in a packrat (*Neotoma cinerea*) midden in a small cave near the mountain's top. The net is estimated to measure 50-65 m long and 1.5-2 m high. It is constructed out of juniper fibers twisted into cordage. An estimated 2 km of cordage was needed for the construction of the net. Frison et al. (1986) hypothesize that the net was used to ensnare bighorn sheep. This is based on the frequency of bighorn sheep traps in the region, ethnographic examples, and the long sequence of bighorn sheep procurement and utilization at the nearby occupation site, Mummy Cave. What makes this discovery particularly interesting is the date of the find. Pieces of hardwood incorporated into the net were radiocarbon dated, yielding a date of 8,860 radiocarbon (Frison et al. 1986:352) years -- well within the Paleoindian period for Wyoming. Very little preserved organic material has been recovered with this early a date.

The Absaroka Mountains have also yielded abundant archaeological evidence for bighorn sheep hunting and high altitude game procurement. Frison reports several game drive complexes in the Absaroka Mountains. The Boulder Ridge trap is described in the most detail (Frison 1991:248). Beginning at timberline (3048 masl) and extending well above timberline, discontinuous lines of stones extend for 1.6 km funneling animals to a final trap point. Along the stone lines, small stone walls may have served to conceal hunters to aid in driving the animals. The Boulder Ridge Complex lies approximately 32 km northwest of the project area. Frison estimates that this complex is "several hundred years old" based on tree remains near the end of the drive line (Frison 1991:249). Frison

(1991:250) also reports small hunting blinds, rock shelters and other wooden structures that probably also represent hunting features in the Absaroka Range. In addition to these hunting features, Frison (1991:125, 250, 252, and 257) reports lithic scatters, metal projectile points, cairns and cribbed log structures. This creates a richer picture of prehistoric occupations in the Absarokas.

The Dead Indian Creek site is a Middle Plains Archaic site in the Sunlight Basin on the eastern slope of the Absaroka Mountains, north of Cody, Wyoming. The site consists of a buried deposit of stone tools and bone eroding into Dead Indian Creek. The site is unique as it contains evidence of hunting and plant processing. The faunal assemblage is dominated by mule deer and mountain sheep (Frison and Walker 1984:112). Frison suggests that this is evidence of individual or small group hunting (1984:112). Ground stone tools are present in the forms of 16 manos and 3 metates (Miller and Bedord 1984:34). There are also the buried remains of a child (Gill 1984:97). The site has yielded three radiocarbon dates of 4,400, 4,200, and 3,800 BP. (Frison 1991:99). There is also evidence for a pit house structure (Frison 1991:99).

The Bugas-Holding site (48PA563) is in the Sunlight Basin on the eastern slope of the Absaroka Range northwest of Cody, Wyoming (Rapson 1990:77). The basin ranges in elevation between 2050 m at the floor of the basin to over 3700 m at the top of the surrounding peaks. Bugas-Holding is on the floor on the basin on a terrace above Sunlight Creek. Radiocarbon dates and diagnostic cultural material date this site to the Late Prehistoric period (500± 100 bp) (Rapson 1990:137). Rapson identified Bugas-Holding as a winter residential site. The seasonality was determined from fetal bison bone and tooth eruption studies. The site has eight hearth features and over 51,000 documented and piece plotted artifacts (Rapson 1990). Artifact types include faunal remains, chipped stone, fire-cracked rock, ceramics, and worked bone (Rapson 1990). Human exploited faunal remains at Bugas-Holding are primarily bison and bighorn sheep.

The Helen Lookingbill site is a high altitude occupation site in the Southern Absaroka Mountains. The site is at 2620 masl in an open spring fed meadow. The site is a deeply stratified open air site with deposits ranging from Paleoindian through Late Prehistoric. During the course of the investigation well over 125,000 artifacts were recovered and analyzed (Kornfeld et al. 2001). Twenty-one radiocarbon dates were carried out, which yielded uncorrected results ranging from 10,405 bp through 360 bp (Kornfeld et al. 2001:310). Based on diagnostic, tools it appears that there were Late Paleoindian (Haskett/Hell Gap), Early Archaic, Late Archaic, and Late Prehistoric occupations at the site.

Faunal remains recovered at the site include deer and bighorn sheep indicating the hunting and butchering of animals at the site (Kornfeld et al. 2001). It appears that the majority of this bone is from the Early Archaic occupation. The Helen Lookingbill site represents the only stratified site in the Absaroka Mountains that has been excavated (with the exception of Mummy Cave). The early dates and Paleoindian materials represent an initial occupation of the Absaroka Mountains following the last glacial maximum.

Table 1.1- Table of site reported by Breckenridge (1974) during his geomorphology study of the Upper Wood River. All dates are based on diagnostic artifacts.

Summary of Breckenridge's Sites				
Site	**Location**	**Elevation**	**Date**	**Site Type**
Cascade Creek	High Cirque	3179 m	Early Archaic	Lithic Scatter
Meadow Creek	High Cirque	3230 m	Late Prehistoric/Early Archaic	Lithic Scatter
Upper Wood River	Terrace	3170 m	Late Prehistoric	Lithic Scatter
JoJo Fan	Alluvial Fan	--	Late Prehistoric	Lithic Scatter
Funnel Mountain	Rockslide	--	Late Prehistoric	Hunting Blind

In 1974 Breckenridge recorded archaeological sites in the Upper Wood River (Breckenridge 1974a). This was done as part of his research into the geomorphology of the Upper Wood River. Archaeological data were used to provide relative dates for terraces and glacial moraines in the watershed (Breckenridge 1974a). Breckenridge located five sites in the Upper Wood River (Table 1.1), ranging in elevation from approximately 2,500 masl to 3,230 masl (Breckenridge 1974b). All of Breckenridge's dates are based on temporally diagnostic projectile point chronologies (Breckenridge 1974b). His lowest two sites, near the Double D Ranch, indicate Late Prehistoric use of the Upper Wood River. Archaeological evidence includes a scatter of lithic debitage and point on the Jojo Creek Fan and a hunting blind feature on the Funnel Mountain Rockslide (Breckenridge 1974b:24). Near the head of the Wood River, Breckenridge (1974b:24) located another Late Prehistoric lithic scatter site on a terrace at approximately 3,170 masl. This site may have been relocated during the 2003 field work, though no diagnostic Late Prehistoric material was recovered. Breckenridge also reports the occupation of two other high altitude cirques in the Upper Wood River. The Meadow Creek Site is at 3,230 masl (Breckenridge's highest) and is a scatter of lithic debitage and points of Late Prehistoric and Early Archaic (possibly) ages (Breckenridge 1974b:24). This site is currently eroding out of the sod. Some sod has also been removed for the roof of a nearby sheepherder's cabin and artifacts were reported to be eroding out of this roof (Breckenridge 1974b:24). Work during the 2004 field season relocated this site and found several others in Meadow Creek Cirque. Diagnostic Archaic and Late Prehistoric material was recorded. The final site that Breckenridge reported was located in Cascade Creek Cirque, at 3,170 masl, and is an Early Archaic lithic scatter (Breckenridge 1974b:24). This site is the earliest of those reported by Breckenridge in the Upper Wood River.

In contrast to the relatively unknown Absaroka Mountains, the archaeological record of the neighboring Bighorn Basin and Bighorn Mountains to the east are understood much better. The majority of the archaeological analysis in this part of Wyoming has concentrated on the Bighorn Basin and the Bighorn Mountains that frame the basin's eastern margin. Frison provides a review of the Paleoindian (1977) and other sites in the Bighorn Basin (1975). The Big Horn Basin contains the well studied sites Horner and Hanson, the former near Cody and the later on the north-east side of the basin. The Hanson site represents a Folsom age occupation of the basin (Frison & Bradley 1980), while the Horner site is representative of the Cody complex (Frison & Todd 1987). The Colby site on the east side of the Big Horn Basin (Frison & Todd 1986) is a Clovis age mammoth kill site with prehistoric artifacts being recovered in direct association with extinct fauna (bone collagen also provides an average date of 11,000 years BP). The Medicine Lodge Creek site in the basin contains a stratified record similar to Mummy Cave dating back to 10,000 year BP. (Frison 1991) as do the Bighorn Canyon sites (Husted 1969). Extensive Archaic occupations have been recorded at the Wedding of the Waters, Laddie Creek and Southsider Cave (Frison 1991), all within the

Basin and surrounding foothills. The Big Horn Basin contains extensive rock art including complex anthropomorphic figures (Frison 1991:409). In addition to the extensive archaeological work, studies of the lithic raw materials have been conducted in the Bighorn Mountains and basin (Francis 1983, Craig 1983).

Work in the Absaroka Mountains will augment this present body of research in order to create a better picture of the prehistory of Wyoming. In summary this thesis will address two questions, 1) were the high altitude cirque basins in the Absaroka range utilized by prehistoric peoples and 2) was the fine-grained cryptocrystalline chert from Dollar Mountain used by prehistoric peoples. The analysis will incorporate archaeological survey methodology to address these questions and combine this with geoarchaeological and geomorphological analysis to construct models of human past. Specifically this thesis will concentrate on increasing an understanding of the formation of landscapes and the use of these landscapes by prehistoric human populations.

Chapter Two: Methods and Results

In the introduction to the first chapter the idea of archaeological context was introduced. Objects cannot yield the same information once context has been lost. The methodology employed here is a function of the research questions asked and will define the analytical context. By defining the landscape as a unit of analysis, large scale observations must be taken into account. Landforms act as data points and geomorphic change provides a temporal element for this framework. But this approach must be coupled with a smaller scale in its approach to archaeological analysis. To insert a prehistoric human component into landscape analysis, artifactual data must be used as the baseline for addressing questions of human behavior. Treating landscape change as a variable that affects human behavior, and understanding how human behavior effects landscape change will lead to the generation of more complete models of human behavior.

Field Methodology

The summer 2003 field project employed two basic field methodologies, pedestrian survey, and in-field data recording.

Survey Methodology

Pedestrian survey was conducted on a variety of scales (see discussion in Burger 2002 for ideas of multiple scales). Based on previous studies of multiple scale survey, a 5 m interval was considered adequate to locate concentrations of surface artifacts (Banning 2002; Burger 2002). A 5 m wide transect survey was conducted across the flat floor of the hanging valley in all snow free areas. In addition to this survey, the crests of the earlier period protalus ramparts (Chapter One) were surveyed at a 70 cm interval (approximately arms length apart) and any concentration of artifacts encountered was recorded.

In addition to this landscape scaled survey, small scale survey was conducted in the form of a single crawling transect across a portion of DM001 in the location of the densest concentration of surface artifacts. This strategy was termed 'iterative box survey methodology' and recorded the frequency and raw material type of chipped stone in 50 cm^2 boxes plotted in a straight transect line. By crawling, a more accurate estimate of chipped stone could be obtained in this portion of the site.

Topographic points were recorded on DM001 and the surrounding moraine deposits to construct a detailed topographic map. Finally, glacial landforms were identified based on geomorphic context and spatial location. Many of these glacial landforms were mapped and compared to the deposits mapped by Breckenridge (1974a).

Four different methods were used to collect spatial data in the field. Garmin Rino 110 handheld global positioning systems (GPS) receivers (WAAS enabled) were issued to all members of the field crew. The accuracy of these handheld units varied, but the mean error associated with the handheld units was approximately 5 m when compared to sub-centimeter accurate EDM data (Burnett et al. 2004). These were used to pinpoint a

UTM location for every artifact and feature. Outcrops and secondary deposits of raw material were also given UTM coordinates with these units. A Sokkia SET-4B EDM total station with sub-centimeter accuracy was used to provenience artifacts on sites DM001, DM005, and DM010. All of the artifacts on DM010 and DM005 were recorded with this instrument as well as a large percentage of the artifacts recorded on DM001.

Having artifacts shot in with both handheld GPS units, and the total station, allows a comparison of the accuracy of the handheld units. Even with this amount of error, clusters of artifacts can be spatially located. While intra-site patterning may be difficult to assess (Burnett et al. 2004), with these spatial data, it is more than adequate to evaluate inter-site variability and landscape patterning in relation to geomorphic landscape features.

An Ashtech Locus sub-centimeter GPS was used to set accurate datum points, and conduct topographic surveys (Thales 2004). This instrument was also used to measure the retreat of a sample of snow banks within the project area. Finally, a Brunton Pocket Transit and Sokkia topographic Abney level were used to correlate glacial deposits of similar geomorphic origin and compare field observations with map data (Compton 1962).

Artifact Documentation

The full coding system recorded a maximum of 30 possible attributes on chipped stone, bone, and historic artifacts (Appendix Four). Artifacts were first divided into chipped stone, historic, or bone classes. The chipped stone sample was grouped into formal tools, bifaces, and debitage classes. Metric attributes of tools were recorded as completely as possible. Projectile points were assigned to temporal periods based on the Mummy Cave chronology (Husted and Edgar 2002). Bifaces were assigned stages of reduction based on the five tiered system outlined in Andrefsky (1998:181). Debitage was further divided into discrete element categories for analysis (Figure 2.1). Historic artifacts were recorded with narrative descriptions and metric data were recorded for later comparison. Bone was recorded to species of animal whenever possible and the most specific portion and condition possible was recorded for each bone.

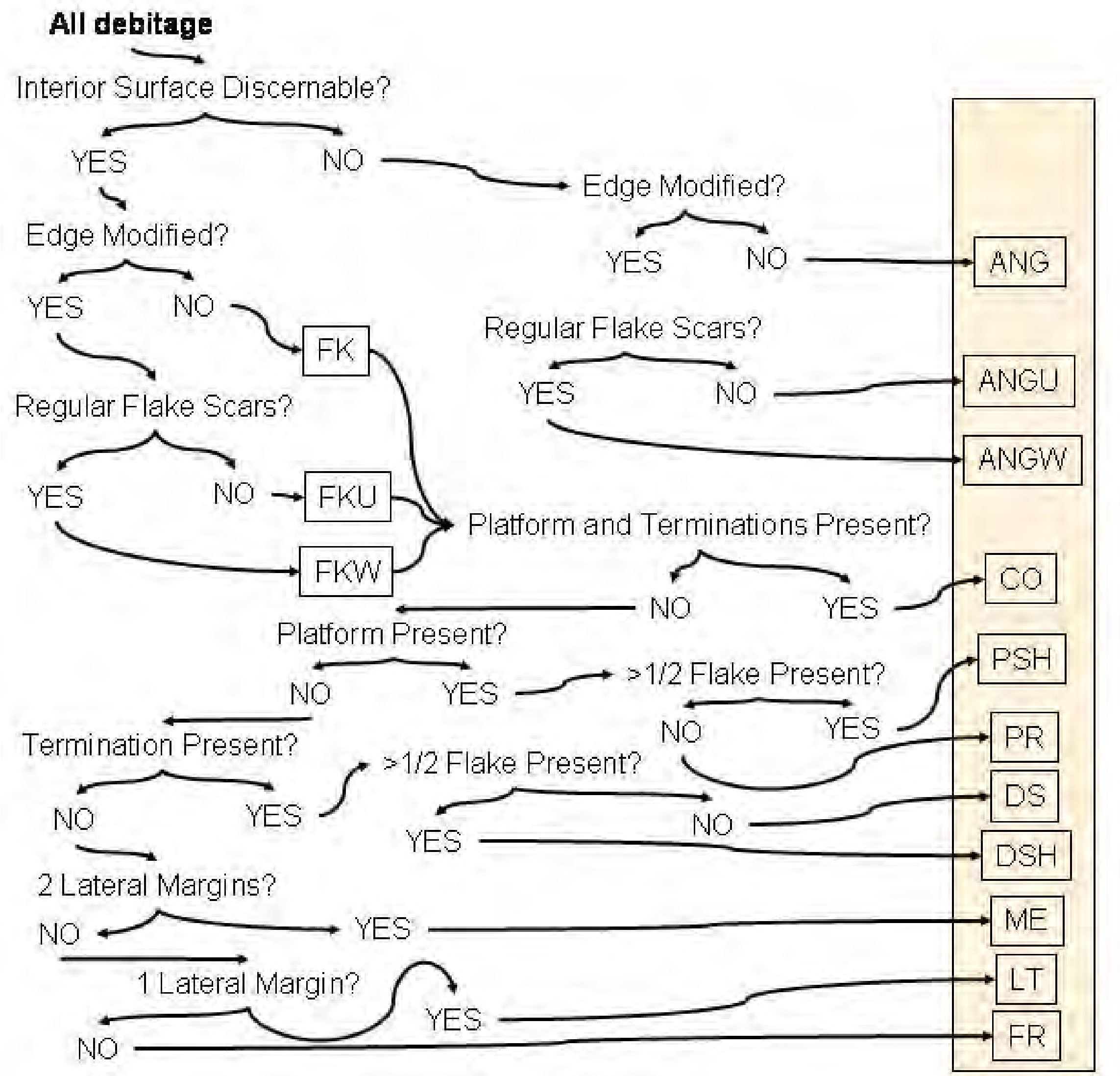


Figure 2.1- Debitage flow chart to identify non-formal chipped stone artifacts; the boxed items are element codes that correspond with Appendix Three.

All artifacts were analyzed in field and left in place. All metric data were recorded with digital calipers and combined with observed data into site specific Excel database files on pocket personal computers (HP iPAQs). The iPAQs provide immediate access to computer data analysis, and eliminate possible later transcription errors associated with field books. Field books were used to record site details, GPS shot ranges, artifact numbers, and sketch maps of sites.

During the survey of Dollar Flats, a shortened coding system was used, recording only the artifact element codes (Appendix Four) except in the case of tools and bifaces, which were coded completely. In the 'iterative box survey' only the number of artifacts and their raw material types were recorded in each 50 cm square. For laboratory analysis, a selection of lithic raw material and chipped stone was collected that represented the variability encountered in the infield analysis. Collection was done in order to identify macroscopic characteristics to aid in field identification. Location of this material was recorded as well as its depositional environment.

The apparent site size provides an estimate of the extent of the scatter of artifacts. Apparent site size was generated by calculating the area of an ellipse whose axes are the north/south and east/west distance to the edge of the artifact scatter. The center points of sites used for mapping purposes and GIS modeling were generated by averaging all of the artifact locations (i.e., mean northing, mean easting, and mean elevation) in a cluster. Whenever possible, round aluminum datum tags were set on site to aid in relocation. These were usually set either in the center of artifact clusters or on prominent topographical features adjacent to the cluster (DM001, DM002, DM004, DM005, DM007, DM008, DM010, DM011, DM014, DM015, and 48PA249).

Laboratory Methods

Laboratory analysis was conducted by the author during the fall of 2003 and the spring of 2004. Raw material types were analyzed and recorded. Samples of Dollar Mountain chert were recorded to develop a baseline data set to compare the archaeological material. Chipped stone data were analyzed to determine what types and quantities of tools and debitage were present. Spatial locations of archaeological material were mapped and analyzed.

Lithic Analysis

Chert is formed by the silicification of other minerals in a preexistent rock. Because chert is a secondarily deposited material, there is the potential for a wide range of variations in its physical properties. To address this variation a large number of specimens were analyzed using a modified macroscopic classification scheme developed by Banks (1990: Appendix A) in his analysis of Southern Plains lithic raw material. Because chert is predominantly composed of silica, all cherts have virtually identical physical properties. Streak, hardness, and some degree of conchoidal fracture are the same for all cherts (Banks 1990:117). Quantitative measurements of texture are only possible with petrographic analysis (Banks 1990:117). The variables of interest in this analysis include color, diaphaneity, texture/structure, luster, and fluorescence under ultraviolet light. These properties were chosen for analysis for two reasons. First, they are easily recorded by archaeologists and geologists and can provide a method for distinguishing lithic raw material without petrographic or geochemical analysis. Second, these variables address the problem highlighted by Banks (1990:6), that lithic raw material is often described in a non-uniform manner and comparison across classification systems becomes difficult. By using a standardized methodology lithic raw material variability can be better quantified. This analysis will lead to textual descriptions of the material and its range of variation. This will then be supplemented with a series of true color photographs of the Dollar Mountain Source.

Color

The color of specimens is visually indexed to the Munsell color series under natural light. Comparisons are made to the Munsell Rock (1991) color chart as well as the Munsell Soil (1988) color chart in an effort to capture the closest possible color. Often colors do not match exactly; in all cases the closest possible color will be used.

Diaphaneity

The diaphaneity of a chert is a relative measure of the light transmitting ability of the material. The ability of a material to transmit light varied on a continuum between opaque and translucent. Diaphaneity is recorded qualitatively as opaque or translucent with modifiers to better represent the variation (i.e., if it is translucent on edges or in thin flakes, or has bands of opaque material).

Texture & Structure

The texture will be recorded based on macroscopic observation. As stated above, without petrographic analysis, texture cannot be quantified, but it can be divided into broad general categories. The divisions used by Banks are microcrystalline and cryptocrystalline which are then further modified by fine, medium, or course. This analysis will use the terms microcrystalline (crystal grains visible under magnification) and cryptocrystalline (no crystals visible under magnification). This portion of the analysis is based on samples collected in the field. The fracture properties of the material are also included in this category, as well as, any inclusions, imperfections, or other structural properties visible in the rock.

Luster

Luster is a measure of the ability of the material to reflect light. Luster will be recorded qualitatively as a range from dull (not reflecting much light), to waxy, to vitreous (resembling glass) and will be recorded as such.

Ultraviolet Light Fluorescence

Some rocks and minerals fluoresce when exposed to ultraviolet light. Some cherts can be directly associated to source areas with distinct ultraviolet light signatures when exposed to high or low frequency ultraviolet light (Banks 1990; Hofman et al. 1991). Samples collected from the Dollar Mountain source were fluoresced under both high and low frequency ultraviolet light to determine if an ultraviolet signature could be found. Fluorescence was conducted using a Mineralight Lamp model UVGL - 55 with multiband UV- 254/366 NM.

Archaeological Material

As all data were recorded in field, artifact analysis has been conducted to look for patterns in the assemblage. Lithic tools and debitage were analyzed comparing differences in metric attributes, color, prehistoric use, heat modification, and location and position on the landscape. Calculations were done using Excel spreadsheets. Artifact clustering and patterning on a landscape scale was observed using GIS (geographic information system) maps that plot artifact distribution. All raw material samples were numbered sequentially (presented in Appendix Four) and all other artifacts were given item numbers as follows INI X.XX.XX.2003 where the three letters are the initials of the person who recorded the artifacts location, followed by the sequential number assigned to the artifact by the GPS, followed by the date (month.day.year).

Geological analysis

Geological formations were mapped using Arcview 3.2 based on geo-rectified aerial photos and surface geological maps. These data were compiled into a GIS database so comparisons of landforms and the relation of the Quaternary deposits and archaeology can be drawn.

Stream Gradient Analysis

Data were collected from Digital Elevation Models (DEM) of the region, through map analysis (both topographic and geologic), and field measurements. The potential for formations to contain raw materials was assessed by first examining the stream drainage patterns to see if the material was accessible in the different watersheds. A preliminary analysis of the stream sediments was conducted to identify alluvium that could be traced back to the source. The stream gradients were analyzed by two different methods; the first, involved using 10 meter DEMs to plot the slopes of different channel reaches along the Wood and Greybull Rivers. The channel reaches were divided into two categories: lower reaches (areas where terraces were present), and upper reaches (where terraces are less developed). The division was made using geological maps showing Quaternary alluvial fill, field observation of terrace deposits, and with the aid of Breckenridge's (1974a: Figure 16) description of locations of terrace deposits. The DEMs allowed for the elevation of specific points to be measured and the distance between them computed. The second method involved in-field measurement of stream gradient and was accomplished by measuring the change in elevation between two points of a known distance using a hand level and a stadia rod (Kavahagh & Bird 2000).

Results

The preliminary results of the archaeological work in Dollar Mountain Cirque are presented here. Due to the non-collection nature of this project, all artifacts were recorded in the field and left in place.

Vegetation Data

Vegetation was recorded using an identification handbook, *Plants of the Rocky Mountains* (Kershaw et al. 1998) as well as the environmental description provided in *Mountains and Plains: The Ecology of Wyoming Landscapes* (Knight 1994). Plants were recorded to the species level whenever possible. Plant species identified in the project area are provided in Table 2.1.

Table 2.1- Vegetation recorded in the Dollar Mountain Project area presented by site

Dollar Mountain Vegetation Table 2.1

Site	Species
DM001	Alpine Smelowskia
DM001	Alpine Forget-Me-Not
DM001	Prairie Crocus
DM001	Ross' Avens (yellow)
DM001	Moss Phlox
DM001	Salix sp.
DM001	Timberline Bluegrass
DM001	Spike Tristeum
DM001	Blistered Rock Tripe
DM001	Hooded Monks Beard
DM001	Green Reindeer Moss
DM001	Alpine Star-moss
DM001	Northern Fleabone
DM008	Bog sedge- carex sp.
DM008	Stonecrop
DM008	White bark pine
DM008	Limberpine
DM008	Engleman Spruce
DM008	Sub alpine fir
DM008	Cinquefoil
DM011	Salix sp.

Soil Depth

Soil depths were recorded in two different ways during the course of the field season. As part of an undergraduate research project (Cale 2003) average soil depths, ground cover, and surface pieces of bedrock were recorded for two sites in the project area; DM002 & DM005. These data are presented in Appendix Two. In this study depths were recorded in transects across the sites using a pin flag. The author recorded soil depths in cut banks, rills and other erosional features to supplement these data. The soil depth data from this study and observation by the author are summarized below, along with the method of observation.

Table 2.2- Summary of soil depth data recorded in the Dollar Mountain project area. Complete data are presented in Appendix Two.

Soil Data

Site	Average Depth (cm)	Observation Method
DM001	25	Cut bank
DM002	28	Pin Flag
DM003	50	rill erosion
DM004	unknown	
DM005	18	Pin Flag
DM006	50	rill erosion
DM007	unknown	
DM008	unknown	
DM009	50	rill erosion
DM010	unknown	
DM011	10	rill erosion
DM012	50	rill erosion
DM013	Thick- spring deposit	
DM014	50	rill erosion
DM015	unknown	
DM016	unknown	

Chipped stone represents the majority of the archaeological data recorded in the Dollar Mountain project area. Aside from the historic material, all of the sites are best described as open lithic scatters or raw material reduction sites. Site information is presented in tabular form for comparison. Table 2.3 presents a basic overview of site location, size, and age. Table 2.4 presents the site's environmental setting (both the geomorphic and vegetation settings). Table 2.5 presents the artifactual data recorded from each site. Following the tables is a section detailing unique attributes of individual sites.

Table 2.3- Overview of Dollar Mountain sites and temporal period.

Site no.	Site Type	Temporal Period	Elevation (m)	Slope (º)	Aspect	Apparent Size (m^2)	Distance to Timberline (m)
DM001	Lithic scatter	Early Archaic	3333	11	SW- 100º	12,000	100
DM002	Lithic scatter	Unknown Prehistoric	3139	12	S- 180º	400	below
DM003	Lithic scatter	Unknown Prehistoric	3263	8	SW-125º	15,800	10
DM004	Lithic scatter	Unknown Prehistoric	3326	14	E- 70º	8,500	85
DM005	Lithic scatter	Unknown Prehistoric	3336	14	E- 75º	7,150	85
DM006	Lithic scatter	Late Archaic	3271	12	E- 95º	600	10
DM007	Lithic scatter	Unknown Prehistoric	3309	12	E- 65º	Unknown	50
DM008	Lithic scatter	Unknown Prehistoric	3180	13	S- 150º	Unknown	0
DM009	Lithic scatter	Unknown Prehistoric	3264	15	S- 120º	13,250	10
DM010	Lithic scatter	Unknown Prehistoric	3381	20	SE- 110º	2,050	150
DM011	Cabin/adit	Historic	3122	5	E- 90º	15,200	below
DM012	Lithic scatter	Unknown Prehistoric	3290	13	SE- 110º	1,200	10
DM013	Adit	Unknown Historic	3004	8	N- 340º	700	below
DM014	Lithic scatter	Unknown Prehistoric	3276	5	E- 100º	360	20
DM015	Lithic scatter	Unknown Prehistoric/Historic (1943+)	3140	15	S-180º	700	0
DM016	Lithic scatter	Unknown Prehistoric	3149	unknown	unknown	Unknown	below
DM017	Cabin/Lithic scatter	Unknown Prehistoric/Historic	2931	unknown	SE- 125º	910	below

All distances, slopes, and bearings are approximate

Table 2.4- Summary of environmental data by site. Geomorphic setting is defined from Breckenridge 1974a. Geomorphic setting refers to the sites location on the landscape in relation to the surface geology and lichen cover is the average surface area covered by lichen on rocks on site.

Site no.	Geomorphic Setting	Nearest Permenent Water	Distance (m)	Soil & Deposition	Vegetation	Lichen Cover
DM001	Protalus Rampart	Dollar Creek	100	Thin/thick: bare rock to 25cm- Aeolian/pedogenic	Alpine tundra, grasses, lichens and forbs in thicker soils few grasses, mostly lichens in thin soils	>50%
DM002	Pleistocene Rubble	Wood River	50	thick: Unknown depth- Aeolian/colluvial	forest meadow, thick grasses	0
DM003	Pleistocene Erosional surface	Dollar Creek	140	thick: ~50 cm- Aeolian/pedogenic	think spongy alpine tundra	0
DM004	Protalus Rampart	Dollar Creek	100	thin: bare rock to 10cm- aeolian/pedogenic	thin soils, few grasses mostly lichens	>50%
DM005	Protalus Rampart	Dollar Creek	80	thin: bare rock to 10cm- aeolian/pedogenic	thin soils, few grasses mostly lichens	>50%
DM006	Pleistocene Erosional surface	Dollar Creek	75	thick: ~50 cm- Aeolian/pedogenic	think spongy alpine tundra	0
DM007	Protalus Rampart	Dollar Creek	130	thin: bare rock to 10cm- aeolian/pedogenic	thin soils, few grasses mostly lichens	>50%
DM008	Pleistocene Outwash	Wood River	170	thick: Unknown depth- Aeolian/colluvial	treeline, pine/spruce, grasses	0
DM009	Pleistocene Erosional surface	Dollar Creek	110	thick: ~50 cm- Aeolian/pedogenic	think spongy alpine tundra	0
DM010	Protalus Rampart	Dollar Creek	250	thin: bare rock to 10cm- aeolian/pedogenic	thin soils, few grasses mostly lichens	>50%
DM011	gravel bar	Wood River	0	thin: exposed gravel to 10cm- fluvial	gravel bar	0
DM012	Pleistocene Erosional surface	Dollar Creek	150	thick: ~50 cm- Aeolian/pedogenic	think spongy alpine tundra	0
DM013	river terrace	Wood River	5	thick: Unknown depth- Fluvial	Pine/Spruce, grasses, willow, moss	0
DM014	Pleistocene Erosional surface	Dollar Creek	30	thick: ~50 cm- Aeolian/pedogenic	think spongy alpine tundra	0
DM015	Pleistocene Rubble	Wood River	180	thick: Unknown depth- colluvial	forest meadow, thick grasses	0
DM016	gravel bar	Wood River	Unknown	unknown depth- fluvial	unknown	0
48PA249	Alluvial Cone	Wood River	50	thick: Unknown depth- Colluvial	mountian grasses, pines	0

Table 2.5- Summary of artifactual data by site. Historic data are presented in Appendix One. DMC refers to Dollar Mountain Chert, DMQ is Dollar Mountain Quartzites. Some data were not collected by individual artifact cluster by combined in Dollar Flats total (Inc. in Doll). Unknown data are recorded as UNK. Tool types are presented by number and raw material by the percent of the assemblage.

Site no.	Artifacts	chipped stone	Flakes	Worked/used flakes	Angular	Cores	Bifaces	Nodule	Scraper	PP	Blades	DMC (%)	DMQ	Local	Average Length (mm)	Average Width (mm)	Average Thickness (mm)	Historics?
DM001	1723	1723	491	100	34	5	6	1	0	1	0	96	0.1	96	18	14	4	no
DM002	65	61	51	7	2	4	4	0	0	0	0	41	0	41	26	21	7	yes
DM003	Inc. in Doll	346	330	N/A	N/A	N/A	N/A	N/A	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM004	215	215	187	38	24	3	1	0	0	0	0	95	0.5	95	23	16	6	no
DM005	68	68	61	4	4	2	1	0	0	1	0	82	1.5	84	28	21	8	no
DM006	Inc. in Doll	346	330	N/A	N/A	N/A	N/A	N/A	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM007	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM008	UNK	UNK	UNK	UNK	UNK	UNK	UNK	UNK	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM009	Inc. in Doll	346	330	N/A	N/A	N/A	N/A	N/A	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM010	23	22	21	3	0	0	0	1	0	0	0	100	0	100	35	25	11	post
DM011	10	0	0	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	yes
DM012	Inc. in Doll	346	330	N/A	N/A	N/A	N/A	N/A	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM013	UNK	2	2	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	yes
DM014	31	31	26	0	3	0	1	0	1	0	1	97	0	97	34	23	8	no
DM015	58	50	50	0	0	0	0	0	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	yes
DM016	2	2	1	0	0	0	1	0	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	no
DM017	16	16	16	0	0	0	0	0	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	yes
D.Flats	349	346	330	3	11	2	3	0	0	0	0	UNK	UNK	UNK	UNK	UNK	UNK	yes

DM001 (Figure 2.2) is in the center of Dollar Cirque, just north of Dunrud Creek and is the principle site recorded during the 2003 field season. The greatest number of chipped stone was recorded on this site as well as the highest density with one concentration of 234 pieces per 50 cm square (Figure 2.3). Soil depth is quite extensive and has chipped stone eroding out of the banks of Dunrud Creek on the southern margin of the site. Deep sediment has allowed for the formation of patterned ground features in a small drainage on the site. There are also a couple of dead pine trees on site that stood approximately 30 cm high and were approximately 25 years old (based on ring counts). One of two temporally diagnostic projectile points (as of the 2003 field season) was recovered on the surface of the site, related to the Early Archaic period (8,000 to 5,000 BP).

Figure 2.2- Overview photo of DM001. Photo taken from the west looking to the east, Dunrud creek is on the far right of the photo.

Figure 2.3- Density of lithics on DM001. In this portion of the site, a crawling survey was employed to obtain artifact counts and raw material types.

Several sites have multiple components. DM002 (Figure 2.4), DM011 (Figure 2.5), DM013 (Figure 2.6), DM015, and 48PA249 (Figure 2.7) all had both prehistoric and historic material. DM011 and DM013 were primarily historic sites with a few pieces of chipped stone (one flake at DM011 and 2 at DM013). DM002 is an extensive lithic scatter with some historic trash, possibly from the above DM015. DM015 is also an extensive lithic scatter but also has a large number of historic artifacts (and is discussed in Appendix One). Chipped stone is found in the ruins of the cabin at 48PA249. The present site form does not contain any information regarding anything other than a historic site.

Figure 2.4- Site overview of DM002. Photo taken from the west to the east of the site, the Wood River is just out of the frame to the right.

Figure 2.5- Overview photo of DM011. The cabin is on a gravel bar in the Wood River. The photo is taken from the west of the site looking east. Photo by Andy Mueller.

Figure 2.6- Overview photo of DM0013. The photo is taken from the northeast of the site looking southwest.

Figure 2.7- Overview of 48PA249. The log structure three courses high in the foreground is the remains of Amelia Earhart's cabin. The photo is taken from the southwest looking northeast.

During the 2004 field season a brief visit was made by the author to the project area and new data were collected on DM007. Thirty-four pieces of chipped stone were recorded in addition to a diagnostic Archaic point. Further investigation and a formal survey are required before any analysis can be made.

The large floor of the Pleistocene hanging valley (termed Dollar Flats) (Figure 2.8) was surveyed and recorded as one large unit (~285,500 m^2). Initial reconnaissance identified four clusters of artifacts (DM003, DM006, DM009, and DM012), after which a systematic pedestrian survey was conducted along the entire snow free portion of the hanging valley floor at an interval of 5 m. After this survey it became difficult to separate the originally identified sites in to discrete clusters of artifacts, and particularly to separate DM006 from DM012 and DM003 from DM009. It is possible that the originally identified sites are parts of a larger cluster of artifacts and surface visibility is a product of erosion or other taphonomic agents. This surface is the oldest in the cirque and is has the greatest potential for human occupation as well as the greatest possible soil depth. On the surface of DM006 a single diagnostic Late Archaic projectile point (3,500 to 2,000 BP) was also found eroding out of a small melt water rill.

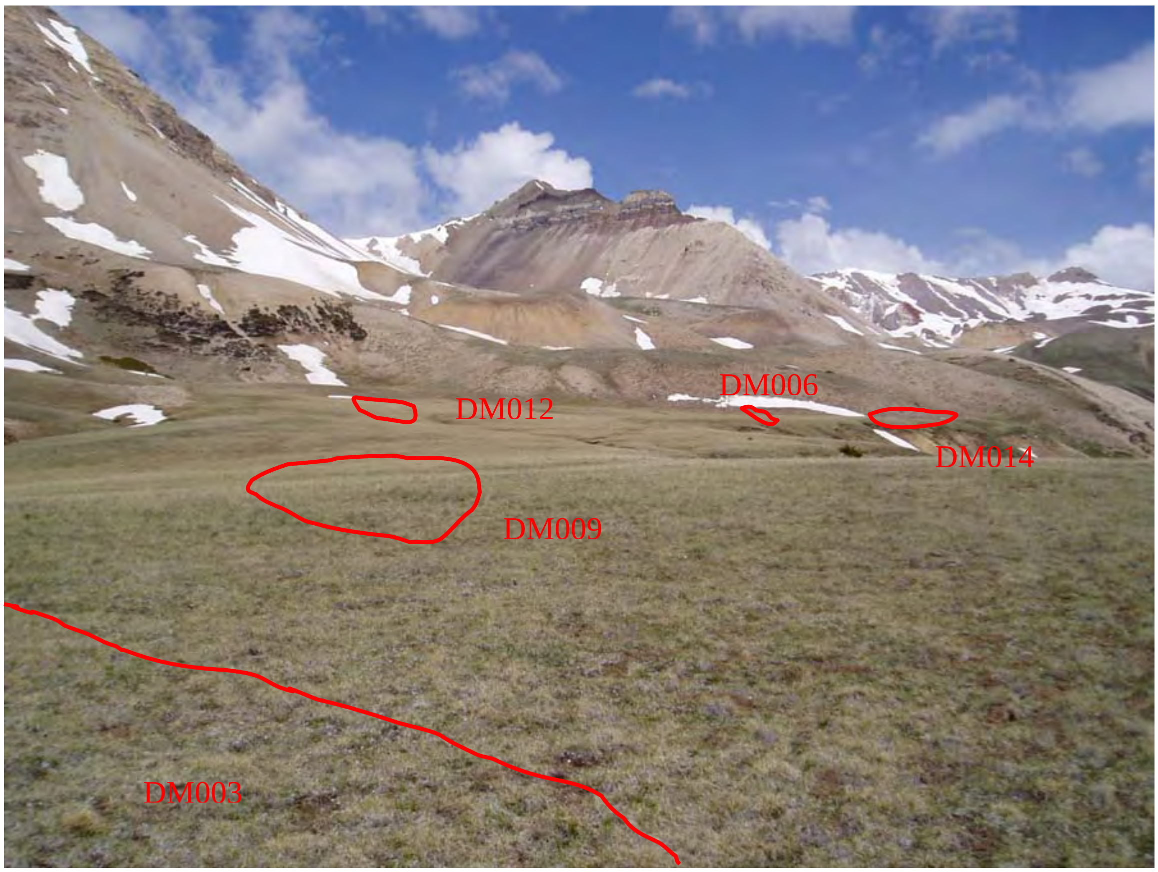


Figure 2.8- Dollar Flats looking across sites DM003, DM006, DM009, and DM012. The peak in the background with the banded stratigraphy is Dollar Mountain. The photo was taken from the south looking north.

Field and laboratory methodology provide a means to sample the archaeological material encountered during field research in the Upper Wood River. These archaeological data address the question of prehistoric occupation in the Dollar Cirque area. The nature of this occupation will be discussed in Chapters Four and Five. But the mere presence of archaeology ignores the interaction of the archaeological record with its environment. The form and formation of the landscape must be understood to interpret the archaeological record, and thus past human behavior. Incorporating geological data sets in the following chapter will allow the construction of a framework for understanding landscapes.

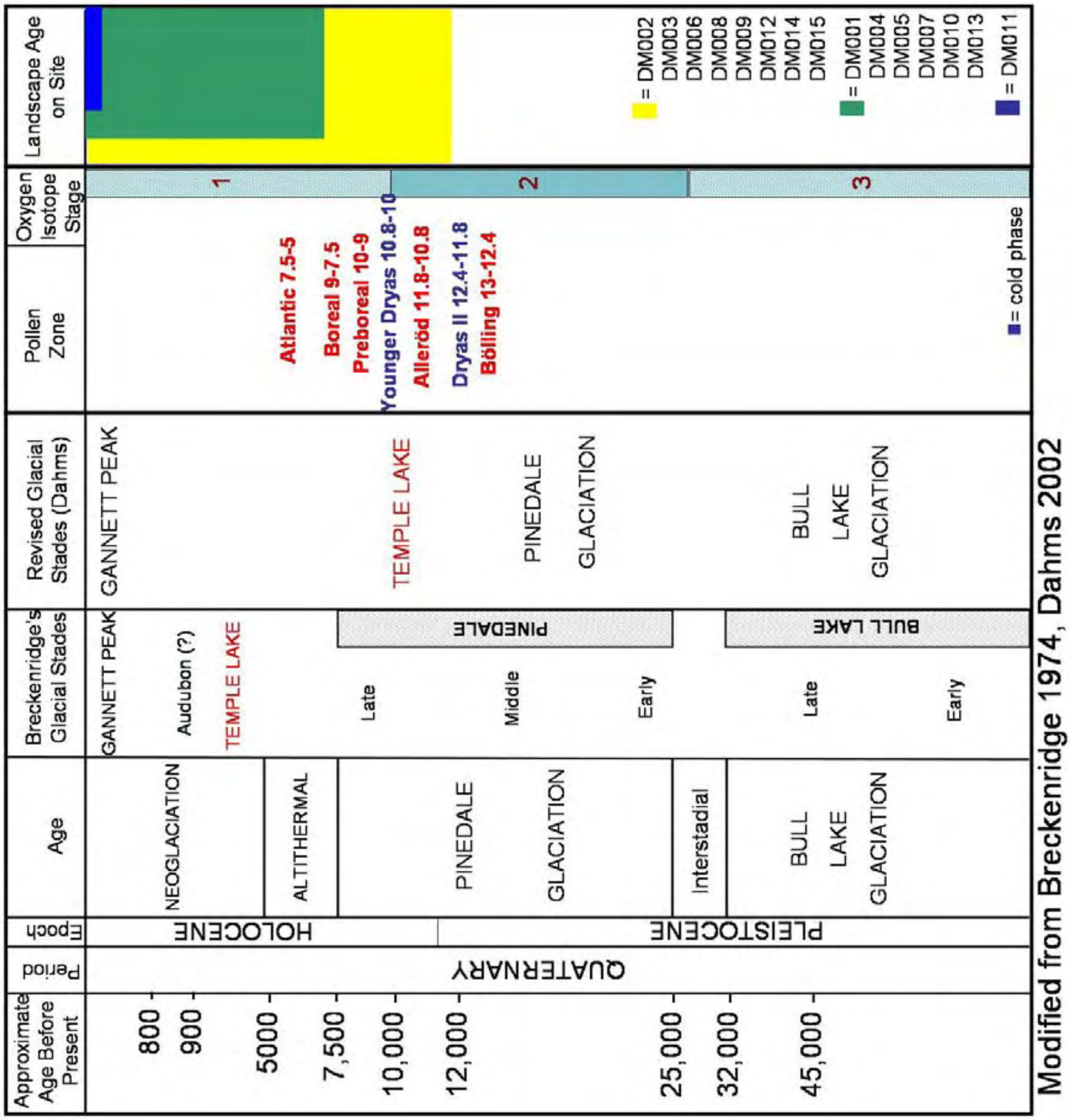
Chapter Three: Geoarchaeology and Geomorphology

"…a man who keeps company with glaciers comes to feel tolerably insignificant by and by. The Alps and the glaciers together are able to take every bit of conceit out of a man and reduce his self-importance to zero if he will only remain within the influence of their sublime presence long enough to give it a fair and reasonable chance to do its work."
Mark Twain (1907:157)

Vance Holliday (2001:3) states, "Quaternary environments and environmental change have provided a backdrop…for most of human prehistory." The formation of archaeological sites cannot be separated from geological and geomorphological processes. Breckenridge (1974a:132) stresses the importance of "quantifying the natural relationship of man and geology." While this statement was intended for modern populations and development, it directly applies to the interpretation of prehistoric populations in changing landscapes. Since the retreat of the Wisconsin glaciers, the landscape has developed under the watchful gaze of human populations. Geoarchaeological interpretation is necessary to understand prehistoric occupation at a landscape scale. The landscape of the Upper Wood River was created, and continues to be modified, in part, through glacial action.

Sediments of the Upper Wood River have recorded four visible periods of glaciation (Table 3.1). No absolute dates have been taken in the Upper Wood River, thus all dated periods mentioned here concerning the Upper Wood River are part of a relative chronology. The classic moraines found in neighboring ranges are absent in the Absarokas, thus detailed study of non-moraine glacial landforms and highly weathered moraines must be conducted to understand the glacial sequence. After the formation of the Absaroka Volcanic Plateau, and its subsequent high elevation surface, Pleistocene glaciation created the landscape, carved the hanging valleys, and shaped the cirques. Subsequent Neoglaciation altered and modified the Pleistocene patterns. Fluvial activity is constant, aggrading and degrading the landscape surface and periglacial action persistently modifies the present landscape.

Table 3.1- Summary of the glacial periods of the Upper Wood River. Breckenridge's original dates are contrasted with the revised chronology.



During the Pleistocene, the Upper Wood River experienced two distinct pulses of glaciation. While the potential exists for pre-Wisconsin glacial advances, Breckenridge reports that evidence for this has either been destroyed or has yet to be recovered. However, evidence for an Early and a Late Wisconsin glacial advance are present in the Upper Wood River (Richmond 1976:357, 358). The Early Wisconsin glacial advance is referred to as the Bull Lake period, named after its type site in the Wind River Range to the south of the Absarokas (Richmond 1976). While no direct correlation or dating exists between the Early Wisconsin deposits in the Upper Wood River and known Bull Lake, Breckenridge (1974a) tentatively assigns this glacial advance to the Bull Lake period due to its close similarity with other deposits on the South Fork of the Shoshone River and in the Sunlight Basin (Parsons 1939; Potter 1967). In the Upper Wood River the majority of depositional features associated with this glacial stade have been eroded away, but patches of Bull Lake till remain (Breckenridge 1974a:57). Bull Lake glaciation is not as well dated as later advances. Gosse et al. (1995:1331) date the Bull Lake period to approximately 179,000 BP based on beryllium dating while Breckenridge (1974a) suggests a date of 45,000 years BP. The Bull Lake period was also the most laterally extensive glacial episode recorded in the Upper Wood River, with the terminal deposits some 25 km from the present Dollar Cirque headwall down stream of the Double D ranch.

The Late Period Wisconsin glaciation is referred to as the Pinedale, again named after its type site in the Wind River Range. Glacial deposits from this stade are much better preserved (Breckenridge 1974a:61). Near its former end moraine (either eroded or obscured by the landslides) are inter-tongued deposits of till and glacial outwash. An excellent example of a Pinedale lateral moraine is found at the mouth of Jojo Creek. This lateral moraine was probably left by the main Wood River valley glacier. This glacial advance dates to approximately 12,000 to 25,000 years BP (Breckenridge 1974a). This date has subsequently been refined to 20,800 to 10,200 radiocarbon years before present (23,800 to 11,200 calibrated years BP). This date has been confirmed through beryllium-10 dating (Gosse et al. 1995). The maximum down valley extent of this glacial advance is approximately 17 km from the present Dollar Cirque headwall just below the Double D ranch.

Pleistocene glacial activity carved the Upper Wood River Valley's diagnostic u-shape and created numerous cirques and hanging valleys. Pleistocene glaciation is only evidenced in the project area in the form of Dollar Cirque itself, no other Pleistocene glacial landforms are present in Dollar Cirque. As Wisconsin glaciers scoured out the cirques they created, steep headwalls, a u-shaped profile, and a relatively flat cirque floor. The cirque is a hanging valley, and its flat floor has been geomorphically stable since the Pleistocene (Breckenridge 1974a). This flat surface has been dissected by fluvial action along Dollar Creek. Breckenridge notes that most evidence for Pinedale tills is found at cirque thresholds, and this is true with Dollar Cirque. Deposits between the cirque floor and the floor of the Wood River consist of outwash gravels and rubble of Pleistocene age (Breckenridge 1974a: Figure 2).

Following the end of the Pleistocene were two periods of Holocene Neoglaciation. Throughout this paper Neoglaciation will refer to renewal of glacial activity after the retreat of Wisconsin glaciers (post Pleistocene ~12,000 years ago). Breckenridge (1974a:65) identified a single distinct early advance and several later pulses. The former he has associated with the Temple Lake stade, and the latter with the Gannett Peak stade, based on their morphology and similarities to well-defined glacial sequences in neighboring watersheds and ranges. Both of these stadia have been defined from type sites in the Wind River Mountains. There has been little debate as to the dates and nature of the Gannett Peak stade, but the Temple Lake stade has remained controversial in its chronological relationship with the Altithermal Period. This climatic period is characterized by warmer, dryer climatic conditions in North America during the early to mid Holocene. The original work at the type locality by Moss (1951; Holms & Moss 1955) defined the Temple Lake advance as a Holocene period event, but predating the Altithermal. Richmond (1965) completely reworked the dating sequence of Holocene glaciation in northwestern Wyoming. Richmond (1965) extends the Pleistocene to approximately 5,000 years BP and places Temple Lake at approximately 2,000 years BP.

Recent work in northwestern Wyoming has modified the temporal sequence. Sediment and ice core work have pushed back the end of the Pleistocene to approximately 12,000 to 10,000 years BP and moves Temple Lake to the position Moss originally assigned it, before the Altithermal (Dahms 2002: Table 4). This new chronology is based on detailed analysis of the sequence of glacial deposits and radiometric dates of surface features. The chronology that Breckenridge used in his geomorphic study is modified from the Richmond chronological model. I propose a modification of Breckenridge's relative age chronologies in the Upper Wood River to correspond with new dates from the Wind River Mountains and developing archaeological data. The most likely candidates for the two periods of Neoglaciation identified by Breckenridge are Temple Lake and Gannett Peak, based on depositional characteristics and surface traits. I agree with Breckenridge's assignment of lithological units, but I propose changing the date ranges that Breckenridge has assigned to encompass the newer chronology proposed by Dahms (2002). The original assignment of relative ages by Breckenridge was based on relative glacial chronologies in the Wind River Range. Better dating techniques have modified Temple Lake period dates to 11,700 years BP corresponding to the Younger Dryas climatic episode. The maximum down valley extent of the Temple Lake glaciation is approximately 1-2 km from the present Dollar Cirque headwall.

The Gannett Peak Stade is represented in all of the cirques in the Upper Wood River. It is usually less than a kilometer from the headwall and dates to the 'Little Ice Age' (Breckenridge 1974a:68). The 'Little Ice Age' has been dated from ice cores in the Wind River Range to begin approximately 1730 (^{18}O date of 1736 ± 10 AD and a ^{14}C date of 1726 ± 95 AD) and ends at approximately 1845 (Electric Conductivity Measurement date of 1845 ± 10 AD) (Schuster et al. 2000). It appears that there was not a single definite advance during this time but rather multiple smaller advances.

In addition to glacial action, fluvial processes have acted to modify the landscape in the project area. Fluvial erosion has obliterated many of the glacial features, through aggradation, degradation, and re-deposition. Fluvial action has also deposited material in the form of terrace deposits. These are depositional terraces and represent two distinct events. Breckenridge (1974a:46) associated the terrace deposits to the late Neoglacial advance (0.6 to 1.5 m above the river) and the early Neoglacial advance (3 to 4.5 m above the river).

Wisconsin

Deposits dating to this period are characterized by glacial moraines, both terminal and lateral, and landslide deposits. There are also deposits of outwash gravels and rubble. Pleistocene glaciation has created the basic landforms (i.e., the cirques and valleys) as well as the flat geomorphically stable surfaces that are represented in the floors of hanging valleys. The surfaces of the deposits are slightly weathered with azonal to zonal soil profiles extending to depths of 30 - 90 cm (Breckenridge 1974a:62). The Wisconsin age deposits have also been re-vegetated with grasses and pines (Breckenridge 1974a:61). The only remnants of Pleistocene glaciation in Dollar Cirque are outwash gravels, rubble veneer, and a Pleistocene surface.

Temple Lake

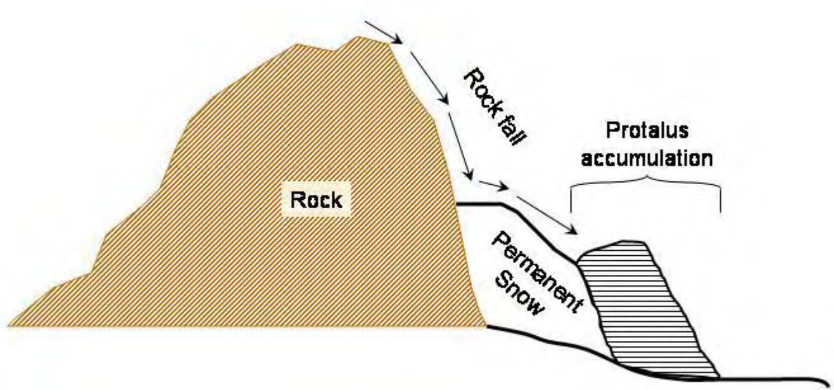


Figure 3.1- A model of protalus rampart formation. Rock passes over a permanent snow field and accumulates on the other side.

Deposits dating to this period are varied and include glacial landforms and Periglacial features. Temple Lake protalus ramparts are found in Dollar Cirque (Figure 3.1), as are tills (Figure 3.2). These account for the majority of the Temple Lake deposition in Dollar Cirque. Temple Lake protalus deposits are approximately 300 m from their source slopes. When soil development is present it is weak and azonal and rarely supports more vegetation than grasses, forbs, and occasional krummholz spruce. Lichen cover on these deposits is >50% (Breckenridge 1974a:66).

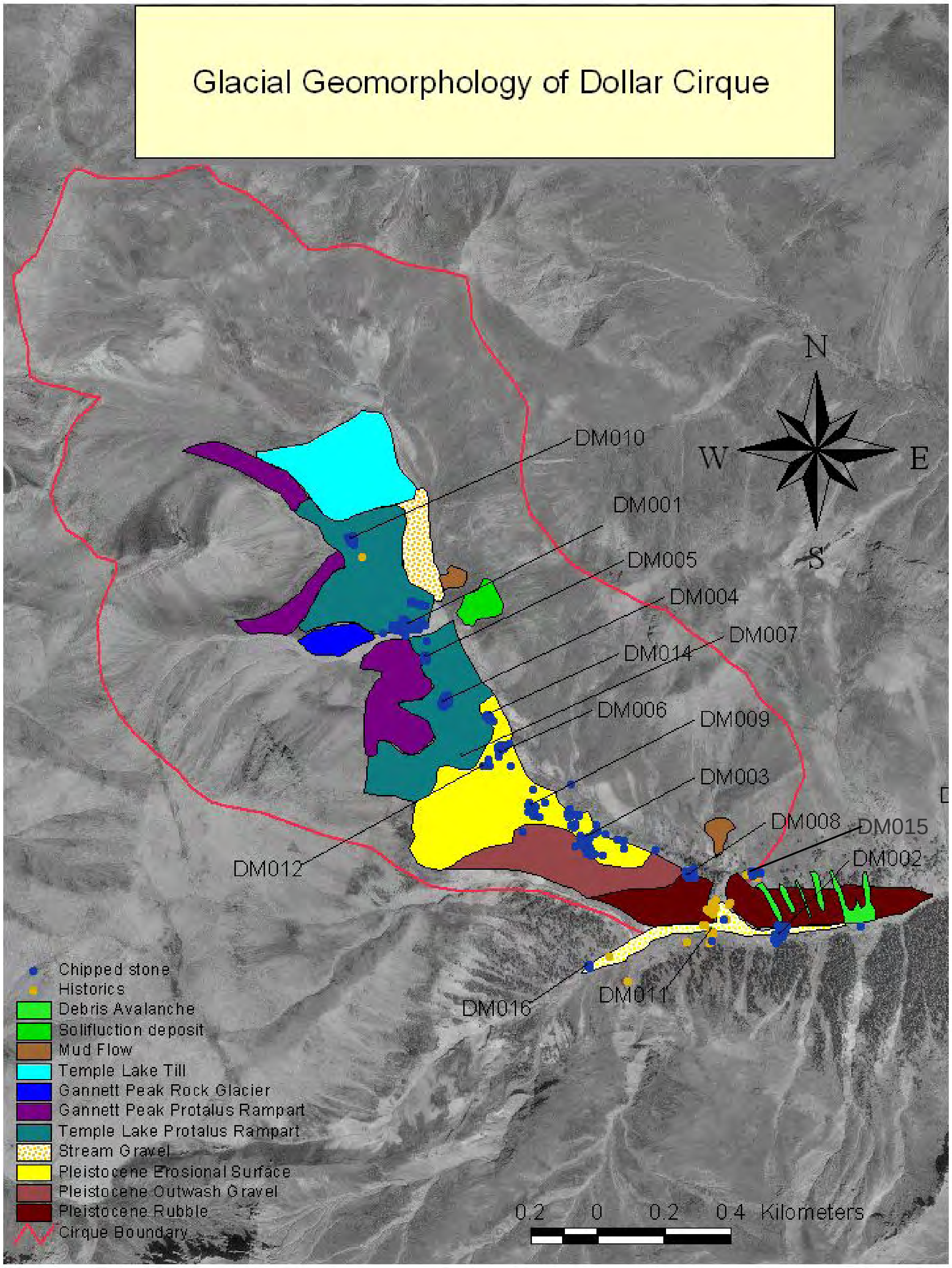


Figure 3.2- GIS model plotting all artifacts recorded during the 2003 field season on to the geomorphic units. The base map is a USGS DOQQ; the geologic units are from Breckenridge 1974a.

Gannett Peak

Deposits dating to the Gannett Peak period are very similar to those of Temple Lake. Within Dollar Cirque is an active Gannett Peak rock glacier and extensive protalus rampart deposits (Figure 3.1). A rock glacier is a large mass of angular rock whose interstices are filled with permanent ice. This ice/rock body has sufficient mass to creep downhill. The rock glacier is less than 200 m from the principle site in Dollar Cirque (DM001) and consists of a debris mantled core of ice moving slowly down slope. Gannett Peak protalus deposits are approximately 80 m from their source slopes. Soil, when present, is very thin (~15 cm). The deposits are usually piles of very coarse material (angular rock) and lack interstitial fines due to their origins on the steep sides of valley walls instead of the cirque headwall (Breckenridge 1974a:68). Lichen cover is >20% and little to no vegetation are found on these deposits (Breckenridge 1974a:68).

Fluvial Action/Colluvial Action

Fluvial processes in the Upper Wood River have caused significant down-cutting and erosion. At present the stream has a fairly steep gradient, but still has a significant bed load of gravel and some meandering characteristics. The Upper Wood River has deposited material in the form of stream terraces and outwash gravels. The floor of Dollar Cirque has been down-cut by fluvial erosion. These processes created a deep, steep sided canyon that cuts through the Pleistocene surface. Alluvial gravel deposits are found throughout the Wood River and stream gravels fill the majority of large drainages. Below the mouth of Dollar Cirque, along the Wood River, is a sequence of two laterally accumulated terraces. These terraces are composed of silt-sized to boulder-sized clasts, and the higher of the two is vegetated with grasses, pine, spruce, and fir trees; the lower terrace is vegetated with grasses, shrubs, and willows (Figure 3.2).

There are also mudflow, rock fall, talus, and solifluction deposits in Dollar Cirque. The upper reaches of the cirque and the high slopes of the cirque are covered with loose fragments of talus. Accumulations are derived from sporadic rock fall events that were observed on a daily basis. Breckenridge (1974a: Figure 30) also discusses the possibility of talus slope creep, moving down slope with the aid of minor amounts of water. On the eastern side of Dollar Creek are several mudflows and a solifluction deposit. The eastern side of the cirque is both more stable and heavily weathered than the western side. It is possible that these deposits occur in a finer grained substrate, which has yet to develop on the more geomorphically active western half of the cirque (Figure 3.2).

Periglacial Processes

The most obvious periglacial feature in Dollar Cirque is patterned ground. Good examples of patterned ground occur on the surface of DM001 in areas of deeper soil accumulation. These features have a rough polygonal structure and are approximately 2-3 m across (Figure 3.3). These are the results of frost heave (Benedict 1992; Bryan 1946). A second, easily diagnosed, periglacial features are nivation hollows. These occur throughout Dollar Cirque and are recognized as shallow depressions under and around permanent snow banks and fields caused by sheet wash of melt water (USDA 2001). Breckenridge (1974a:91) also discusses the possibility of snow or ice cored protalus creep. Thus downhill movement of protalus could behave very similarly to rock glacier creep.

Figure 3.3- Patterned ground on DM001. The large polygonal blocks are formed through periglacial processes for scale the ice axe is approximately 70 cm tall. The photo is taken from the north of the site looking south.

What Archaeology can tell us About Landscapes, What Landscapes can tell us About Archaeology

Humans have been in Northwestern Wyoming since at least the end of the Wisconsin Glaciation. Prehistoric human use of high altitudes and been documented in the Rocky Mountains (Benedict 1981, 1985, 1990; Cassells 2000; Frison 1991; Frison et al 1986, Hutchinson 1990; Kornfeld et al. 2001). The geomorphic record in Dollar Cirque is highly dynamic and has included humans for, at least, the Holocene. By understanding the relationship of prehistoric material with the Quaternary deposits we can learn two things; first is the potential for prehistoric material to be preserved as intact subsurface deposits on visible on the surface, and second is to develop a methodology to generate relative ages of past cultural material, or the potential minimum and maximum landscape ages, developing temporal constraints of the surface's age.

Potential for intact subsurface deposits is a function of the burial of the prehistoric material by geologic processes. DM002 is an example of material being deposited slowly by fluvial and colluvial sources, burying archaeological material. Long term weathering and aeolian accumulation of sediment on stable Pleistocene surfaces have the best potential for containing intact subsurface deposits. Material may also be incorporated into relatively shallow surfaces and in areas of sediment accumulation through the actions of cryoturbation. As frost heave churns the substrate, archaeological materials may be incorporated into the sediment (Benedict 1992; Johnson 1974).

One of the most interesting taphonomic processes taking place in Dollar Cirque is the burial of archaeological material by later glacial advances. It appears that the Gannett Peak protalus has advanced over DM005. This provides minimum age constraints for the archaeological material. This may be happening at DM014 as well, with Temple Lake deposits advancing over archaeological material

Table 3.2- Summary of site location in relation to geomorphic setting and approximate age.

General Land Surface Ages

Site no.	Geomorphic Setting	Formation	Relative Age (years)
DM001	Protalus Rampart	Temple Lake	8,000
DM002	Pleistocene Rubble	Pinedale	12,000
DM003	Pleistocene Erosional surface	Pinedale	12,000
DM004	Protalus Rampart	Temple Lake	8,000
DM005	Protalus Rampart	Temple Lake	8,000
DM006	Pleistocene Erosional surface	Pinedale	12,000
DM007	Protalus Rampart	Temple Lake	8,000
DM008	Pleistocene Outwash	Pinedale	12,000
DM009	Pleistocene Erosional surface	Pinedale	12,000
DM010	Protalus Rampart	Temple Lake	8,000
DM011	gravel bar	Gannett Peak	100
DM012	Pleistocene Erosional surface	Pinedale	12,000
DM013	river terrace	Temple Lake	8,000
DM014	Pleistocene Erosional surface	Pinedale	12,000
DM015	Pleistocene Rubble	Pinedale	12,000
DM016	gravel bar	Unknown	Unknown
DM017	Alluvial Cone	Unknown	Unknown
Dollar Flats	Pleistocene Erosional surface	Pinedale	12,000

As relative ages of the Quaternary deposits in the Upper Wood River are well defined, prehistoric material found on and in these deposits can be relatively dated (Table 3.2). Deposits of three ages are found in Dollar Cirque (excluding the relatively new fluvial and colluvial deposits). These date to 1) the end of the Pleistocene, 2) to immediately before the Altithermal, and 3) to the 'Little Ice Age.' Temporally diagnostic prehistoric material is found on the Pleistocene and on the pre-Altithermal land surfaces. As the floor of the hanging valley was created and scoured by Late Wisconsin glacial activity, all prehistoric material must post-date the end of the Wisconsin. Pleistocene aged surfaces are the oldest in the cirque and thus the potential exists for the oldest archaeological material. The Pleistocene surface was then partially covered by glacial material during the pre-Altithermal Temple Lake period. These new deposits have two geomorphic effects. They destroyed, or buried, any prehistoric material dating to before 10,000 years BP in the area of Temple Lake deposits. It also created a surface with a minimum age predating the Altithermal. The 'Little Ice Age,' Gannett Peak advance scoured the back of the cirque and deposited material on part of the Temple Lake surface. Just as Temple Lake covered the Pleistocene surfaces, Gannett Peak deposits have the potential to destroy or bury prehistoric materials in the area of this depositional event, including any prehistoric material deposited at the chert outcrops in the back of the cirque.

If land surface dates are correct, Pleistocene aged Dollar Flats could contain cultural material dating from the Paleoindian period (Frison [1991:20] dates this period to 12,000 to 10,000 years BP) through the present, the Temple Lake deposits could contain Early Archaic (Frison [1991:20] dates this period to 8,000 to 5,000 years BP) material through the present, and the Gannett Peak deposits can not contain any prehistoric material. Archaeological material was recorded on Pleistocene-aged and Temple Lake-aged surfaces. Temporally diagnostic material found on the Pleistocene surface date to the Late Archaic (Frison [1991:20] dates this period to 2,000 to 1,500 years BP), easily falling within the temporal constraints of the surface's age. Temporally diagnostic material from the surface of the Temple Lake deposit dates to the Early Archaic period (8,000 to 5,000 years BP) corresponding with the dated range of the Altithermal. Archaeologists acknowledge that projectile point chronologies are a continuum and may have a wide range of error. Also taphonomic processes could move surface and subsurface deposits of artifacts. However the placement of the Temple Lake deposit in relation to the Altithermal becomes very important. If Temple Lake post-dates the

Altithermal as Breckenridge suggests, then cultural materials of a significantly earlier period are deposited stratigraphically above Temple Lake. Likewise, if the newer chronology is correct and Temple Lake pre-dates the Altithermal, then it is reasonable to expect Early Archaic material on the Temple Lake deposit. I believe that the archaeological material offers good evidence for revising Breckenridge's glacial chronology.

Geomorphic data also provide an ideal way to interpret small scale taphonomic processes. By understanding the transport, sorting, and deposition of material it becomes possible to sort out in-situ deposits from sites where artifact patterning do not reflect human behavior. Archaeological material can be moved and transported at a variety of scales. Large scale processes such as the movement of glaciers or the advancement of protalus are coupled with smaller scale processes like cryoturbation and nivation hollows. Cryoturbation acts to churn sediment, bringing buried deposits to the surface and drawing surface deposits into the sediment (Johnson and Hanson 1974). The sheet wash processes that create nivation hollows will affect the archaeological record like any fluvial process. Most of the glacial and periglacial process also involve fluvial transport of material as part of the system.

By understanding landscape age, and formation, prehistoric occupation can be discussed on a large scale. The use of geoscientific interpretation can be expanded in archaeological research beyond site specific questions to larger pictures of human behavior on a landscape. By understanding the relative age of a land surface the potential for human use can be assessed. Archaeological data sets can be used in conjunction with geologic ones to generate better ideas of land surface use and change over time. Human land use will be discussed in terms of lithic raw material use in the following chapter and human behavior and geomorphic change will be synthesized in chapter five.

Chapter Four: Making Sense of Dollar Mountain Lithics

Evidence of prehistoric occupation in Dollar Cirque encountered during the 2003 field season is visible archaeologically in the form of chipped stone artifacts. The content of this chapter is divided into two parts, first is the description of the raw material and its geological context and second is the chipped stone artifact analysis.

Dollar Mountain

Dollar Mountain is a unique geological formation and the only place in the Absaroka volcanic field where Paleozoic rocks are found (a discussion is presented in Rouse 1940 and the following formation descriptions are taken from there). A block of rock approximately 2.5 square kilometers was forced into the volcanic rock by a large rhyolite intrusive body (Rouse 1940). The Paleozoic block originated from the sedimentary rock that underlies the Absaroka Range. The surrounding Eocene volcanics were then eroded away creating an outcrop of sedimentary rock (Figure 4.1).

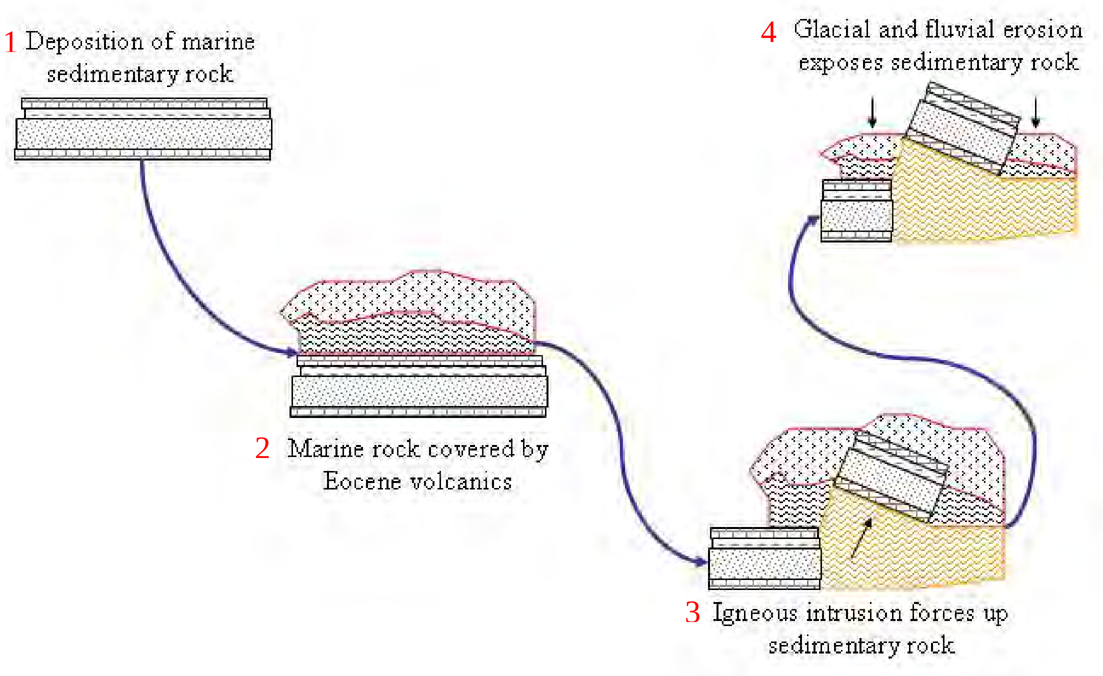


Figure 4.1- Model of the formation of Dollar Mountain. 1) Sedimentary rock is deposited, 2) Sedimentary rock is covered by Eocene volcanics, 3) Igneous intrusion force the sedimentary rock up through the volcanics, and 4) erosion exposes the sedimentary outcrop

The sedimentary rock sequence begins in the Cambrian and ends in the Mississippian/Pennsylvanian period as was described by Rouse (1940) (Table 4.1). At the base of the uplifted block are the Cambrian age Flathead Formation sandstones and shales. Heat alteration is present. The sandstone in direct contact with the intrusive body shows no metamorphism, however the overlying shale layer shows slight metamorphic alteration. Above the Flathead is the Gros Ventre Formation of sandstones, limestones, and shales. Above this is the Gallatin Formation of limestones and shales. The subsequent Ordovician Bighorn Formation is the most interesting from an archaeological standpoint. This dark limestone formation is fossiliferous and contains beds of brown chert and nodules of black chert at its base. It is likely that the Bighorn Formation is where the lithic raw material we have typed as Dollar Mountain chert originates. The chert was regularly found embedded in a dark grey/black limestone matrix. Above the

Bighorn Formation is the Devonian Darby limestone. Darby limestones are brown to black with some beds of greenish shale. Above the Darby is the Mississippian Madison Formation. The Madison limestone layer at Dollar Mountain is not reported to contain any chert. However, Madison Formation limestone at other localities (e.g., the Bighorn Mountains) are known to contain an easily recognizable chert found throughout Wyoming and the Northern Plains in archaeological assemblages, including the Dollar Mountain and the Upper Greybull assemblages. The final sedimentary formation in this sequence is the Amsden Formation. It consists of Mississippian/Pennsylvanian limestones, shales and sandstones with abundant fossils. In places, the Paleozoic material is still overlain by Tertiary volcanic breccias.

Table 4.1- Description of the sedimentary rock sequence capping Dollar Mountain. Table modified from Rouse 1940.

The Paleozoic Block	thickness (meters)
MISSISSIPPIAN AND PENNSYLVANIAN	
Amsden	
Red shale, contains limey concretions and thin bed of limestone near base. Abundant poorly preserved fossils	9
Bedded sandstone	6
MISSISSIPPIAN	
Madison	
Interbedded dark and light limestone layers from 2-10 feet thick. Considerable lime breccia	183
DEVONIAN	
Darby	
Lime intruded by sill 100 feet thick. Brown and buff limestone and some greenish shale at top of sill. 10 feet of dark-brown to black limestone at base of sill	37
ORDOVICIAN	
Bighorn	
Dark limestone but lighter at top. Some beds fossiliferous. Beds mostly massive. Top marked by local beds of limestone conglomerate and dense brown chert. Mottled zone about 50 feet above base. Round black chert nodules near base	46
CAMBRIAN	
Gallatin	
Dark-gray, brown, and black limestones. Flat pebble conglomerate throughout but in thin widely separated zones	24
Limestone with some interbedded shale abundant edgewise conglomerate throughout.	30
Gros Ventre	
Fine grained brown sandstone and black shale	18
Sill	6
Thin conglomerate of rounded limestone, pebbles, and lenticular limestone	1
Black shale with a few limestone beds	15
Interbedded limestone and black shale	8
Flathead	
Interbedded quartzite and indurated shale	46

The sequence of sedimentary rock is similar to the basement rock throughout most of Northwestern Wyoming. It underlies the Bighorn Basin and has been uplifted in other neighboring ranges including the Bighorn Mountains, the Owl Creek Mountains, and on the Southwest flanks of the Absaroka Mountains (Lageson & Spearing 1988).

Transport of Dollar Mountain Rock

Understanding how the material is transported from Dollar Mountain is important in understanding the potential for secondary deposits of Dollar Mountain chert. Once the Dollar Mountain chert was exposed, erosion has been removing Dollar Mountain material and carrying it out of the cirque and down the valley. It appears that the modern drainage divides allow the erosion of material west into the Caldwell drainage and southeast into the Upper Wood River, but not to the north into the Upper Greybull. It appears unlikely that past drainage patterns allowed this material to move into the Upper Greybull.

First, I will address the potential for alluvium to contain usable raw materials that could have been used by prehistoric people for the production of stone tools. The headwaters of the Wood River begin at the foot of Dollar Mountain. A brief analysis of the alluvium in the Wood River immediately above its confluence with the Greybull failed to recover any pieces of the chert, but some limestone was found that may originates from the same outcrop. The Upper Greybull River and its tributaries are separated from the chert outcrop at Dollar Mountain by the Horse Creek (a tributary of the Wood River) drainage basin. No Dollar Mountain chert has been found in the alluvial deposits above the confluence of the Wood and Greybull Rivers. Dollar Cirque contains any drainage off of the north or west faces of Dollar Mountain. The Caldwell River has two upper tributaries (informally called North and South Caldwell) with drainage basins that head at Dollar Mountain. While field analysis of the alluvium in these drainages has not been conducted, it is probable that the Caldwell also provides a secondary source of the Dollar Mountain material. The Greybull River below the confluence of the Wood River is also a possible a source of prehistoric tool stone. Dollar Mountain chert is found in the modern stream alluvium above the town of Kirwin often as large cobble to boulder sized clasts.

A brief study looking at the potential for terrace accumulation was conducted. Eighteen river gradients were measured using both DEMs and direct field measurement. Ten of these slopes were taken from lower, terraced reaches of the rivers, five from the Wood River and five from the lower Greybull. Eight slopes were taken from upper reaches of the rivers where terrace formation is not as extensive, five from the Upper Wood and three from the Upper Greybull. The average gradient in the terraced reaches is 0.8 degrees. The average slope in upper reaches is 4.5 degrees.

A T-test was conducted to compare the significance of the channel gradients of the upper reaches and lower reaches of the rivers. The standard deviation of the lower reaches is 0.17 while the upper reaches have a higher standard deviation of 2.7. The T-value is computed at -4.4 which allows for a p-value of 0.0004. The test was run using two tails and 16 degrees of freedom. The p-value is significant, expressing a significant difference in channel gradient between the upper and lower reaches of the rivers.

Table 4.2- Stream gradient T-test comparing the upper reaches of the channel to the lower reaches. There is a significant difference in stream gradient, with the upper reach being steeper.

T-test Data				
Slope angles	Wood River		Greybull River	
	Terraces	Non terrace	Terraces	Non terrace
	1.1	3.9	0.8	6.7
	0.8	9.9	0.6	5.3
	0.52	2.2	0.9	2.7
	0.8	3.5	0.9	
	0.7	2.1	0.9	
Number	5	5	5	3
Average	0.784	4.32	0.82	4.9
Standard Deviation	0.21	3.22	0.13	2.03
t-test	-3.47		-6.34	
p value	0.0085		0.0007	

When the drainages are statistically compared the results are similar. The Wood River has average slopes of 0.8º and 4.3º for the lower and upper reaches respectively (Table 4.2). The computation of a t-value of -3.5 provides a significant p-value of 0.008 (Table 4.2). The Greybull River has average slopes of 0.8º and 4.9º for the lower and upper reaches respectively (Table 4.2). The T-test provides a significant p-value of 0.0007. Thus, if the rivers are compared together, or separately, there is a significant statistical difference between the stream gradients of the upper and lower reaches of the rivers. It appears the gradients of the lower reaches of the Wood River and the Greybull favor the accumulation of alluvium more so than the upper reaches. This would indicate the potential for the accumulation of Dollar Mountain chert in the terrace deposits as a secondary source of this tool stone.

In addition to the fluvial transport of material, there is also the glacial transport of material. Lateral and terminal moraines have the potential to move tool stone down the Wood River to the maximum extent of glaciation (almost as far as the confluence of the Wood River with the Middle Fork). The field crew recorded Dollar Mountain chert in lateral deposits dozens of meters above the present bed of the Wood River near the mouth of Horse Creek. This indicates another secondary source of Dollar Mountain chert available for prehistoric use.

Identification of Dollar Mountain Chert

The identification of Dollar Mountain chert is vital to elucidate its role in prehistoric tool production. A sample of raw materials was collected from the surface of DM001 in an attempt to identify macroscopic attributes that can be used to separate the lithic raw material originating at Dollar Mountain from other sources on the Northern Plains. The raw material was first divided into 12 categories, based primarily on color

(Appendix Four). Twenty-two samples were recorded using the methodology outlined in Chapter Two. Chert analysis is grouped into three principle color categories: caramel, red, and black. These data are summarized in Table 4.3.

The color of the most abundant raw material varied along a continuum between caramel and red (10YR 3/4 – 10R 3/6, Munsell [1988]). There is significant overlap in the color categories, and sample pieces were collected that show examples of pure caramel, pure red, red mixed with white, red mixed with translucent chalcedony, caramel mixed with translucent chalcedony, and red mixed with caramel (Table 4.3). These two colors outcrop in the same beds of chert and thus are variations of the same material. Some color change may be the results of heat alteration (Collins & Fenwick 1974). Heat alteration is modifying the physical properties of some of the samples. Some samples have blackened surfaces and others have crazing, potlids and thermal fractures. Other samples appear to be oxidized red. The identified Dollar Mountain chert probably corresponds to Rouse's (1940) "dense brown chert" from the Bighorn Formation.

This material ranges in diaphaneity from the semi-opaque caramel to the opaque red. Both colors have slightly vitreous luster. The texture of both colors is cryptocrystalline, but both materials have some variation. Some pieces seem grainier than others, but no individual crystals could be recognized under 30x magnification. None of the red or caramel samples contained recognizable fossils.

Several of the collected samples show the color overlap present in the assemblage. These include a pink sample mottled with red and white, a maroon sample that is probably a variation of the red, a mottled white and red sample, and a few examples of a dark caramel or brown that is probably a variation in the caramel.

The second most abundant color is black. The chert is relatively uniform without much color variation aside from slight shades of grey to black. Black chert was found in dark grey limestone rock (Figure 4.3). Some of the sample pieces exhibit heat modification, but lack associated color changes. The black chert has an opaque diaphaneity, vitreous luster, and a uniform cryptocrystalline structure. No fossils are present in any of the samples.

Three different types of chalcedony were found; 1) a clear chalcedony, 2) an oölitic chalcedony, and 3) one with brown filaments throughout. The plain clear chalcedony has been found throughout the region, in the Upper Wood, Middle Greybull, and Jack Creek. It is clear, slightly vitreous, and has a cryptocrystalline structure. Only a single piece of oölitic chalcedony was recorded, it is translucent with small round inclusions. These inclusions are probably calcium carbonate and are grown in suspension as the chalcedony forms (Thrush 1968). The oölitic chalcedony has a vitreous luster and a cryptocrystalline texture. A single piece of chalcedony was found that contained brown filaments. Its luster and texture were the same as the oölitic chalcedony. It is possible that these two varieties of chalcedony are found throughout the Absaroka Range, but not often in sizes large enough to produce chipped stone tools.

Some pieces of a dark grey quartzite were recorded, which have a vitreous luster, are semi-opaque, and exhibit a grainy texture. It is possible that this material is also from the Dollar Mountain sedimentary sequence, as metamorphosed sandstone, but no reports or examples of quartzite have been recovered from the outcrop.

The results of exposing the samples to long and short wave ultraviolet (UV) light indicate that some samples do react to UV light, however there is no baseline data set to compare these responses to. Samples that appear identical macroscopically do not exhibit the same fluorescence. In the caramel chert, only one sample fluoresced (a light green), while the other sample had no reaction to the UV light. Only the chalcedony had a dependable response. Under both long and short wave UV light, the chalcedony glowed orange. This happened in samples of pure chalcedony and in samples of chert with chalcedony inclusions. Perhaps if more samples were tested and freshly broken pieces were used a more reliable data set could be generated.

Table 4.3- Summary of the raw material comparative collection from Dollar Cirque. It is likely that all six variation outcrop at Dollar Mountain.

Dollar Mountain Comparitive Collection Summary

	Average Color	Color Range	Diaphaneity	Texture
Caramel	10YR 3/6	10YR 3/4 - 10YR 6/8	Semi-opaque	Cryptocrystline
Red	10R 3/6	10R 3/6	opaque	Cryptocrystline
Black	N3	N2 - 7.5YR 2/0	opaque	Cryptocrystline
Chalcedony	Clear		translucent	Cryptocrystline
Oolitic Chert	Clear	clear - 5Y 8/1	translucent	Cryptocrystline
Quartzite	10YR 5/1	10YR 5/1 - 10YR 6/4	Semi-opaque	Microcrystline
	Luster	**UV long**	**UV short**	**Fossils**
Caramel	Slightly vitreous	Some green	Some Green	none
Red	Slightly vitreous	none	none	none
Black	Vitreous	none	none	none
Chalcedony	Slightly vitreous	orange	orange	none
Oolitic Chert	Vitreous	none	none	yes
Quartzite	Vitreous	none	none	none

Artifact Analysis

Several variables were noted on all chipped stone tools recorded. These include the surface context of the artifact, the raw material type, a primary color, a secondary color, and the color of any inclusions. The opacity was recorded for each color. Heat modification was recorded as three classes of modification, thermal fracture, crazing, and potlidding.

The surface context describes the setting in which the artifact was found. Context was subdivided into four categories: erosional, sediment patches, rodent burrows, and vegetated areas. Context was recorded on 919 artifacts. Of these 83% were found in the sediment patches. The recorded context is probably a reflection of the surface visibility of artifacts, not their actual surface distribution. The lack of vegetation allows artifacts to be seen and artificially inflates the contexts with less vegetation. Seven percent were found in erosional contexts, six percent were found in vegetated areas and the final four percent were found in rodent disturbed contexts. Discover of artifacts in rodent backdirt is a good indication of subsurface deposits.

The chipped stone raw material found is primarily Dollar Mountain Chert. Two-thousand one-hundred pieces of the chipped stone recorded in the field were assigned a raw material type based on macroscopic properties. Of this, 95% of the raw materials are from Dollar Mountain. The next highest percentage is unsourced chert (nearly 2%) followed by unsourced chalcedony (1.5%) (Table 4.4).

Table 4.4- Summary of the difference in source of chipped stone

Table 4.4- Raw Material

Raw material	Amount	Percentage
Dollar Mountain Chert	1990	94.76
Chert	39	1.86
Chalcedony	32	1.52
Silicified Sediment	13	0.62
Quartzite	10	0.48
Madison	6	0.29
Dollar Mountain Quartzite	4	0.19
Irish Rock Chert	2	0.10
Mudstone	2	0.10
Oolitic Chert	1	0.05
Petrified Wood	1	0.05

The general color of the lithics is important in the macroscopic determination of probable raw material sources, as explained at the beginning of this chapter. Only the primary color of each chipped stone was analyzed. The use of multiple colors indicates the wide range of variation that is present, and show the overlap in the color categories identified in the Dollar Mountain Chert section above. The majority of the chert is caramel colored, followed by red, and then by maroon, white, and black (the remaining colors are: brown, red-brown, grey, orange, pink, clear, peach, yellow, green, and purple). Because the vast majority of the assemblage is Dollar Mountain chert this color distribution represents the range of variation from that source (Figure 4.2). Figures 4.3 and 4.4 are color photographs of the principle chert colors (caramel, maroon, and black) and their associated Munsell color chip.

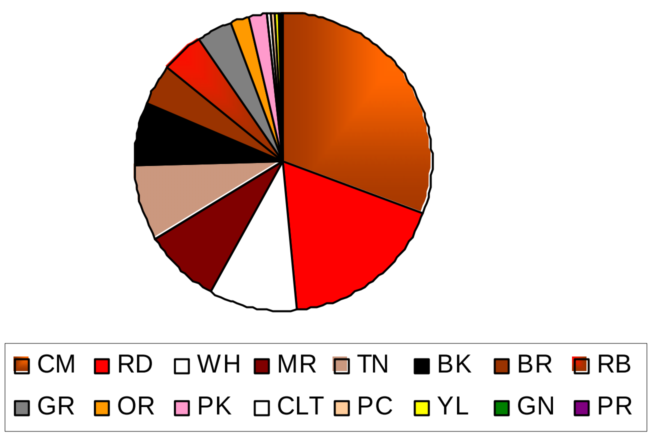
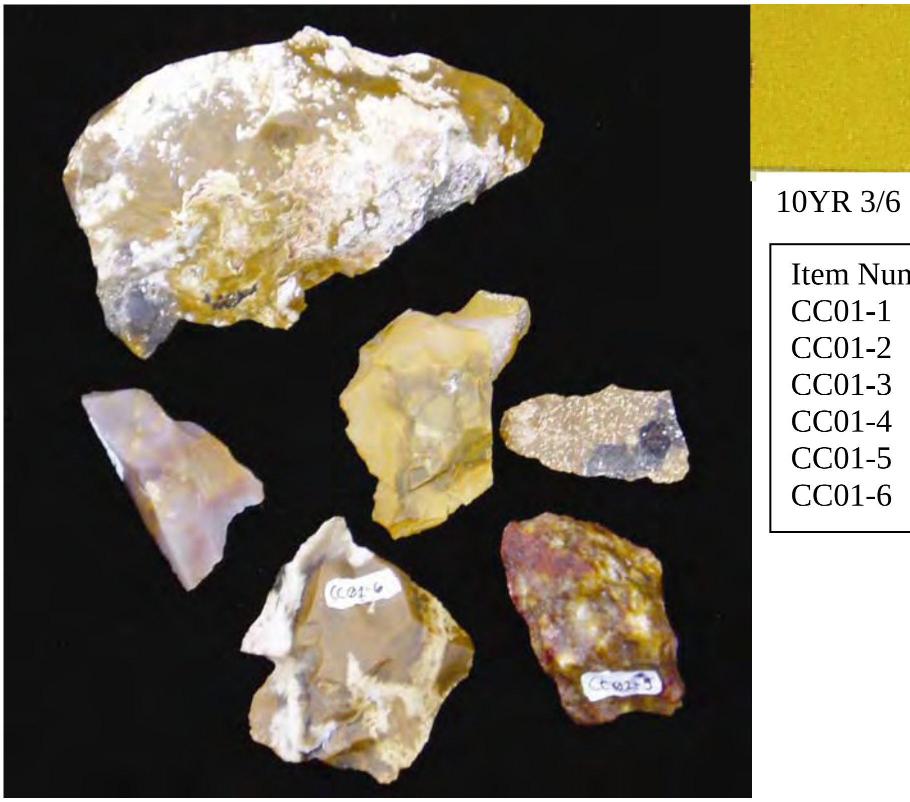
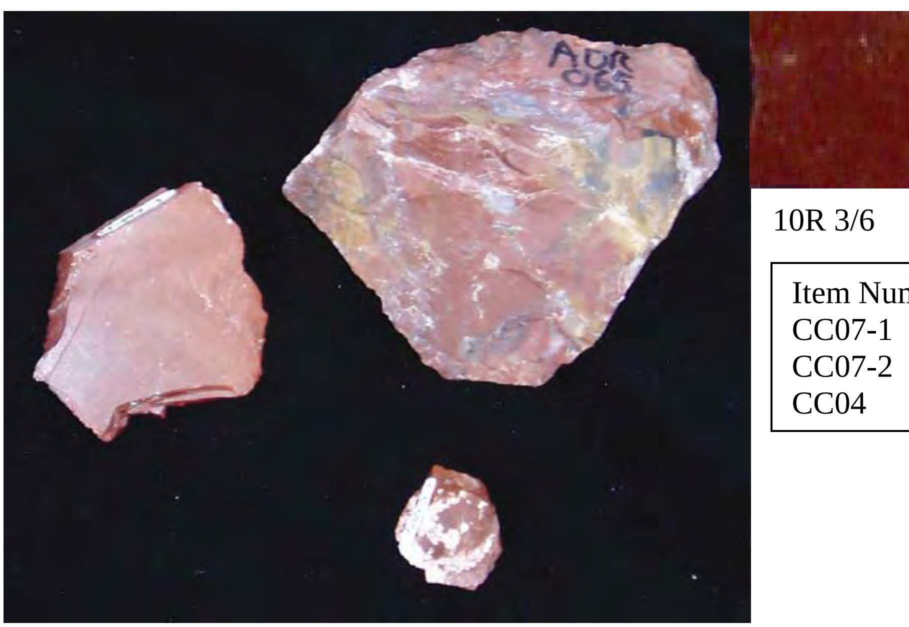


Figure 4.2- Pie chart represents the difference in color abundance among the Dollar Mountain material recorded in the project area. CM= caramel, RD= red, WH= white, MR= maroon, TN= tan, BK= black, BR= brown, RB= red/brown, GR= grey, OR= orange, PK= pink, CLT= clear/translucent, PC= peach, YL= yellow, GN= green, and PR= purple.



10YR 3/6

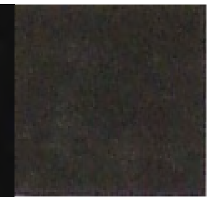
Item Numbers
CC01-1
CC01-2
CC01-3
CC01-4
CC01-5
CC01-6



10R 3/6

Item Numbers
CC07-1
CC07-2
CC04

Figure 4.3- Samples of caramel (10YR 3/6) (above) and red (10R 3/6) (below) Dollar Mountain chert shown with their associated Munsell color chip.



N3

Item Numbers
CC08-1
CC08-2
CC08-3

Item Number
CC05

Figure 4.4- Samples of black (Munsell N3) Dollar Mountain Chert and local chalcedony.

The opacity of the raw material varied with sample and color. It appears to be tied directly to material thickness, as opacity increase on the edges, and on thinner artifacts. Some materials generally always had a high degree of opacity (chalcedony) while specific colors were rarely anything but opaque (black chert).

Heat modification was recorded on nine-hundred and twenty-five artifacts (925). These were analyzed for the presence of potlids, angular thermal fracture, and crazing (or a high degree of angular internal fracturing). These three categories have been associated with the thermal modification of chipped stone. Separating human created heat modification from non-human heat modification is difficult, but some methods have been hypothesized (Butler & Brooks 1971). Twelve percent of the assemblage exhibits heat modification: four percent being crazing, three percent of the assemblage exhibits multiple types of heat modification, three percent potlids, and two percent thermal fracture. Crazing and potlids have been associated with burning of material, rather than heating material to increase workability (Butler & Brooks 1971). Thermally fractured pieces are difficult to distinguish from angular shatter, so this number may under or over represent this heat modification type.

Tools

tools include cores, bifaces, scrapers, nodules, gravers, blades, and projectile points. The tool category is an inclusive category aiding in the separation of artifacts that received more descriptive analysis from the debitage. The artifacts included in it do not necessarily represent formal tools.

Sixteen cores were recorded during the course of the project: two on Dollar Flats, four at DM001, four at DM002, three at DM004, and two at DM005. Of these, thirteen have identified raw materials: twelve (92%) are of Dollar Mountain Chert and one (8%)

is chalcedony. Four (31%) have thermal modification. The average length, width, and thickness are 66.8 mm, 51.4 mm, 31.6 mm respectively. Five of the cores have no cortex, one has 1-25% cortex, one has 26-50% cortex, one has 51-75% cortex, and one has 76-95% cortex.

A single tested nodule was recorded. This was at DM010, the highest site, and closest to the outcrop source. It is a caramel colored variety of Dollar Mountain chert. Its length, width, and thickness are 139.7 mm, 99.1 mm, and 93.7 mm respectively. The nodule has 1-25% cortex and is heavily fractured.

Eighteen bifaces were recorded: three on Dollar Flats, six at DM001, four at DM002, a single biface at DM004, DM005, DM014, DM016, and a single isolated biface on the Wood River trail. The bifaces have been analyzed based on production stage as outlined by Andrefsky (1998:181); two were assigned to the edged biface (BF2) category, four were assigned to the thinned biface category (BF3), five to the preform category (BF4), and a single biface to finished biface category (BF5). The remaining six bifaces were not assigned to a production stage. The average length, width, and thickness are 42.7 mm, 27.2 mm, and 12 mm respectively. None of the bifaces have cortex. Seven (39%) are of Dollar Mountain Chert, two (11%) unidentified chert, two (11%) unidentified chalcedony, one (6%) Irish Rock Chert, one (6%) Madison Chert, one (6%) silicified sediment, and four (22%) had no raw material identified.

A single blade fragment of Dollar Mountain chert was recorded at DM014. Its length, width, and thickness are 81.7 mm, 16.2 mm, and 7.2 mm respectively. Blade technology has been associated with Clovis (early Paleoindian) technology (Collins

1999) but as of yet not enough information is available to claim a Clovis age site in Dollar Cirque.

As for functionally identified tool types, the sample is quite limited. This may be a function of taphonomic patterning in the surface record or perhaps a function of the activity (quarrying) taking place in Dollar Cirque. A single graver of red chert (Dollar Mountain) was recorded at DM002 (NIN 5.6.12.2004). It has a lightly retouched point on a worked flake (Figure 4.5). The graver measures 28.1 mm by 23.3 mm by 9 mm. A single caramel colored scraper of Dollar Mountain chert was recorded on DM0014. The scraper's length, width, and thickness are 40.2 mm, 47.6 mm, and 9.3 mm respectively.

Figure 4.5- Possible graver from DM002. ITEM # NIN 5.6.12.2003

Only two temporally diagnostic artifacts were recorded during the 2003 field season and are summarized in Table 4.5. A single diagnostic projectile point was recorded during the 2004 season. While the sample size is small, they have important implications for the ages of the land surfaces and the temporal range of occupation in the cirque. Projectile point chronologies used here are based on those at Mummy Cave (Husted & Edgar 2002). The first is a Late Archaic projectile point that was found at DM006 (Figure 4.6 Item # HTH 5.6.12.2003). It is made of grey quartzite and is 29.2 mm long, 23.3 mm wide and 4.5 mm thick with a notch depth of 9.5 mm. The second is an Early Archaic projectile point that was found at DM001 (Figure 4.6 LCT 5.6.18.2003).

This point is made of a grey chert and is 29.5 mm long, 25.6 mm wide, and 5 mm thick (Figure 4.6). Neither point is made of Dollar Mountain Chert. This is potentially significant as it shows the discard of worn, non local tools, implying that they were replaced by tools made of Dollar Mountain material in prehistoric tool kits. The projectile point found in 2004 is probably Late Archaic and was found at DM007 (Figure 4.6 WTR 16.6.24.2004). This point is also made of non local raw material, a white chert. The point is 31 mm long, 20 mm wide, and 4 mm thick. As with the points recorded in the 2003 season, this point implies the discard of worn tools for replacement.

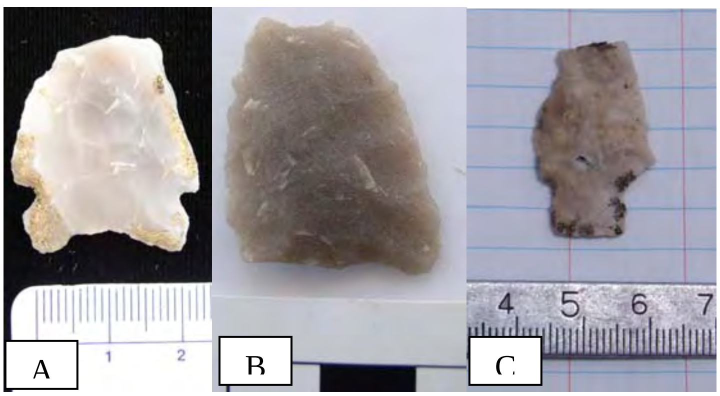


Figure 4.6- Projectile points from Dollar Cirque. A) is an Early Archaic from DM001, B) is a Late Archaic from DM006, and C) is a Late Archaic from DM007. ITEM #'S A) LCT 5.6.18.2003, HTH 5.6.12.2003, and C) WTR 16.6.24.2004

Table 4.5- Summary of the projectile point attributes.

Projectile Point Summary

SITE	Age	Material	Color	Max Length	Max Width
DM001	EARLY ARCHAIC	Chert	grey	29.5	25.6
DM006	LATE ARCHAIC	Quartzite	grey	29.2	23.3

SITE	Max Thickness	Axial length	Notch Depth 1	Notch Depth 2	Neck Width
DM001	5	26.4	2.8	2.6	20
DM006	4.5	N/A	9.5	N/A	N/A

SITE	Neck Height	Base Height	Base Width	Item Number
DM001	10.1	5.7	19.6	LCT 5.6.18.2003
DM006	N/A	N/A	N/A	HTH 5.6.12.2003

Debitage

The debitage recorded in the Dollar Cirque project area has been divided into two basic types; flakes, and angular debris (Figure 4.6). A flake is defined as having properties of conchoidal fracture, such as a striking platform, bulb of percussion, or visible ventral/dorsal sides (Andrefsky 1998:15). Angular debris lack conchoidal fracture properties. A total of 1,315 pieces of chipped stone debitage were documented. Measurements of debitage were conducted in two ways. If the item was a complete flake, then the length is the straight line distance between the origin of force (striking platform) and the termination (Andrefsky 1998:97). All other debitage was measured as a clast and the length is the longest distance between two points on the artifact. Widths were always taken perpendicular to the length and thickness is always the maximum thickness.

Seventy-eight (78) pieces of angular debitage and 1,237 flakes were documented (Table 4.6). Of the angular pieces recorded, only one had a retouched margin. The vast majority of this material was from the Dollar Mountain source. The second most abundant raw material was unidentified chert. The average length, width, and thickness of the angular material are 22 mm, 18.5 mm, and 6.7 mm respectively.

Of the 1,237 flakes, 150 exhibit some marginal retouch and 5 exhibit possible use. Like the angular pieces, these too are primarily Dollar Mountain chert, with no flake category with less than 80% Dollar Mountain chert. The second most abundant material was unidentified chert in the flake and utilized flake category, and chalcedony in the worked flake category. Average length, width, and thickness of the flake categories are presented in Table 4.6.

Table 4.6- Summary of raw material and average dimensions by debitage type.

Debitage Summary	**Number**	**% Dollar Mtn**	**2nd Raw Material**
Angular Debris	77	88	Chert (6%)
Worked Angular Debris	1	100	None
Flake	1082	89	Chert (4%)
Worked Flake	150	92	Chalcedony (3%)
Utilized Flake	5	80	Chert (20%)
	Average Length	**Average Width**	**Average Thickness**
Angular Debris	22.8	16.1	8.3
Worked Angular Debris	14.3	11.8	4.7
Flake	20	17	6.5
Worked Flake	20.8	15.8	4.5
Utilized Flake	23.6	18	5.1

Worked flakes and utilized flakes both exhibit edge modification. This is seen through the removal of material along the margins of a flake. This could be either a human activity, sharpening or otherwise preparing and edge for use, or through taphonomic processes removing edge material. Worked flakes are defined as having regular marginal retouch, and utilized flakes are defined as having irregular marginal retouch.

Flake portion was also documented. More complete fragments were recorded than any other portion. This is followed by flake fragments. These data are presented by flake type for all portions in Table 4.7.

Table 4.7- Summary of flake portion.

Table 4.8- Portion	Complete	Proximal	PSH	Distal	DSH	Medial	Lateral	Fragment
Flake	171	100	54	117	26	52	5	136
Worked Flake	61	8	19	29	8	11	1	9
Utilized Flake	0	0	1	0	1	0	1	2
Total	232	108	74	146	35	63	7	147

Striking platforms were also recorded (Table 4.8). These were identifiable on two-hundred and ninety (290) flakes. Their average length and width are 8.8 mm and 3.5 mm respectively. The majority of these were unprepared (268), while twenty-two showed grinding or flaking in preparation for striking.

Table 4.8- Summary of platform type.

Table 4.9- Platform	Prepared	Unprepared	Average Length	Average Width
Flake	20	204	9.2	3.8
Worked Flake	2	64	8.4	3.3
Total	22	268		

Description of cortex was conducted to study lithic reduction sequences. Cortex values were assigned in a six rank system that functions exactly like the system outlined by Andrefsky (1998:103). In this system 0 represents 0% of the dorsal surface is cortical material and 5 represents 100% of the dorsal surface is cortical material. The intervening stages are 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, and 4 = 76-100%. Ninety-two (92%) percent of the debitage have no dorsal cortex, four percent is type 1, two percent is type 2, types 3, 4, and 5 each have one percent. Across artifact types, there is a strong trend towards highly reduced material (having less cortex) and no artifact category has greater than 11% cortical stage higher than 1 (Figure 4.7).

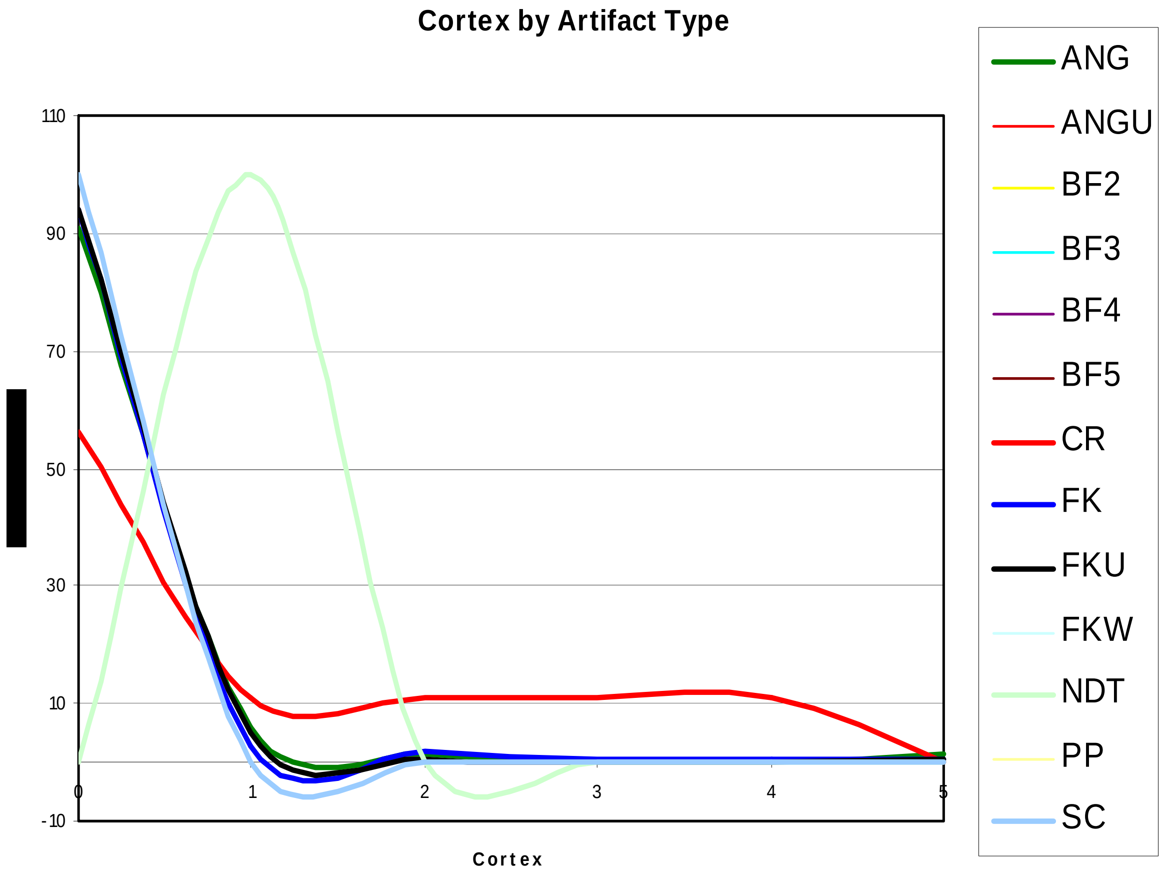


Figure 4.7- Summary of cortex by artifact element. Note the sharp decline n the amount of cortex for all tool categories.

What do these data tell us?

Basic artifact description can allow us to create hypotheses of past human behavior. Several models have been created to infer behavior from the archaeological record. Andrefsky (1994) generated a model of expected tool production based on lithic quality and lithic abundance built with samples from modern hunter/gatherer populations and archaeological assemblages. In areas of high lithic abundance and high quality one can expect formal and informal tools to be produced. In areas of high quality and low abundance one can expect primarily formal tool production. In areas of low quality one can expect primarily informal tool production. This model can be applied to the sites in

Dollar Cirque. The Dollar Mountain source represents a high quality material due to its fine-grained structure and good conchoidal fracture properties. There is abundant material in the cirque but the region has very low lithic abundance. According to Andrefsky's model one would expect the assemblage at Dollar Mountain to represent formal tool production. The low numbers of formal tools and a high ratio of flake to flake tools (utilized and worked flakes) support this. As formal tools are being produced for use elsewhere they will be leaving the area and thus are not found on site. Likewise, if the primary activity is reducing lithic raw materials or producing formal tools (as represented by unused debris) artifacts used for other activities (worked/utilized flakes) will be low.

The large amount of field data collected by the GRIZ project allows the comparison of Dollar Mountain material to material found outside of the cirque. Two comparisons that have been made are the size of debitage in the Dollar Mountain project area versus debitage size at Jack and Venus Creeks and a general comparison of biface reduction.

Debitage size has been used as a marker of intensity of lithic reduction as the size of the debitage can be a relative gauge to the size of the piece from which it was removed (Andrefsky 1998:96). As lithic debitage size decreases it can be assumed that the size of the objective piece decreases. The objective piece size will decrease in the number of reduction events that have taken place since the material was procured (Ingbar 1994), thus the size of the debitage can be used to estimate the relative intensity of lithic reduction. Table 4.9 compares the average length, width, and thickness of debitage from the Dollar Mountain source. In the general categories of all sites, the two specific Dollar

Mountain sites, and the debitage from the two watershed examples, the average size of the debitage is greater in the Dollar Mountain sample. I suggests that the objective pieces that debitage were removed from are larger in the Dollar Mountain sample, thus as the distance from the source increases the number of reduction events also increases.

Table 4.9- Average dimensions of debitage. Note the decrease in size outside of the cirque.

Average Debitage Dimensions

	Length	Width	Thickness
All Dollar Mountain	19.9	14.9	5.1
All non Dollar Mountain	15.5	11.2	3.3
DM001	19.0	15.2	4.1
DM004	21.5	15.4	6.0
All Greybull	17.5	14.0	3.7
All Jack Creek	15.2	10.8	3.2

Comparisons of bifaces show a similar pattern of lithic intensification. Twelve bifaces of Dollar Mountain chert have been recorded by the GRIZ project, six at Dollar Mountain and six outside the project area. Of the six at Dollar Mountain there are two stage 2s, three stage 3s, and one stage 4. Outside of the Dollar Mountain project area are one stage 2, two stage 4s, and three stage 5s. The bifaces of Dollar Mountain chert are in a more advanced state of reduction, or have a finer finish outside of the Dollar Mountain project area. This indicates that Dollar Mountain chert is being used more intensively as the distance from Dollar Mountain increases.

The surface archaeological record at Dollar Mountain is chipped stone. Any models of past human behavior must be drawn from this limited record of human activity. The spatially discrete geological deposits containing Dollar Mountain chert provide a fixed datum to begin studies of prehistoric raw material use. By understanding Dollar Mountain chert use close to the source, and at increasing distances from the source, ideas of human use and mobility can be gained. This knowledge, in turn, generates ideas of past human behavior. The types of prehistoric artifacts found also contribute to the interpretation of past human behavior. Notions of human use in the area, other then the collection and reduction of chipped stone must be drawn from these artifacts. Information gathered from artifactual data will be presented in the following chapter in conjunction with all of the data collected from the project in order to provide a synthesis of the archaeological and geological data with the aim of constructing conclusions of prehistoric human behavior.

Chapter Five: A Synthesis

"Archaeology is rather like a vast, fiendish jigsaw puzzle invented by the devil as an instrument of tantalizing torment, since:

a) it will never be finished
b) you don't know how many pieces are missing
c) most of them are lost forever
d) you can't cheat by looking at the picture."

Paul Bahn (1999:5)

Robert Braidwood states "There are lessons to be learned from man's past. … Many of these lessons can only be looked for in the prehistoric past" (1950:111). But we must remember that human past is not independent of the changes in the physical world. Most evidence of human occupation in North America points to a post glacial phenomenon. Climate is not divided into stable periods that switch from one state to another at each glacial division. We must acknowledge that landscapes are also not stable. We should develop a model of landscape genesis that does not treat a site as an unchanging surface, aggrading sediments. It is a dynamic interaction between physical, natural, and cultural processes. The concept of landscape taphonomy (Burger 2002) certainly applies to these processes; not all physical processes are small scale, and site specific. This chapter will provide a synthesis of data collected during this research. To return to the words of Mortimer Wheeler in the first paragraph of the first chapter, archaeology must draw on information from a variety of sources. It is through the synthesis of this information that past human behavior can be inferred. We can the return to Braidwood's goal of interpreting the lessons of prehistory, by understanding how humans have interacted with the natural world and each other, we may be able to better interpret our present interactions.

Geological Uniqueness

The sedimentary rock originating from the Dollar Mountain outcrop is the only recognized significant source of fine-grained cryptocrystalline chert for hundreds of square kilometers. Aside from the local chalcedony and the minor Irish Rock sources the nearest primary sources of chert are the Bighorn Mountains across the basin to the east and the Southern Absarokas and Owl Creek Mountains to the south. The geological forces that uplifted the sedimentary block have few parallels in North America. It is very rare to have a large block of rock uplifted by volcanic forces and not have those same forces metamorphoses the rock. The soft rock of the Absaroka Range has recorded four major episodes of glaciation in the Upper Wood River, two Pleistocene and two Holocene periods of glaciation. After the ice retreated at the end of the Pleistocene the region was occupied by humans, who had to deal with changes in climate, vegetation, landscape and how these factors affect resource distribution. This unique situation allows models to be built with large scale block of time. Once a framework has been created, the model can then be refined and more detail can be added.

Site Summary

Seventeen sites were located during the course of the field project. Of these, thirteen are prehistoric lithic scatter sites, two are historic mining sites, and two have prehistoric and historic components. The smallest site has an area of 360 m^2 (DM014) and the largest has and area of 15,800 m^2 (DM003). They range in elevation from 2,931 m to 3,381 m. Two-thousand, six-hundred and twenty-six artifacts were recorded, 60 historic artifacts and 2,566 prehistoric artifacts. Forty-three samples were used to establish a baseline set of macroscopic raw material attributes. Of the artifacts that were identified by raw material source, nearly 95% are identified with the Dollar Mountain chert source.

Geomorphology and Geoarchaeology

Geomorphic change is the biggest factor in understanding prehistoric occupation in the Upper Wood River. The dynamic glacial environment has acted to simultaneously preserve and obliterate the archaeological record, creating and modifying a landscape that has been occupied by humans since the end of Pleistocene glaciation. As was addressed in Chapter Three, geoarchaeological interpretation can be used to infer the age of the landscape. Landscape age allows us to generate models of possible occupation in Dollar Cirque. Figure 5.1 graphs the amount of time that each surface has been exposed based on Breckenridge's (1974a) identification of deposits and the revised dates suggested by Dahms (2002). This provides a rough estimate of the potential for human occupation; as the age of the surface increases the temporal potential for human occupation increases. Similar graphs could be created for sediment depth and soil development, as the surface increases in age so too does the potential for sediment depth and soil formation.

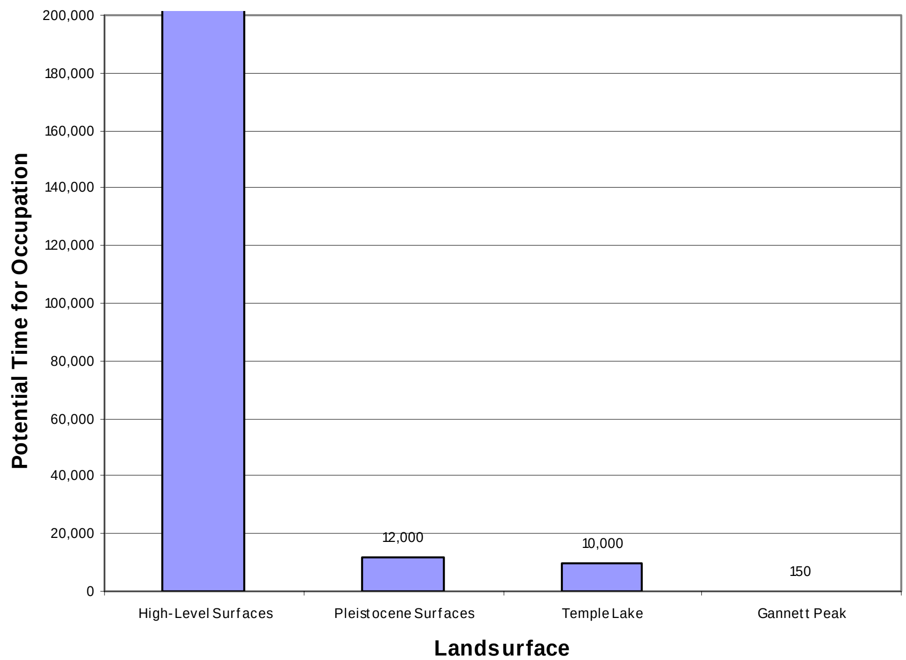


Figure 5.1- The relative chronology can provide an approximation of how much potential exists for human occupation. As depth increases so does the potential for human occupation.

This dynamic geomorphology also affects site placement and site visibility. In areas with more sediment accumulation (like Dollar Flats) the archaeology becomes more difficult to observe. Likewise, in areas with no accumulation (the protalus rampart crests) archaeological material can be incorporated into the substrate through more limited (often at the expense of original context) means such as cryoturbation, and so the archaeology is more visible. Factors governing site location, such as access to water, elevation, temperature, vantage point, access to raw materials and game, have changed through time. By understanding these variable have changed, better past human behavior patterns can be inferred.

The potential exists for human occupation predating the Altithermal (approximately 8,000 years ago). Dollar Flats has a surface age of approximately 12,000 years BP. It also appears that the Temple Lake protalus rampart has advanced over part of

DM014. If this is the case it produces a relative date of 12,000 to 10,000 years BP. This same context allows Neoglacial processes to wiping the record clean. Prehistoric materials in an area that has been subjected to Neoglacial advance will be destroyed or covered with the new material. DM014 also looks different archaeologically, with a blade fragment and the only scraper found in the project area. In addition to the DM014 example, this also appears to be happening at DM005, but with a Gannett Peak deposit covering the prehistoric material on a Temple Lake surface.

Site Function and Arguments for Quarrying

Artifact data suggest that the Dollar Mountain sites may indicate quarrying or lithic reduction activities. Often the lack of formal tools and the high ratio of debitage to tools suggest that the activities taking place do not require the use and discard of chipped stone tools. Multiple models for human behavior exist based on the presence of formal tools (Binford 1979; Binford & Binford 1969; Kelly & Todd 1988), but the lack of formal tools is more difficult to explain. The production of tools or the reduction of raw material for transport can be explained by the data from the Dollar Mountain project area. Andrefsky (1994) suggests that in an area of high quality raw material formal and informal (flake tool) production can be expected. If the formal tools are leaving the system through mobility and informal tools are not being produced then the logical model of human behavior is tool production, retooling, or raw material quarrying. Evidence for non-quarrying site function is limited to the 2 projectile points, 1 scraper, 1 graver and 150 retouched flakes. This may indicate a kill (from the discarded broken projectile points), butchering (from the flake tools) or retooling event (from the discard of tools and debitage indicating toolkit replenishment). The discarded projectile points are made of non-Dollar Mountain material, and would be difficult to re-sharpen into usable tools due to their small size. This is a solid indication of discard of artifacts and retooling.

A Regional Comparison

Only seven other sites have been reported for the Upper Wood River. Of the five sites that Breckenridge (1974a) identified four are open lithic scatters and one is a hunting blind. These date to the Late Prehistoric (with a possible Late Archaic component in the Meadow Creek Cirque) except the Cascade Creek site that Breckenridge dates to the Early Archaic. Field work in 2004 in Meadow Creek Cirque identified possible early, middle, and late archaic, as well as late prehistoric components. This corresponds to the range of temporal occupation found in Dollar Cirque. Two of Breckenridge's sites are in high cirque basins and may mirror the prehistoric occupations at Dollar Cirque. The site types and artifact assemblage are similar to those in the Dollar Cirque project area, except that Breckenridge found more projectile points. Perhaps this is a function of less quarrying or lithic reduction and more hunting adaptations. The two sites that Frison reports (Wyoming state site forms 49PA49 [2250 masl] and 49PA87 [2360 masl]) are lithic and bone scatters along Deer Creek. These are different from the occupation reported by Breckenridge and the sites recorded at the head of the Wood River.

Comparisons can be drawn to other areas in the GRIZ project (Burnett et al. 2003; 2004; Reitze et al. 2003; Reitze and Todd 2004; Todd et al. 2003). When Dollar Cirque is compared to the sample recorded in the Greybull River, several distinct differences can be seen. The Greybull River sample contains some dense and extensive lithic landscapes, extending for square kilometers, with a much higher density of projectile points. There is also a better representation of continuous occupation than in Dollar Cirque. This is perhaps due to a greater number of projectile points creating a better temporal chronology. There is also a significantly smaller percentage of Dollar Mountain chert than in the Upper Wood River. Samples recorded in Jack Creek are similar to the Greybull. Jack Creek has large dense palimpsest sites with numerous projectile points and a greater temporal range of occupation. Jack Creek has more obsidian than Greybull (6% of the assemblage compared to Greybull's 2.9%, no obsidian was recorded in the Dollar Mountain project area). Exotic material, such as obsidian, may indicate patterns or distances of mobility. This implies a different pattern than what is suggested from the Dollar Mountain sample. The Dollar Mountain sample also appears to have more burning then the Jack Creek or Greybull materials.

The archaeology of the upper reaches of the river valleys can also be compared to the middle reaches. These regions have been impacted by modern agriculture and grazing and thus little archaeology remains on the vast terraces of the Middle Greybull and Lower Wood Rivers (Burnett et al. 2003). It is possible that the bluffs above the rivers contain archaeological material, but not enough data have been collected to show this.

The next step is to compare Dollar Mountain to other high altitude sites (Stiger 2001). The most prolific high altitude archaeologist, James Benedict, has four sites that are easily compared. At the Fourth of July Valley site (3,415 masl) 1,425 chipped stone artifacts were recovered along with radiocarbon dates of 5880 and 6045 years bp. The Ptarmigan site (3,460 masl) has an average date of 6380 years BP, with 1,427 artifacts were recorded. Arapaho Pass (~3,350 masl) has 2,214 pieces of chipped stone, 5 ground stone, 416 pieces of pottery, an inferred structure and an age range of 8460 to 765 years BP. The Coney Creek Valley site (3,160 masl) has 3,042 chipped stone artifacts, and an age range of 5710 to 1200 years BP. The Vail Pass site (3,224 masl) (Gooding 1981) has date ranges of 7,310 to 190 radiocarbon years bp but most cluster around 3,000 years BP. How do these data compare to Dollar Mountain? In artifact numbers Dollar Mountain is lower than most, but no subsurface testing was done and only partial surface documentation was conducted at Dollar Mountain. The time periods of the other high altitude sites are well within the range of Dollar Mountain, but Dollar Mountain does not have any identified occupations at later dates.

Dollar Mountain chert is being transported out of the upper reaches of the Wood River. No secondary deposits of the material exist in the Upper Greybull but the material is not uncommon. It appears that the average size of debitage decreases outside of the Upper Wood River indicating a series of lithic reduction events since the material was procured. This is an important consideration for prehistoric mobility. As current models are based on the limited availability of useable tool stone in the Absaroka Mountains, the discovery of Dollar Mountain chert forces us to reconsider how human mobility between the Bighorn Basin and neighboring ranges are constructed. Previous models (Craig 1983; Francis 1983; Frison 1991) have concentrated on all lithic material that originates in the Bighorn Mountains, Yellowstone Plateau, or from the Basin quartzites. This must be modified to account for potential movement into the Absaroka Range to procure lithic materials. The procurement of lithics is an immensely important aspect of prehistoric adaptation. Subsistence would be difficult if not impossible without a source of quality tool stone for the production of hunting and butchering tools.

Conclusion

This study has generated four solid conclusions:

- There *is* high altitude occupation of the Absaroka Mountains
- Dollar Mountain chert was utilized by Prehistoric peoples

- Dollar Cirque provides an opportunity to explore dynamic geoarchaeological processes
- Understanding the age of the landscape is vital to understand prehistoric occupation on it

The Dollar Mountain sites are the highest elevation of reported prehistoric sites of the Absaroka Range and among the highest in Wyoming. There is no doubt of the existence of the previously unreported chert source at Dollar Mountain. There is also no doubt that this material was used by prehistoric people in the production of chipped stone tools. The long history of human occupation and the dynamic nature of the geomorphology in the Upper Wood River provide a unique opportunity to understand landscape use, site formation, and landscape taphonomy.

Chapter Six: Future Directions

"Ancient traditions, when tested by the severe process of modern investigation, commonly enough fade away into mere dreams: but it is singular how often the dream turns out to have been a half-waking one, presaging a reality."

Thomas Huxley (1904:1)

The work done in Dollar Cirque is a pilot study. The portion of the cirque floor that was surveyed only represents a fraction of the Upper Wood River, and an even smaller fraction of the Greybull watershed. When added to the other archaeological work done in the watershed, it is clear much remains to be learned about prehistoric use of the Greybull watershed system. In addition to the seventeen sites identified during the summer field work in 2003, Roy Breckenridge recorded four others, and George Frison recorded two sites above the confluence of the Wood River with the Middle Fork of the Wood River (also note that in the 2004 field season eight additional sites were recorded on the Upper Wood River, two in Horse Creek cirque, and fifteen in Meadow Creek Cirque). The entire area of Dollar Cirque is approximately 3 km^2, most of which was not tested by the project. The Wood River above its confluence with the Middle Fork of the Wood River has an area of approximately 140 km^2. Two percent of the watershed above the Middle Fork has been surveyed for prehistoric sites, and the site density reflects this.

The entire Wood River watershed is approximately 570 km^2, which again has received little archaeological attention. The field work in the 2003 and 2004 seasons provides a good preliminary investigation but more work remains to be done.

It was the intention of this thesis to show the utility of coupling geomorphic research with archaeological analysis. While geology has always been a part of archaeological investigation, it rarely extends beyond site specific analysis. I believe to understand the dynamics of human landscape use we must understand how the ground has and is continuing to change under our feet. Lewis Binford has called for the use of multiple data sets in the interpretation of past human behavior (Binford 2001). But Binford doesn't address the changes in climate, much less the physical changes in landscape. Archaeology has always been an interdisciplinary science, incorporating knowledge from outside traditional anthropological data sets. To truly interpret human behaviors and understand the processes that drive the creation of archaeological sites, we must use geological data to understand the broader landscape formation in concordance with a narrow focus observing specific micro-processes that modify the archaeological record.

Coupled models should be constructed that incorporate climate, vegetation, geology, geomorphology, and archaeology in both the present and the past. To understand the creation of present landscapes, an understanding of the past landscape is necessary. A research strategy that links these ideas in the present is essential to understand the system dynamics between them. If a model of present interaction is created, it becomes possible to project that model into the past. Archaeological research is only a single component of interpreting past human behavior. The focus of archaeology has shifted from a purely descriptive endeavor to a science that seeks to explain past human behavior. The explanation of behavior cannot be independent of the variables, problems, and environments that are compelling or constraining these behaviors. If archaeology is a science that relies on the importance of context in understanding the material record from the past, it to must interpret human behavior within the context in which it was expressed.

This thesis provides suggestions for the enhancement of survey strategy. It is not uncommon for archaeologists to stratify survey by factors such as ground surface or slope steepness (Banning 2002), but rarely is the land surface itself considered. Banning (2002:22) discusses the idea of developing a paleolandscape model for archaeological survey. He states:

> This is a geoarchaeological approach that goes a step further [than place based survey] by using subsurface and geomorphological evidence to define a series of changing landscape surfaces, each of which has its own distribution of cultural remains (Stafford 1995). The paleolandscapes are conceived as sets of landforms, each of which has a particular probability of having cultural material (Banning 2002:22).

I feel that this is an important consideration for developing a survey strategy. If time or monetary constraints force the limitation of surveying for prehistoric material, why not limit it in a fashion that merely excludes land surfaces too young to contain past cultural material? For example, in Dollar Cirque, greater than 60% of the land surface is between 300 and 100 years old. But while Banning's (2002:22) paleolandscape model separates surface deposits of archaeological material from potential subsurface deposits, "this…does not involve the assumption that remains on the modern surface have any predictable relationship with buried remains." I think that subsurface testing in Dollar

Cirque has the potential to link temporally diagnostic surface material to subsurface deposits.

The identification of a high quality source of fine grained cherts has the potential to rework ideas of prehistoric mobility in the Bighorn Basin. The lithic sources of the Bighorn Mountains have received extensive study and interpretation (Francis 1983). The movement of toolstone into the basin has always been seen as a movement west from the Bighorn Mountains (Francis 1983; Frison & Wilson 1975). The former lack of lithic sources in the western Absarokas seems to support this hypothesis, but the addition of the Dollar Mountain source has added a new range of mobility possibilities. In the Greybull River (above its confluence with the Wood) Dollar Mountain material was located and identified. But the amounts and uses of material has yet to be ascertained. In the course of this research I have encountered several other possible sources of chipped stone of which little is known. Breckenridge (1974a:40) reports a possible source of obsidian to the southwest, and sources of local jaspers, in addition to secondary metamorphic rocks, silicified sediments, and unreported local chert (Irish Rock chert) that were encountered throughout the field session. None of these possible sources have been studied or otherwise reported.

The presence of the Dollar Mountain lithic source and its quarrying activities has been identified, but the relation of this activity to any other human activity has yet to be documented. How these lithic scatter sites relate to human subsistence activities needs to be tested. The potential exists for preserved non-lithic materials in subsurface contexts at several of the sites, but this requires excavation to test for intact deposits. Also subsurface testing may uncover more tools and debitage to make a better assessment of prehistoric human behavior. Detailed studies are required to link the Dollar Cirque sites with the other prehistoric sites in the Wood River (Breckenridge's lithic sites and Frison's lithic scatter and hearth/bone site), as well as linking it to the expanding body of archaeological research in the Upper Greybull.

The lithic data collected during the field study require additional documentation and analysis. The work conducted in this work is very simplistic, basically documenting the presence of the assemblage. Typological categories were constructed for the tools and many different attributes of flake morphology were collected, but little of the collected field data were used in this analysis, due to the narrow scope of this project. Andrefsky (1998, 2001) provides many directions and possibilities for lithic analysis. The assemblage has the potential to trace reduction sequences, refit sequences (with additional fieldwork or collection), scar count or flake size versus distances from source, or many other simple reconstructive models, all of which would create a much better idea of past human behavior.

An interesting aspect of the Dollar Mountain assemblage is the degree of heat modification found with the raw materials. While the reasons for this have been speculated on in the previous chapter (heating materials to improve workability, burning of material), a great deal of potential data could be collected to directly address this question. Raw material samples could be collected and heated to look for direct signs of modification instead of the implied ones used in the field analysis. This would provide a baseline of data to compare the lithic assemblage with, thus providing a stronger case for human modification of the raw material (Collins & Fenwick 1974; Purdey & Brooks 1971). While additional lithic analysis has been outside of the scope of this research, the potential is there and hopefully this lithic assemblage will receive the attention that it deserves.

This region has the potential to construct detailed models of past climates and environments. The landscape formation data collected during the course of this project provides a generalized reconstruction of past climates. While the scale of the climatic events is broad, recording only glacial advance and retreat, it is a starting point to construct a better picture of climate change in the Absaroka Mountains. An extensive glacial lake existed in the Wood River at the approximate location of the Double D Ranch. This lake’s sedimentary record has the potential to provide a more specific climatic chronology. This can be augmented by varve chronologies from other small glacial lakes in the Wood River (Jojo Lake) watershed and Upper Greybull (such as the small kettle-like lakes near Jack Creek). Lake sediment deposits can provide detailed records of minor fluctuations of climate, and trap pollen and datable materials in a potentially easily identifiable chronological sequence.

In the spirit of multiple data sets, climate reconstructions based on sedimentary records can be augmented by vegetation data. The movement of the treeline can be documented through the presence of relic tree stands, or stumps and dead trees above the present treeline. On DM001, 173 m above the present treeline, we documented two recently dead (still having brown needles attached), stunted pine trees representing a shift in timberline. The highly dynamic nature of the geomorphology has undoubtedly trapped vegetation in alluvial, fluvial and colluvial deposits. These organic remains can be dated, through radiometric means, and can provide a direct age and snapshot of the environment that the plant or tree grew in.

Human impact is increasing in the Upper Wood River. Before the mining activities at Kirwin the area had received little impact, even the Kirwin impact was highly localized. After the Upper Wood River was closed by AMAX it had a chance to recover somewhat, but now that the area has been opened by the Forest Service, more people are visiting the Upper Wood River. This affects the environment and the archaeology. More individuals are using wilderness areas, and recreational impact is intensifying (Cole 1996). As impact increases the archaeology will be lost or damaged. Baseline archaeological and environmental data sets are needed to assess the impacts of increased human activity (Wing 1998). As the use of the area shifts from light animal grazing to human recreational use, the system will begin to change. Over time these small changes may add up to a threshold that, if crossed, will cause massive environmental change (Holling 2004).

This study has the potential to generate future research questions outside of Dollar Cirque. By creating a uniform methodology of macroscopic lithic raw material analysis, better comparisons of raw material types can be created across the Northern Plains. This has the added benefit of allowing archaeologists to create methodologically concordant data sets. With defined traits, lithic analysis can be conducted by a variety of peoples with similar results, instead of relying on comparative collections and knowledge of experts. The Upper Wood River (above the confluence with the Middle Fork) has over a dozen cirques, only two has been formally surveyed for archaeological material, and yet Breckenridge’s (1974a) informal survey found prehistoric material has been found in three of them. Archaeological material is undoubtedly present in many of these cirques. This represents only a tiny fraction of the Greybull watershed. The stable, high-altitude, surfaces have received no archaeological investigation, but have a high potential for game drive systems like those found elsewhere in the Absaroka Range (Frison 1991) and throughout the Front Range and Rocky Mountains (Benedict 1985; Cassells 2000; Hutchinson 1990). These surfaces should be studied, and the relationship between archaeological material found at this elevation and archaeological material found in the valley should be investigated.

Yellow Creek Model

Finally, building a research strategy that takes landscape into account in a glacial/periglacial environment is easily expanded into the neighboring watersheds. As an incentive to continue research in alpine geoarchaeology and show the potential of GIS analysis of geomorphic deposits, I have generated a map of potential landforms as distinguished from 1:24,000 aerial photos (1994 DODQ available from http://wgiac2.state.wy.us/) of two small drainages immediately north: the terminal Greybull River and Yellow Creek (Figure 6.1). From the aerial photo it is possible to identify three different geomorphic features. The first are protalus ramparts. These have a rough hilly appearance and do not match the rest of the terrain. The 'fresh' and un-eroded appearance of the protalus may indicate a relatively new surface, possibly corresponding to the Gannett Peak Neoglacial advance. Also identifiable are alluvial cones. These are diagnostic cone shaped formations flowing out of side drainages. These are also probably relatively new features. Finally there are stream gravels and alluvial accumulation. Of course, field checking is required to verify this analysis but if accurate it would be possible to begin to study surface ages in other watersheds and in areas where the Quaternary geology has not been examined and identified. Knowledge of landscape age can allow archaeological survey to be stratified to target surfaces with the greatest potential.

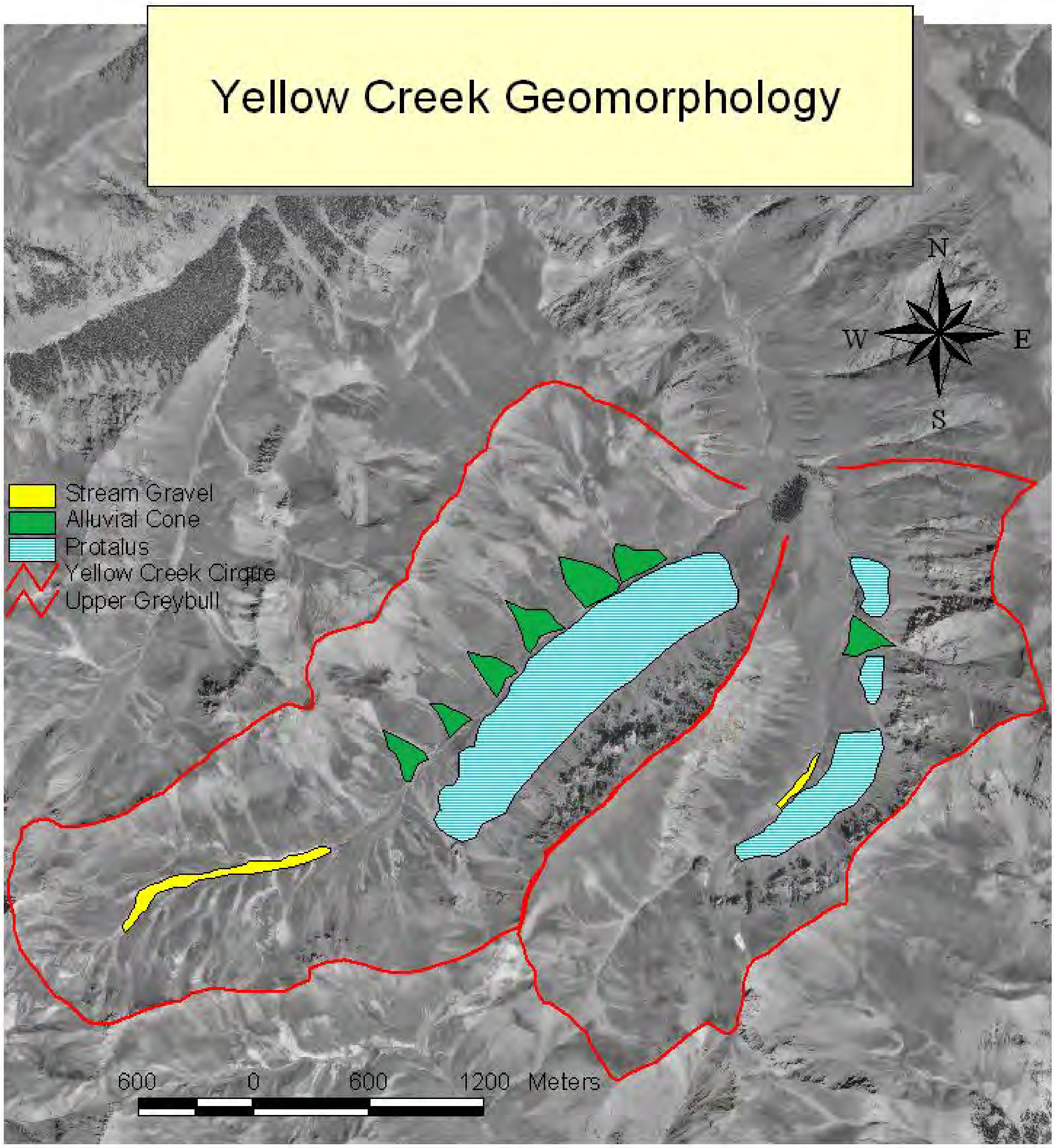


Figure 6.1- GIS model of the potential landscape ages of a neighboring watershed, Yellow Creek, which lies to the north of the project area. It is likely that glacial formation and processes at identical to those operating in Dollar Cirque.

Incorporating geological analysis into archaeological interpretation is not a new concept. As discussed by Holliday (2001) and Haynes (1990), geological data has formed a cornerstone of archaeological interpretation. Historically the question of the antiquity of humanity has been a geological one and humanity's antiquity was established by geologists working with geological and paleontological data. The use of geology then became a way to establish archaeological context. The relationship of the material remains of past human cultures with their surroundings and understanding changes that have taken place since their deposition form this contextual basis. Taphonomy in archaeological analysis (Burger 2002) should be expanded to the creation of the landscapes that are used by prehistoric humans. As the concept of treating landscapes as a unit of archaeological analysis (Butzer 1980; Steward 1977; Willey 1953) is vital to understand past human behavior patterns. The complex relationship between the dynamic natural landscape and human behavior can be explored through the generation of models predicting the changing interaction of these two variables. Understanding the age and formation of a landscape and potential for human use of that surface can be expanded to a common form of analysis applicable in any archaeological context and temporal period.

This research has accomplished three goals. First it has begun to fill in a blank spot on the map of Northern Plains archaeology. During the Archaic period humans were at high altitudes in the cirque basins of the Absaroka Mountains. The potential exists for other high altitude occupations in other ranges and at different times. This work has identified some areas which could be targeted to search for evidence earlier occupation (i.e. Paleoindian). The second goal of this research is to highlight the importance of understanding the geomorphic and geologic processes that alter the archaeological record. While the scope of this research has been limited primarily to glacial and periglacial processes, understanding of landscape again is vital to interpret past human land use and landscape taphonomic processes. The final goal accomplished by this research has been to highlight the importance of a landscape based perspective. Interpreting past human behavior is more than a catalog of the remains of material culture; it involves modeling the intricate interaction of humans and their environment. To return to the Thomas Huxley quote that begins this chapter; as modern investigation solidifies our awareness of the past then perhaps this appreciation can be used to understand our interactions with the environment and prepare for the inevitability of change.

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Appendix One
The Historic Occupation of Dollar Cirque

by

Andrew Mueller and William Thomas Reitze

The historic occupation recorded within the project area is manifested in two forms. First, the bulk of the historic occupation is related to mineral exploitation. Second is an ephemeral camp on a small hill above the Wood River. The Wood River region provided sources of raw material in the prehistoric (chipped stone) and historic periods (mineral exploration), and until recently fodder for grazing animals.

The mining use of the area is probably associated with the ghost town of Kirwin. Gold, silver, and galena were targeted at the Kirwin mineralized area. While the district never gained production status and was never profitable, mining was attempted from 1898 through about 1907 when most of the town was destroyed by a snow slide. Extensive activity took place between 1904 and 1907 (Chapman 1917). The majority of the mining activity at Kirwin was conducted by the Galena Ridge Mining Company and the Shoshone Mountain Mining Company (Chapman 1917). It is interesting to note that the mining claims in the Dollar Mountain project area were filed by the Shoshone Mountain Mining Company after the abandonment of Kirwin.

DM011

DM011 is a cabin and dug-out at the head of the Wood River. The cabin is oriented to the cardinal directions. The highest surviving wall (west) is four courses high. Logs vary from ~15 cm to ~30 cm in diameter. No evidence of a doorway exists in the north, west, or east walls. The door was probably in the south wall, which has been largely obliterated by a fallen tree. Corners exhibit simple “V” notching style. The cabin interior has accumulated a substantial amount of alluvial sediment (~10-20 cm). Some of this may have originally been fill to smooth the gravel/cobble bar upon which the cabin was constructed. Some pieces of milled lumber exist within the structure, but are mostly buried under the alluvium. It appears that water may pool in the structure during high-water periods. Evidence of roofing material is limited to small portions of sheet metal located around the cabin. The artifact scatter around the cabin is generally located down-stream (east) consisting largely of unidentified metal fragments and one porcelain cup fragment. A cluster of cans exists to the northwest of the cabin along the stream edge and may indicate a possible dump area.

Also included in the DM011 site boundaries are a dug-out located on the steep hill slope lying to the north of the cabin across a branch of the Wood River. The dug-out is located on the southwest aspect of the hill and appears to have originally been approximately 3 m by 3 m and of an unknown depth. The dug-out has undergone significant slumping. Current depth varies from 80 cm on the uphill side to 20 cm on the downhill side. A large deadfall lies across the center of the pit with a second, later deadfall along the southern margin. One possible burned post was located on the northern (uphill) side of the pit. Other artifacts within the structure are limited to one can and one possible lard bucket. The feature could alternatively be a shallow prospect pit, though the location lacks rock outcrops demonstrating signs of mineralization.

Table A1.1- Artifact summary of historic material from DM011

Artifact Summary DM011	
Number	Artifact
1	Hole-in-cap can, crimped seam
1	Crimped seam, 4.25" tall, crushed
1	Iron lid
1	corrugated metal in east wall of cabin
1	cap from hole-in-cap can 1 3/4" dia
1	portion of tobacco tin lid
1	9 d wire nail
1	porcelain cup fragment
1	sanitary can. Church-key opened, 2 5/8" dia
1	sanitary can, cut-around opening 2 5/8" dia
1	sanitary can, badly deformed. 4" x 4 3/4"
1	sanitary can, fragmentary. 3 1/4" diameter ~4" tall
1	Hole-in-cap lid 3 1/4" dia, cap 1 1/2" dia.
1	can in dugout, lapped seam. Fragmentary
1	small pail 6 1/4" tall, 6" dia top, 5 1/8" dia bottom, wire handle
1	hole-in-cap can 4" dia, 4 5/8" tall, cap 2 5/8" dia
1	condensed milk can 3 1/4" tall x 3" dia, cap 1/2"
1	sanitary can. 4 1/4" x 3 1/4"
7	Fragments and unidentified cans
8	Unidentified metal fragments

The cabin itself is located on a very slight terrace/large bar in the Upper Wood River floodplain. The terrace consists of large cobbles to small gravels and is covered with abundant grasses and low forbs. The majority of the artifacts associated with the cabin have probably been removed by water action (Table A1.1). The majority of the remaining artifacts are located within or immediately downstream of the cabin. The site datum is an aluminum tag labeled “111” set on a small rock outcropping to the south of the cabin. The dugout is located immediately adjacent to a modern trail. The final feature consists of two possible doors removed from the cabin and transported to a modern fire pit adjacent to an unnamed stream just above its confluence with the Wood River.

This site is on the Plat of the Upper Lode mining claim (Figure A1.1). The claim was filed by the Shoshone Mining Company on August 12, 1908 (records on file at the General Land Office). This provides a good date of site activity.

DM013

DM013 is a mine adit south of the Wood River. The adit is dug into the hillside immediately above the flood plain of the Wood River. The northeast facing slope is covered by numerous young and old pine trees and the area is deeply covered by forest litter. The adit possesses collapsing lagging along the walls and remnants of roofing. Lagging is constructed of 1” by 10” and 1” by 5” boards. All hardware appears to be wire nails and a few screws. One vertical post at the adit entrance bears the initials “MC” and “JES.” Lagging is roughly shaped, probably by ax and disappears into the slumped soils spilling from the surface. The first 6.5 m of the adit are open to the sky. Total length is unknown as the end portion has slumped/collapsed and was filled with abundant organic debris and snow. A steady stream of water emanates from the adit forming a swampy area on the small waste-rock pile. The waste rock pile forms a small bench 3 m by 15 m directly in front of the adit. The water drains from this bench into numerous small

Table A1. 2- Summary of historic artifacts from DM013

Artifact Summary for DM013	
Artifact	**Date**
solder-dot can 2 7/8" dia, 4 1/2" tall. Crimped seam	post 1869, pre 1922
fragmentary metal box. 19" x 13" x ?	unknown
Two fragments of lid with hand-made holes	unknown
crimped seam can	unknown
Fragmentary can	unknown
unidentified can 3 1/4" dia. Crimped seam	unknown
Unidentified metal	unknown
unidentified metal	unknown
Unidentified metal	unknown
solder-dot can lid fragment	unknown

channels emptying into the Wood River. Numerous pieces of unidentified metal protrude from the moss and needle detritus on the waste rock. Additional artifacts are scattered for several meters onto the gravel bar. Unknown quantities of artifacts were probably swept away by fluvial action. Waste rock was piled along the edges of the adit and forms the bench. The amount of waste rock doesn’t indicate a long tunnel, but it is hard to tell how deep the adit went. The rock does show that blasting was utilized for digging. A piece of sheet metal and part of an attached pipe near the entrance may indicate some form of ventilation system. Close examination of the adit was impossible due to both the unstable nature of the feature and the large amount of snow and debris that were still present within it.

Only a single temporally diagnostic artifact was recorded (Table A1.2). This artifact dates post 1896 and pre 1922. The adit appears on the Plat of the mining claim of the Black Pine Lode (Figure A1.1). This claim was filed by the Shoshone Mining Company on August 12, 1908 (records on file at General Land Office). This provides an exact date of the mining activity.

DM015

DM015 is a scatter of historic artifacts on a small knob above the Wood River at 3140 masl. The site is in a clearing at timberline and is covered with grasses and low forbs and the surrounding forests are spruce/pine. Eight artifacts were recorded. One can lid, one bottle cap, some unidentified metal, a crockery fragment, one complete jar, and two shell casings (Table A1.3). The occupation probably relates to a temporary camp, dating to the early to mid 1940's.

Table A1.3- Summary of historic artifacts from DM015

Artifact Summary DM015		
Artifact	Portion	Date
Can	Lid	Unknown
Jar	Complete	1943
Metal	fragments	Unknown
Shell Casing	25-20 W.R.A. CO	pre 1940
Bottle	neck	Unknown
Crockery	fragment	Unknown
Bottle	cap	Unknown
Shell Casing	REM - UMC 25-35	post 1911

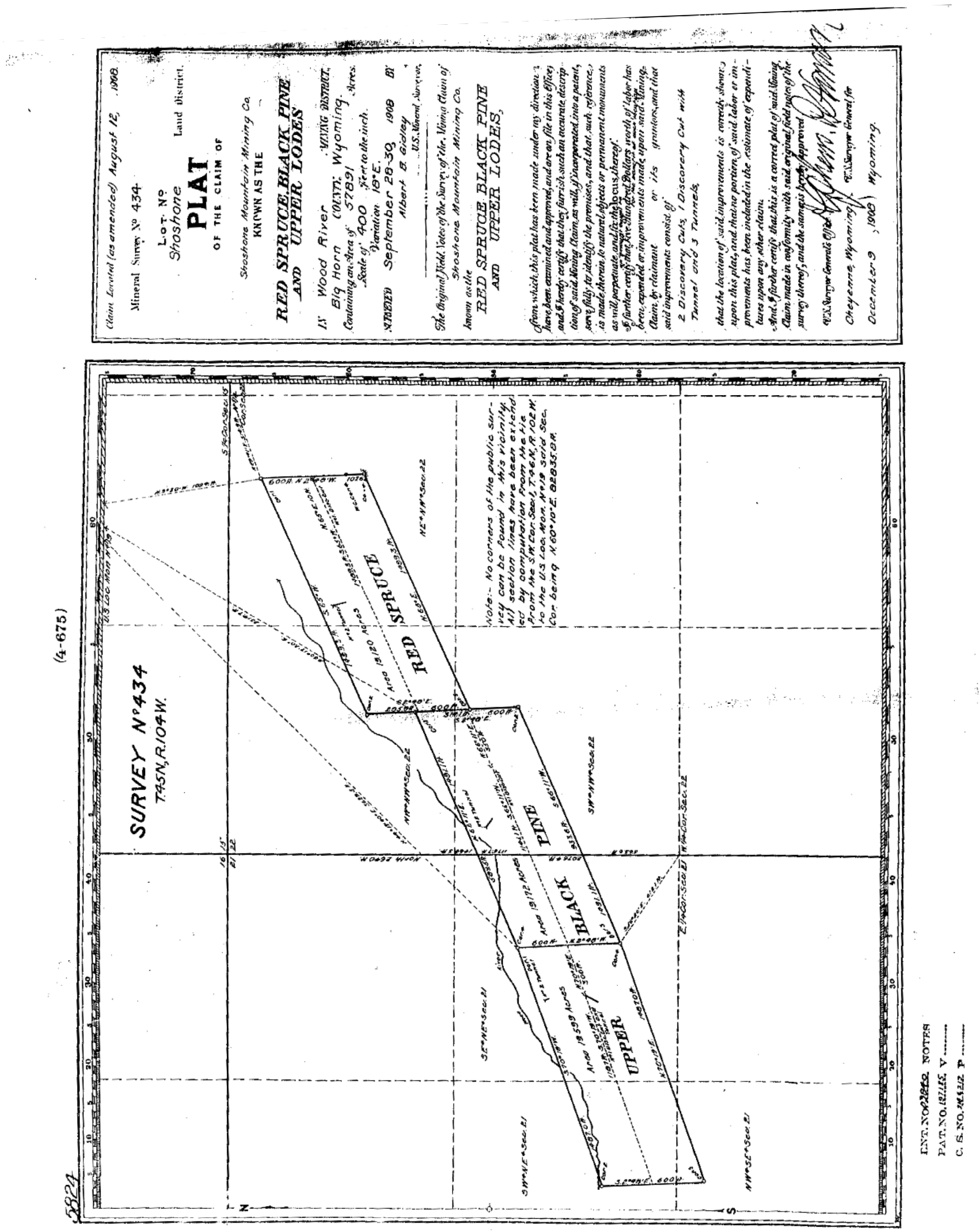

Figure A1.1- Plat of mining claims in the Upper Wood River. Site DM011 is on the Upper claim and DM013 is on the Black Pine claim. General Land Office mining Plat of Red Spruce, Black Pine, and Upper Loads.

Appendix Two
Soil Depth Data

By

James Cale

Appendix 2- Collected Soil Depth Data

SITE	#	MAX DEPTH (cm)	PIECES OF BEDROCK	BEDROCK SIZES (OVER 3cm)	% Visible Ground	COMMENTS
DM002	4	29.4	27	4		RODENT MOUND
	5	OVER 46.1	56	ALL UNDER 3cm		RODENT MOUND
	6	33.6	44	6, REST UNDER 3		RODENT MOUND
	7	30.4	39	4, 4.5, 3.1		GRASS AREA
	8	18.7	7	ALL UNDER 3cm		GRASS AREA
	9	15.8	4	8.2		GRASS AREA
	10	18.9	11	ALL UNDER 3cm		GRASS AREA
	11	18.1	6	5.1		GRASS AREA
	12	17.6	30	ALL UNDER 3cm		PATCHY GRASS, LOOKS SLIGHTLY ERODED
	13	38.4	56	9, 3.2, 4.2, 3.2, 3.3		EDGE OF RODENT MOUND, SOME GRASS
	14	OVER 46.1	78	3.8, 3.6, 3.1, 3, 4.5		RODENT MOUND
DM005	72	12.3	OVER 100	.9, 3.4, 5.9, 5, 4.5,	90	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS
	73	15.2	OVER 100	5, 3.9, 4.9, 6.6, 7.2	90	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS, SOME LICHENS
	74	14.1	OVER 100	6, 6.2, 4.5, 7.9, 8.5	95	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS, SOME LICHENS
	74	12.8	OVER 100	5.5, 3.9, 5.9, 6.7, 4	95	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS, SOME LICHENS
	76	14.9	OVER 100	2, 4.5, 3.6, 4.2, 3.9	95	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS, SOME LICHENS
	77	14.5	OVER 100	1, 8.5, 5.7, 5.9, 6.1	95	GLACIAL MORAINE DEPOSIT AREA, MOST ROCKS PEA-SIZED OR SMALLER, SMALL PATCHES OF GRASS, SOME LICHENS
	78	17.9	OVER 100	3.5, 6.9, 4.5, 3.2	55	GLACIAL MORAINE AREA WITH GRASS
	79	17.5	OVER 100	4.6	45	GRASSIER THAN RP 078 BUT SAME AREA
	80	13.5	OVER 100	3.3, 8.4, 5.5, 5.2, 5	95	ROCKIER THAN RP 079 & 078
	81	32.9	75		33	GRASSY AND APPEARS TO BE SOME RODENT ACTIVITY AND HEAVY EROSION
	82	37.4	7	ALL UNDER 3cm	5	VERY GRASSY MIGHT EXPLAIN WHY SOIL IS SO THICK, ALSO BETWEEN 2 SOMEWHAT ROCKY SMALL HILLS

Appendix Three

Code Explanations

Column Heading	Description
Em.000	east NAD83/WGS84 rounded to nearest meter
Nm.000	see Em.000
EAST83	with decimals - raw data
NORTH83	with decimals - raw data
INI	GPS initials from PDA file
NAME	GPS waypoint name from PDA file
DATE	waypoint date
SITE	site or modified-whittaker name
SURVEY	sampling method
GPS INI	gps initials from the gps file
GPS NAME	GPS name from GPS file
DWNLD DATE	download date
ELEVATION	elevation (m)
DATUM	UTM datum
GPS COMMENTS	comments entered into GPS
CON	context
CL	artifact class
EL	artifact element
POR	artifact portion
MAT	artifact material type
CLR1	color 1 and opacity
CLR2	color 2 and opacity
INCL	inclusions color and opacity
HT	heat modifications
PTY	platform type
C/T	clast or technological measurements?
MLEN	max. length (mm)
MWID	max. width (mm)
MTHK	max. thickness (mm)
PTW	platform width (mm)
PTT	platform thickness (mm)
CTX	cortex values
COMMENTS	additional artifact comments
PHOTO1	photo log number
PHOTO2	photo log number
PHOTO3	photo log number
AXLEN	axial length (projectile points only)
BLL1	blade length (pps only)
BLL2	blade length (pps only)
ND1	notch depth (pps only)
ND2	notch depth (pps only)
ND3	notch depth (pps only)
NW	neck/haft width (pps only)
NH	neck/haft height (pps only)
BH	base height (pps only)
BW	base width (pps only)
MATS	arbitrary material type number (rarely used)
INI	initials
TIME	time period

Appendix 3 Table 2- Code Explanations

Column Heading	Description	Codes	Description
CON	**MICRO-SCALE ARTIFACT CONTEXT**	ERD	ERODED SURFACE
		PRG	PRAIRIE GRASSLAND (OR SURROUNDED BY (TOUCHING) PLANTS)
		RBB	RODENT BURROW BACKDIRT PILE
		RK	ROCK
		SDP	SEDIMENT PATCH (BARE GROUND)
		TREES	TREES
		US	UNSPECIFIED
CL	**ARTIFACT CLASS**	CS	CHIPPED STONE
		HS	HISTORIC
		N	NONE
		OT	OTHER (SEE COMMENTS)
		RK	ROCK
		UD	UNIDENTIFIED DIMINUTIVE FAUNA
		UL	UNIDENTIFIED LARGE UNGULATE
		UN	UNIDENTIFIED FAUNA
		US	UNSPECIFIED
		WOOD	WOOD
EL	**ARTIFACT ELEMENT**	ANG	ANGULAR DEBRIS
		ANGU	EDGE-DAMAGED ANG
		ANGW	WORKED ANG
		BEAD	BEAD
		BF	BIFACE
		BF2	MINIMALLY FLAKED BIFACE
		BF3	REGULARLY FLAKED, UNTHINNED BIFACE, IRREGULAR MARGINS
		BF4	MARGINS REGULAR, THINNING BEGUN
		BF5	FINAL BIFACE
		CAN	CAN
		CR	NONBIFACIAL CORE
		CRN	CRANIUM
		ES	END SCRAPER
		FCR	FIRE-CRACKED ROCK
		FK	FLAKE
		FKU	EDGE-DAMAGED FLAKE
		FKW	WORKED FLAKE
		FR	FRAGMENT
		GL	GLASS
		GR	GRAVER
		HEARTH	HEARTH
		HM	HAMMERSTONE OR HUMERUS (SEE CLASS CODE TO FIND OUT)
		LB	LONG BONE
		M	MULTIPLE (SEE COMMENTS)
		MC	METACARPAL
		MP	METAPODIAL
		MR	MANDIBULAR RAMUS
		MTL	METAL
		N	NONE
		ND	NODULE
		NDT	TESTED NODULE
		NDU	EDGE-DAMAGED NODULE
		NDW	WORKED NODULE
		OF	OTHER FORMAL TOOL (SEE COMMENTS)
		OT	OTHER (SEE COMMENTS)
		PL	POTLID

Column Heading	Description	Codes	Description
		POST	MODERN POST
		PP	PROJECTILE POINT
		RD	RADIUS
		RDU	RADIUS-ULNA
		SC	SCRAPER
		SHELL	SHELL
		SS	SIDESCRAPER
		TFR	TOOTH FRAGMENT
		TREES	TREES
		UF	UNIFACE
		US	UNSPECIFIED
		WOODPILE	WOOD PILE
POR	**ARTIFACT PORTION**	AX	AXIAL
		CO	COMPLETE
		DS	DISTAL
		DSH	DISTAL PLUS OVER 1/2 SHAFT
		EN	ENAMEL
		END	END
		FK	FLAKE
		FR	FRAGMENT
		HS	HORN SHEATH
		IC	INCISOR
		LT	LATERAL
		M	MULTIPLE (SEE COMMENTS)
		ME	MEDIAL
		MMX	UNSPECIFIED MAXILLARY MOLAR
		N	NONE
		PR	PROXIMAL
		PRS	PROXIMAL PLUS LESS THAN 1/2 SHAFT
		PSH	PROXIMAL PLUS OVER 1/2 SHAFT
		R	RIGHT
		SH	SHAFT
		TFR	TOOTH FRAGMENT
		US	UNSPECIFIED
MAT	**MATERIAL TYPE**	BS	BASALT
	(SEGMENT CODE FOR FAUNA)	CH	CHERT
		CL	CHALCEDONY
		DMC	DOLLAR MOUNTAIN CHERT
		DMQ	DOLLAR MOUNTAIN QUARTZITE
		GL	GLASS
		IR	IRISH ROCK CHERT
		MAD	MADISON FORMATION CHERT
		MTL	METAL
		N	NONE
		NDMC	NOT DOLLAR MOUNTAIN CHERT
		OB	OBSIDIAN
		OC	CHERT WITH OSTRACOD INCLUSIONS
		PWD	SILICIFIED WOOD
		QT	QUARTZITE
		QTM	MORRISON QUARTZITE
		SLS	SILICIFIED SILTSTONE
		ST	STEATITE
		US	UNSPECIFIED
		VO	UNSPECIFIED VOLCANIC
	FAUNA:	CO	COMPLETE
		EN	ENAMEL

Column Heading	Description	Codes	Description
		FR	FRAGMENT
CLR1, CLR2, INCL	**PRIMARY, SECONDARY, AND INCLUSION COLORS AND OPACITIES**	BK*	BLACK
	EVERY COLOR DESCRIPTION HAS AN OPACITY SUFFIX	BR*	BROWN
		BU*	BLUE
		CL*	CLEAR
		CM*	CARAMEL
		GN*	GREEN
		GR*	GRAY
		MR*	MAROON
		N	NONE
		OR*	ORANGE
		PC*	PEACH
		PK*	PINK
		PR*	PURPLE
		RB*	RED-BROWN
		RD*	RED
		TN*	TAN
		WH*	WHITE
		YL*	YELLOW
		QTC	QUARTZ CRYSTAL (INCLUSIONS ONLY)
	OPACITIES:	**T	TRANSPARENT
		**S	SEMI-TRANSPARENT
		**O	OPAQUE
		US	UNSPECIFIED
HEAT	**HEAT MODIFICATIONS**	CN	CARBONIZED
		CZ	CRAZED
		M	MULTIPLE (SEE COMMENTS)
		N	NONE
		PL	POTLID SCARS
		TFR	THERMAL FRACTURE
		9	NOT RECORDED
	BONE:	0	NONE
		1	CARBONIZED
		2	CALCINED
		3	CARBONIZED AND CALCINED
PTY	**PLATFORM TYPE**	9	DOES NOT APPLY OR NOT RECORDED
		CR	CRUSHED
		N	NONE
		OT	OTHER (SEE COMMENTS)
		PR	PREPARED
		UN	UNPREPARED
C/T	**CLAST OR TECHNOLOGICAL MEASUREMENT?**	C	CLAST
	TECH. LENGTH IS PERPENDICULAR TO PLATFORM,	N	NONE
	TECH. WIDTH IS PARALLEL TO PLATFORM	T	TECHNOLOGICAL
CTX	**CORTEX VALUES**	0	NO DORSAL CORTEX
		1	UNDER 25% CORTEX
		2	25-50% CORTEX
		3	51-75% CORTEX
		4	76-99% CORTEX
		5	100% CORTEX
		9	DOES NOT APPLY/ NOT RECORDED

Appendix Four

Dollar Mountain Chert Table

Specimen Number	Site Number	Color 1	Color 2	Inclusion Color	Diaphaneity
CC001	DM001	10YR 3/6	5YR 8/1	10YR 2/1	3
CC001-2	DM001	10YR 6/8	2.5Y 5/4	7.5YR 8/0	3
CC001-3	DM001	7.5R 6/0	7.5YR 6/8	7.5R 4/6	3
CC001-4	DM001	10YR 3/6	10YR 6/6	7.5YR 2/0	3
CC001-5	DM001	7.5R 3/4	10YR 3/4	2.5Y 7/6	3
CC001-6	DM001	10YR 3/6	10YR 8/1	10YR 8/4	2
CC002	DM001	10YR 3/3	10YR 5/4		2
CC003	DM001	10YR 3/2	10YR 3/4		4
CC004	DM001	2.5YR 2.5/4	10R 6/4	5YR 8/2	3
CC005	DM001	CL			1
CC006-1	DM001	10YR 8/2	10YR 8/1	10YR 4/6	3
CC006-2	DM001	2.5Y 3/0	2.5Y 8/0	7.5R 3/4	3
CC006-3	DM001	7.5R 6/4	7.5R 3/4	7.5R 5/0	3
CC007	DM001	10R 3/6	10R 3/3	10R 2.5/1	4
CCOO7-2	DM001	10R 3/6	10R 6/3	7.5YR 4/6	4
CC008-1	DM001	7.5YR 2/0	N9	2.5Y 6/0	4
CC008-2	DM001	N3	5B 7/1	10YR 8/2	4
CC008-3	DM001	N2	10YR 8/1	2.5Y 5/0	4
CC009	DM001	CL	10YR 2/1	10YR 6/4	1
CC010	DM001	CL	5Y 8/1		1
CC011	DM001	10R 6/3	10YR 8/2	5B 5/1	4
CC012	DM001	10YR 5/1	10YR 6/4		3
DML-11	DM CIRQUE	N3	10YR 6/1		4
DML-12	DM CIRQUE	N4			4
DML-13	DM CIRQUE	10YR 7/3	10YR 8/1		2
DML-4	DM010	10YR 5/6	2.5Y 5/4	CL	4
DML-1A TO 1I	Wood River	N2 CL			4
DML-7	below DM005	10R 4/6	10YR 5/6	CL	3
DML-5	Wood River	10YR 5/6	10YR 8/2	CL	4
DML-6	Wood River	N3	10YR 8/3		4
DML-8A TO B	Wood River	10YR 8/1	7.5YR 5/8	7.5YR 7/0	4
VC01	Venus Creek	9	9	9	4
VC02	Venus Creek	9	9	9	4
VC03	Venus Creek	9	9	9	1
VC04	Venus Creek	9	9	9	4
GR1-3	Meeteetse Rim	9	9	9	9
GR1-15	Meeteetse Rim	9	9	9	9
GR-10	Meeteetse Rim	9	9	9	9
GR1-11	Meeteetse Rim	9	9	9	9
GR1-14	Meeteetse Rim	9	9	9	9
GR1-16	Meeteetse Rim	9	9	9	9
GR1-20	Meeteetse Rim	9	9	9	9
GR1-21	Meeteetse Rim	9	9	9	9

Specimen Number	Texture	Luster	UV Long	UV short	Fossils	Heat	Photo?
CC001	CRY	SV	N	N	N	N	Figure 4.3
CC001-2	APH	DL-SV	N	N	N	N	Figure 4.3
CC001-3	CRY	V	N	N	N	N	Figure 4.3
CC001-4	CRY	SV	N	N	N	N	Figure 4.3
CC001-5	CRY	V	N	N	N	Color	Figure 4.3
CC001-6	CRY	SV	GR	GR	N	N	Figure 4.3
CC002	CRY	V	N	GR	N	N	
CC003	CRY	W	N	N	N	N	
CC004	CRY	SV	N	N	N	TF, CZ	Figure 4.3
CC005	CRY	SV-W	OR	OR	N	N	Figure 4.4
CC006-1	CRY	DL	N	GR	N	N	
CC006-2	CRY	SV	N	N	N	COLOR, TF	
CC006-3	CRY	SV	N	N	N	COLOR	
CC007	CRY	SV	N	N	N	N	Figure 4.3
CCOO7-2	CRY	DL-SV	N	N	N	N	Figure 4.3
CC008-1	CRY	V	N	N	N	TF	Figure 4.4
CC008-2	CRY	V	N	N	N	N	Figure 4.4
CC008-3	CRY	V	N	N	N	N	Figure 4.4
CC009	CRY	SV	N	GR	N	N	
CC010	CRY	V	N	N	MAYBE	N	
CC011	CRY	DL	N	N	N	N	
CC012	CRY	V	N	N	N	N	
DML-11	CRY	SV	N	N	N	N	
DML-12	9	9	N	N	N	N	
DML-13	CRY	W-SV	OR	OR	N	N	
DML-4	CRY	DL-V	OR	OR	N	TF	
DML-1A-1I	CRY	V	9	9	N	N	
DML-7	CRY	SV	OR	GR	N	N	
DML-5	CRY	DL	N	GR	N	N	
DML-6	CRY	SV	N	N	N	N	
DML-8A-B	9	9	N	N	N	N	
VC01	PET	sv	GR	GR	Y	N	
VC02	CRY	9	N	OR	N	N	
VC03	CRY	9	N	N	N	N	
VC04	CRY	V	N	GR	N	N	
GR1-3	9	9	OR	OR	9	9	
GR1-15	9	9	OR	OR	9	9	
GR-10	9	9	N	OR	9	9	
GR1-11	9	9	N	GR	9	9	
GR1-14	9	9	N	OR	9	9	
GR1-16	9	9	N	OR	9	9	
GR1-20	9	9	N	GR	9	9	
GR1-21	9	9	N	GR	9	9	