Analysis of artifacts from Avon Valley, Montana

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ANALYSIS OF ARTIFACTS FROM AVON VALLEY, MONTANA

By

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A large collection of lithic artifacts, excavated from Avon Valley in Powell County, Montana in 1966-67, was obtained by the University of Montana in 2002. The largest part of the collection consists of a sizeable amount of lithic debris, which can be used to demonstrate repetitive patterns and trends. The purpose of my study is to use a variation of Mass Flake Analysis (Ahler, 1975) to answering questions about tool production by the people who moved through this area in Early Prehistoric through the Late Prehistoric times.

The questions to be addressed from this analysis are related to raw toolstone procurement and tool production behavior over time, preferences for material types, and how much preparation was necessary for a material type to be fashioned into a tool.

The analysis was performed using four variables that can be duplicated using any artifact assemblage: 1) progressive size, 2) cortex removal, 3) raw material type, and 4) stratigraphic context. A non-parametric statistical analysis of these variables will demonstrate relationships between them and suggests that 1) preferences for raw material were consistent through time, 2) refinements in tool production technologies changed little over time, and 3) the quality and availability of the raw material was an important consideration for the tool makers.
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On Friday December 2, 1966 the University of Montana’s newspaper, the Kaimin, ran the following headline, “Looters Damage Area, Site Near Drummond Reveals Fossils from 8,000 B.C. Era”. The article reports that graduate students Larry Loendorf and Richard Malouf, and anthropology instructor Phillip Hobler had begun work on a site east of Missoula near Drummond. The researchers explained that since WWII almost half of the state’s historic and prehistoric resources had been destroyed by people due mainly to the lack of knowledge concerning the importance of these sites. The site was described as an ancient pond that people camped near time after time throughout prehistoric time. Cultural remains were incorporated into the five strata the team identified, with estimated dates ranging from 7,000 years to 10,000 years old. The article took great care not to divulge the location of the several sites being studied.

George Arthur and Alan Carmichael first learned of this area of exciting prospects in 1966 at the Montana Archaeological Society meeting in Billing, Montana from Lewis K. Napton (then of the University of Michigan). They confirmed the information on Friday April 8, 1966 by visiting several potential sites in Avon Valley. The party of interested individuals from the University of Montana consisting of Hobler, Loendorf and Malouf were convinced that the Avon Valley sites were too important and too endangered to be left uninvestigated any longer. Philip Hobler and his team of anthropology graduate students were
subsequently recruited to commence excavation and research in Avon Valley. They began work on the site September 25, 1966. They returned again in the spring of 1967 for another season of excavation (Personal correspondence, Malouf).

The Avon Valley material was tremendously exciting to the research team because of the potential Master’s Thesis and Doctoral Dissertation topics suggested by the material. Although many works were eagerly anticipated none came from the initial excavations and investigations. Correspondence between Hobler and Napton between the years 1967 and 1968 suggested that both wanted to publish the site excavations and fieldwork as doctoral dissertations. Ultimately neither of them chose the material although at one time Hobler and Napton discussed the possibility of publishing jointly (Personal correspondence, Hobler).

There were others who wished to write dissertations and present papers, but as everyone wanted to publish and no one wanted to share the information and research, the entire collection finally went with Philip Hobler to Simon Frasier University in Vancouver, B.C. where he taught for many years and now serves as Professor Emeritus. There are, however, several generalized studies of sites in the region have been published since.

Ann Johnson first recorded a site in Avon Valley called the Halfway Creek Site (24PW1044) in 1971. Cathy Cameron discusses this site again in a

During the initial HRA investigation, another site was located in the fiber optic installation area as part of the evaluation for the new fiber optic line regeneration station. Buckie Damone recorded the Finn Regen Station Site (24 PW718), in that area (Beery, et al, 2003:30). Both sites were investigated in depth, independently of the larger project, to determine whether or not each site should be protected or mitigated.

The results of this investigation indicate that like other studies in the valley, there is evidence of several prehistoric occupations at the sites and were most likely used as a seasonal short-term occupation camp. Evidence includes a wide distribution of features and artifacts, including projectile point data beginning in the early Paleoindian period and continuing through the Late Prehistoric period, debitage that indicates middle to late stage manufacture of stone tools, fire cracked rock, culturally modified trees, and a radiocarbon date of
330±60BP (Beery, et al, 2003:35). The investigators recommended that further geomorphological work should be conducted to examine past lifeways and human adaptation to prehistoric environments.

The University of California at Berkley conducted its Archaeological Field School in Avon Valley in 1970 under the direction of Lewis K. Napton. Thomas R. Hester, Alan D. Albee, and Cristy Willer conducted the work and published their findings of the field school in *Plains Anthropologist* Volume 22, 1977. This group of students was one of the first to attempt an analysis of debitage from Western Montana. They were interested in learning more about production techniques, raw material choices, and where and why certain locations were chosen (Hester, et al, 1977).

Catherine M. Cameron conducted a cultural survey of the area in 1983 in conjunction with Robert W. Fields, who performed a geologic survey. Both were interested in procurement of raw toolstone materials and activities by prehistoric people (Cameron, 1984; Fields, 1984).

The Avon Valley collection of 1966-67 remained untouched until 2002. A University of Montana graduate student retrieved the collection from Simon Fraser University in Vancouver, B.C. and returned it to the University of Montana’s Anthropology Department as an addition to its research collection. The 38 year old collection came to my attention as the focus of my research
One of my challenges was taking the collection excavated in a time of a more limited cultural historic perspective and trying to shed light on the processes that produced the artifacts in this overlooked collection.
Geology of Avon Valley

Avon Valley is between the junction of Interstate 90 at the Garrison
turnoff along Highway 141 in Powell County, Montana on the south and Highway
200 between Lincoln and Ovando on the north (Figures 1 and 3).

The valley is surrounded by the Garnet Range on the Southwest, and the
Flathead, Swan, and Lewis ranges on the North and Northeast. A drainage runs in
a northwesterly direction through Avon Valley to the man-made Nevada Lake,
and ultimately into the Blackfoot River which is a tributary of the Clark Fork
River system. The Clark Fork River system drains almost all of Montana west of
the Continental Divide (Malouf, 1982: 1). The Clark Fork River and its
associated tributaries provided natural thoroughfares for the ancient peoples who
traveled from the Columbia Plateau in the west to the Great Plains in the east
(Malouf, 1982: 33). Other drainages were used for similar purposes. For
example, the Upper Missouri Drainage is the location of the South Everson Creek
Mountains, which are part of, the Three Forks Basin just downstream from the
headwaters of the Missouri River is home to the Schmitt Chert Mine (Davis,
1983), and the northern Madison Range near Bozeman, Montana is where the
Flying D Ranch is located (Baumler et al, 1996, pgs. 41-65). All were well-
known travel routes and sources of chippable stone.
The geology of Avon Valley is typical of western Montana basins and dictates the characteristics of the natural and cultural environment (Choquette et al, 1981: 3-5). Avon Valley is structurally related to the regional compressional thrust faulting that occurred during the late Cretaceous and the early Tertiary time. Basin and range extension and the associated Post-Eocene volcanism in Western Montana created the mountain basins. Normal block faulting with basin and range extension continues to be active in western Montana to the present and accounts for most of the seismicity (Fields, 1983: 1-5). Glacial and postglacial processes were the final touches to the landscape upon which most cultural resources are found (Choquette et al, 1982: 3-5).

The cores of the surrounding mountain ranges are composed of Precambrian quartzite, argillite, and limestone of the Belt Supergroup. Almost the entire area south of Nevada Creek is unconformably blanketed with thick deposits of early Tertiary volcanic rock composed of olivine basalt, rhyolitic ignimbrite, and air fall tuff (Fields, 1983: 1-5).

Late Pliocene and early Pleistocene erosion resulted in extensive pediment surfaces extending from the uplands to the edge of the most recent floodplains of the basins in the region. Advances and retreats of the Flathead Glacier during Pleistocene-Holocene times contributed to the deposits in Avon Valley with the extensive moraines and associated outwash gravels that are associated with the glacier (Choquette et al, 1982: 3-5). At the same time, south and east of the ice
lobe, pediment surfaces received significant deposits of water-lain cobble and pebble gravels in variable thicknesses. These gravels contain clasts of Precambrian Belt rock, andesite, basalt, rhyolite, and chert. The present day drainage in Avon Valley was well established by late Pliocene times and survived the glacial episodes to continue developing its drainage pattern to the present (Fields, 1983: 1-5).

Robert W. Fields recognized four serviceable raw lithic materials used by indigenous people in Avon Valley that were readily available for making chipped stone tools, as well as their sources (Fields, 1983:14):

1. Silicified “marls” (Avon Chert) – there are outcrops in the areas of Antelope Hill and Rhine Point. The Tertiary age “marls” are considered to be the primary source material in the area.

2. The pediment capping gravels - these Pleistocene age gravels are found on the surface of the valley. The Douglas Creek basin and the surfaces north of the Garnet Range east of Douglas Creek and northwest of the Nevada Creek-Avon divide constitutes a Pleistocene age non-specific secondary source of volcanic, Precambrian and other toolstone.

3. The Madison Limestone – found south of the present Garnet Range crest is an abundant source of Mississippian age chert nodules.

4. The Phosphoria Formation – also found south of the Garnet Range crest is a thick unit of phosphate bearing rock, which also contains a small source of Permian age chert.

The rock procured at Avon Quarry on Antelope Hill, referred to as “Avon Chert”, and is misleading in that it is actually outcrops of silicified freshwater “marl” or “porcellanite” that was originally deposited in a lake or pond. Marl is a
mixture of calcite and clay that occur in nearly equal amounts. Porcellanite is a mixture of silica and clay with some calcite usually present. Evidence for freshwater calcareous and siliceous deposits were present in the original sediments, possibly alternating mixtures of clay, altered volcanic ash, and calcite with mixtures of clay, altered volcanic ash, and authigenic silica plus calcite. These variations may represent changing environmental conditions over time in the host strata. These sediments have undergone varying degrees of replacement (Fields, 1983:15-17).

Marls and porcellanites are sediments that usually form in playa-lakes or ponds where clay minerals and fine-grained volcanic material are deposited in a body of water. Calcium carbonate and/or silica are formed by evaporative concentration in these bodies of water. These lakes and ponds supported both plant and animal life, as is commonly evident by fossils in the bedding planes. The bedding planes are eventually invaded by silica, which precipitates from groundwater and is highly soluble in humic acids found in carbonized plant material and fossil wood (Fields, 1983: 17). “Avon Chert” is a marl/porcellanite unit 10m to 15m thick with bedding planes of 4cm to 30cm. It is dense and forms short cliffs and resistant outcrops. Weathered material is yellow-white to white due to silica hydration. Fresh rock is darker and tends to be brown to tan and occasionally dark brown to brown-black.

Over the calcareous siltstone bed is a 2m thick exposure of pure calcite limestone. This layer forms the distinct white ledge exposed along the east crest
of Antelope Hill. It is banded in 2cm to 5cm layers and is light tan to pink with a few dark inclusions and some staining. The rock is water-lain and probably represents a long-term evaporative stage in a highly alkaline lake. There are no fossils in this unit mostly because the lake may have been too alkaline to support abundant life (Fields, 1983: 27).

Below the Avon Chert is another concentration of chert, but unlike Avon Chert, it is vitric with 30% chalcedony, 67% clays and amorphous silica, 2% quartz and 1% void space. Voids are completely or partially filled with chalcedony and crystalline quartz. It is white to greenish- or bluish-gray in color with white, yellow and brown inclusions. Broken and weathered faces have a pearly luster. This unit is a breccia composed of sub-angular to well rounded detrital fragments, representing clastic materials and possibly some fossils, but is now completely altered to chalcedony and quartz (Fields, 1983: 1-5).

Cryptocrystalline silicates of the Madison limestone formation containing Avon Chert occur broadly across Antelope Hill. This area was an obvious major procurement site for early groups living in the region. Much time was spent excavating and gathering the better (more cherty) material as suggested by the great amount of discarded materials in waste piles (Choquette et al, 1982: 3-5; Fields, 1983:18).
Researchers disagree as to the quality of the Avon Chert. Hester described it as a fossiliferous chert with poor conchoidal fracture planes and a coarse texture (Hester et al., 1977: 241). Cameron and Fields described it as being of a quality good enough to justify it as a highly valued resource and as an easily quarried supply of a seemingly unlimited quantity of “chert” by prehistoric people (Cameron, 1984:13; Fields, 1983:18). Deaver suggested that a group will seek lithic material in a specific geologic context when it occurs in a density adequately high enough to justify the mining effort in terms of cost-effectiveness (Deaver, 1981: 1), which supports the thinking of Cameron and Fields. Whatever the case, it is agreed that “Avon Chert” was the primary raw stone resource used in this geologic location (Cameron, 1983: 13).
Environment

The modern landscape in Western Montana consists of a series of uplands and basins with elevations ranging from 3600 to 5000 feet above sea level. Winter precipitation, in the form of snow, ranges about 12-14 inches a year in the rain shadow valleys such as Helena, Missoula, and Avon (Greiser et al, 2000: 5). As frigid air sweeps south out of Canada each winter the mountain ranges protect the valleys from the worst of the cold. Average annual temperatures are about -7°C (20°F) in January and about 20°C (68°F) in July. Because major water courses move through these basins, depositional processes during the Holocene have been chiefly colluvial on mountain slopes and alluvial on the basin floors with localized aeolian deposits present (Choquette et al, 1982: 5).

The vegetation in Avon Valley consists of xeric montane pine/fir forests of ponderosa (*Pinus ponderosa*), Lodgepole Pine (*Pinus contorta*), Douglas Fir (*Pseudotsuga menziesii*), big sagebrush (*Artemesia tridentate*), as well as a variety of sedges, grasses, and forbes (Greiser et al, 2000: 5). Many species of plant are edible and extensively used by native people moving through the area. These include but are not limited to serviceberry (*Amelachier spp.*), chokecherry (*Prunus spp.*), and huckleberry (*Vaccinium spp.*). Other plants used by historic native people include bitterroot (*Lewisia spp.*), desert parsley (*Lomatium dissectum*), nodding onion (*Allium cercum*), Wyeth biscuitroot (*Lomatium ambiguam*), sunflower (*Helianthus spp.*), cattail (*Typha spp.*), wild rose (*Rosa*
spp.) as well as gooseberries and currants (Ribes spp.) (Choquette et al, 1982: 6). The inner bark of several species of trees was used for food as well as other household and clothing items (Aldredge, 1995; White, 1954).

Faunal resources in the area include large herds of elk (Cervus Canadensis), antelope (Antelocapra americana), white tail deer (Odocoileus virginiana), mule deer (Odocoileus hemionus), and mountain sheep (Ovis Canadensis). Black bear (Ursus americanus) and grizzly bear (Ursus horribilis), wolves (Canus lupis), and mountain lions (Felis concolor) are common. Other small mammals such as jackrabbits (Lepus townsendii), snowshoe hares (Lepus americanus), cottontail rabbit (Sylvilagus leporidae), marmot (Marmot sp.), beaver (Castor Canadensis), muskrats (Ondatra zebethica), and ground squirrels (Citellus columbiaanus) are prey for carnivores such as coyote (Canis latrans), fox (Vulpes vulpes), badgers (Taxidea taxidea), weasels (Mustela erminea), skunk (Mephitis mephitis), and bobcat (Lynx rufus). In the time of pre-European contact bison (Bison bison) dominated the landscape (Beery et al, 2003: 5; Greiser, et al, 2000: 5; Choquette et al, 1982: 6-7).

Several bird species are present seasonally. Prehistoric people valued Mallard (Anas platyrhynchos), wood duck (Aix sporsa), Canada goose (Branta canadensis), hawk (Buteo spp), bald eagle (Halaeetus leucocephalas), and golden eagle (Aquila chrysaetos) (Choquette et al, 1982: 6).
Although the climate is harsh in the winter, the faunal and plant resources available to the prehistoric groups of people moving through the area were abundant.
History of Investigations and Theoretical Approaches

The theoretical approaches used for studying and interpreting the lithic collection from Avon Valley are as diverse as the collection methods. The earliest researchers were interested in determining the typology and chronology of the sites (unpublished notes, Hobler). Studies of chipped tool industry in the western part of North America have been primarily concerned with classifying stone implements into type, region, and chronological order (Mulloy, 1958; Frison, 1978; Metcalf, 1987).

The University of Michigan performed carbon-14 dating of microscopic fragments of partially decayed vegetal material soils from the lowest level excavated in the Avon Chert Quarry. The extended dates range from 9600-9200 BP and are thought to be associated with the use of Lusk type points (Speth, personal correspondence, April 1968).

Unfortunately, the diagnostic tools from the original collection have been lost, but a very large collection of flakes remains. Although the traditional approaches are important and have a valid place in the exploration of the past, it is now well accepted that the discarded by-products of tool manufacture as well as the use and repaired toolstone are also integral components of an archaeological site. Experience has shown that there is a wealth of information to be gleaned from studying the waste materials of tool production (Bradley, 1991: 369). The
finished product is always exciting to find, but the debris remaining from producing tools give us details as to production and manufacture, reasons for raw material choices, and the knapping behavior of the makers of the tools.

Thomas R. Hester, Alan D. Albee, and Cristy Wilier conducted field work in Avon Valley in 1970 where they performed a surface survey of an area identified as the “Old Cabin Area” near Rhine Point, which is south of the area of artifacts collected in 1966-67. They pinpointed three areas of artifact concentration as Cluster A and Cluster B divided into Sections 1 and 2 (see Figures 2 and 5). Samples were collected from the surface of these areas and returned to the laboratory at the University of California, Stanislaus, for evaluation. The team identified the same raw material sources identified and discussed in Chapter 3 by Robert Fields (Fields, 1984), i.e. basalt cobbles, exotic materials such as obsidian and Madison Limestone cherts, and the ubiquitous Avon Chert.

To define the areas of tool production, the distribution of debris was analyzed and the results were as follows:

- In cluster A primary cortex flakes were completely absent with some secondary cortex flakes. Interior and biface thinning flakes were especially frequent suggesting that a great deal of tool manufacture went on in this area supported by the large quantity of flakes.
• Cluster B, Section 1 had a similar distribution with no cortex and numerous biface-thinning flakes. Cores were not found.

• In Cluster B, Section 2 primary and secondary cortex flakes were located as well as three cores.

This suggests that Section 1, in the northern most area, is where most of the tool manufacture took place. Section 2 is suggested as the place where cores were worked. The researchers also suggest that distribution of the flakes and the material types of the two features represent an area where flint-knappers worked several large blanks into a biface implements as evidenced by the number of flakes of one material type.

The technology and manufacturing process is suggested by the lack of cortex-covered flakes and the scarcity of secondary cortex flakes. The authors suggest that the shaping of the cores was not done in the clusters noted as workshop areas but rather core or partial cores were hewn at the nearby quarry and taken away to be used elsewhere. No hammerstones were found suggesting percussion work done by antler or bone. No unifacial tools were found and only one rejuvenation flake was located that suggested resharpening.

The authors propose two models of aboriginal activity either of which seems applicable to the area: 1) The clusters represent chipping activity subsidiary to nearby base camps, or 2) the debris clusters represent temporary occupation
related to specialized activity from nearby base camps or activities of a group passing through. Although the clusters might represent incidental chipping stations, further investigations indicated that repeated occupations took place over time along Strickland Creek. They concluded that most of the procurement, maintenance, and processing of tools were fashioned from exotic materials, which they believe supports the model of temporary occupations. But the makers of the tools also appear to have used the area to resupply their tool kits by working the local fossiliferous cherts as suggested by the number of broken bifaces and preforms (Hester et al, 1977: 248).

Catherine M. Cameron conducted a cultural survey of the area in 1983 because of the high density of archaeological sites known to exist in the area and the projected impact of logging, land development, and other land/resource uses. Her primary goal during this research project was to determine the significance of sites previously identified in the valley (Cameron, 1984:1).

Robert W. Fields performed a geologic reconnaissance of Nevada Creek in conjunction with Catherine Cameron. His goal was to determine the types and sources of raw lithic materials used by people moving through the area in Paleoindian times (Fields, 1984:1).

Cameron was interested in identifying and describing the number of workspaces at the Antelope Hill sites (see Figures 2 and 4). She estimates the
occupation of this area to be from the Early Prehistoric through Late Prehistoric time and suggests the importance of the Nevada Creek drainage is threefold (Cameron, 1984:12):

1). Environmental resources: The Nevada Creek drainage is situated immediately west of the Continental Divide and less than 100 miles from the Plains. Carling Malouf (1982: 1) notes that there were enough plant and wildlife resources, including bison, in the valley to accommodate seasonal encampments. The valley was ideal winter habitat for bison, antelope, and white-tailed deer. The area would have provided the abundant local resources for seasonal residence or an excellent stopping place for groups on their way to the Plains (Choquette and Holstein, 1982: 21-29).

2). Geographic location: This area would have been extremely accessible to prehistoric people who traveled on foot. In historic times the Nevada Creek area may have been part of and close to several major travel routes (Cameron, 1984:12). The Nevada Creek Drainage runs in a southeast to northwest direction through Avon Valley to the man-made Nevada Lake, and ultimately into the Blackfoot River. The Blackfoot River is tributary to the Clark Fork River system, which was a major east-west travel route. The Nevada Creek Drainage may have been a north-south corridor for indigenous people, trappers and explorers alike as an alternative route to the Great Plains (Cameron, 1984:13)

3). Raw material resources: Avon Valley chipped stone material consists primarily of outcrops of the apparently greatly desired silicified marls better known
as, “Avon Chert”. A secondary raw material source tool manufacture was the cobbles in the basin-fill conglomerate containing other cherts and basalts.

The Avon Valley Quarry site (24PW346) covers approximately 2 square kilometers of the north half of Antelope Hill along Strickland Creek (see Figure 1). Cameron’s crew relocated twenty-eight sites and recorded six new sites. Of the sites located six appeared to be quarry or procurement sites. Of these six, four areas were located in a concentrated area in the southern portion of the drainage that contained the silicified marl known as Avon Chert. Two other procurement areas were located south of Nevada Lake where cobbles from pediment capping gravels were the predominant raw materials used (Cameron, 1984: 2).

Cameron divides the site into five areas (see Figure 3):

1. The first is the quarry pit area containing seventy-six pits that are concentrated in a large stand of trees on the north face of the hill. Sizes of the pits range from 4.25 to 30 meters in diameter and from 1 to 3 meters in depth. The pits are surrounded by large amounts of debitage, blanks, cores, and various other artifacts. Cameron believes this area was used to produce large bifaces to be transported as blanks for future use.

2. The second area includes several workshops and as many as seventeen stone circles were located in a flat area west of the quarry pits. The stone circles measured from 5 to 11.5 meters in diameter with lithic workshop debris located on the southeast and northeast ends of the stone circle area.
The workshop contained debitage, quarry blanks, cores, and large unused pieces of the Avon material. Also present were utilized flakes, retouched flakes, four unifaces, 2 bifaces, and fire-cracked rock. The workshop area also contains a fairly significant amount of other lithic materials such as basalt and various types of chert.

3. The third area is north and west of a spring located on the northern slope of Antelope Hill. The area is covered in Avon Chert debitage and smaller quantities of other cherts. The density of the lithic debris varied but covered a relatively continuous area.

4. The fourth area is located west of the quarry pits and runs along the edge of the drop-off between the north and south sections of Antelope Hill. Quantities of Avon Chert cover the area but substantial amount of other materials, including basalt and other cherts, are also present.

5. The last area is the top of Antelope Hill. It was surveyed and flakes covering the entire area were noted. Time did not permit a detailed examination of the area (Cameron, 1984:5-8).

Cameron concludes that this area was intensively occupied in the summer and autumn during prehistoric times for the purpose of raw toolstone procurement and production as well as a desirable stopping place on a journey to the Plains. She believes this area is a valuable archaeological resource for study of indigenous people over time in Western Montana (Cameron, 1984:15).
Lithic Resource Studies

In the Northwestern United States, lithic procurement sites are among the most common and highly variable remains of prehistoric settlement. They present a wide range of possible research topics and great scientific value in determining the answers to such questions as how early man adapted to his environment, how adaptation through social organization and structure was achieved, and how these circumstances changed through time (Francis, 1995:230).

Lithic resource studies have essentially been ignored, or at best minimalized, in Cultural Resource Management studies (Church, 1994: 220; Francis, 1995:230). This is due to the problems of the overwhelming size of these projects, the potential of data being redundant, and the tremendous expense of such undertakings. Further, Cultural Resource Managers have treated all archaeological resources the same in terms of accepted documentation and evaluation processes. This is slowly changing as we recognize the fact that each lithic site type (i.e. rock art, stone circles, or quarries) presents its own unique research opportunities and analytical problems (Church, 1994: 220; Francis, 1995:230). It is essential that all sites not be treated the same, because no single site will provide all the answers.

Theoretically, the most important component of any lithic production system is the raw lithic material quarry (Ericson, 1984: 1; Francis, 1995.231).
With this in mind it is important to understand that people did not procure and use the available materials in the same manner. Analysis of quarries allows researchers to recognize and reconstruct processes of raw material procurement, selection, and knapping processes. Researchers are also able to reconstruct reduction sequences, changes in technology and the various rates of technological changes over time. Therefore, quarries are the most logical place to begin studying stone-tool cultures and associated behaviors (Ericson, 1984: 1; Francis, 1995:231).

In studying prehistoric quarries it is essential to understand the geology of the area under investigation (Church, 1994; Ericson, 1984; Francis, 1991). This is because the lithic material may be unique to a particular area and provide discernable markers in archaeological assemblages. Even if a particular rock type cannot be typed to a specific source, the area the material originates may be narrowed down to a range of possibilities and provide clues to a potential regional source. It is possible to identify general zones that may have been used for primary raw material procurement as well as recognize materials considered to be “exotic” without having to assume that a particular material was obtained from only one place. It has been determined by many researchers (Church, 1994; Ericson, 1984; Francis, 1991) that the greatest percentage of raw lithic materials is derived from local materials. In using this approach other “exotic “materials can be identified as having been obtained elsewhere (Francis, 1991: 313).
According to Sherri Deaver, archaeologists have used the term “quarry” in several ways. Based on the geologic context an archaeologist makes a distinction between primary and secondary quarries representing primary or secondary deposition. Another distinction made by Deaver is between quarries and procurement areas. The former implies actual mining activity where the latter implies an area where raw materials are obtained without mining (Deaver, 1988: 1).

Deaver discusses three distinct quarry types: the first being episodic or opportunistic. This type occurs when the individual is engaged in some other activity but notices a nice cobble of stone and curates the material. The individual may decide to test the material and chose to discard the stone or keep it. The result would be isolated finds of a few flakes or a few flakes and a tested nodule to exhibit this particular behavioral event (Deaver, 1988: 1).

The second type of quarry is a group’s systematic exploitation of a specific formation of a certain rock type. This quarry could be called a mine. Evidence of this type of quarry is exhibited by the presence pits, shafts, cores, knapping tools, and flaking debris. A periodic reuse of the mine is evidenced by the associated camp sites of the miners. Examples of mine quarries are the Schmidt Site, the Knife River Flint quarries, and the Hartville Uplift quarries (Deaver, 1988: 1).
The third type of quarry is termed a supermarket–selection. It differs from
the episodic/opportunistic quarry in that raw material selection is the primary
behavior carried out in an area where a wide selection of materials are available
and a selection or choice of materials can be made without excavation. This type
of quarry is found in glacial till or alluvial deposits. It is characterized by five
basic attributes:

1. Gravels and tills consist of rounded cobbles and pebbles that the quarrier must
   break open to create a striking platform. This is evidenced by split cobbles
   and pebbles, segmented cores, and bipolar reduction strategies.

2. The cortex on the lithic debris is consistent with the type of cortex displayed
   in the gravel or till. There is a greater proportion of flakes with cortex that
   one expects to find on irregular nodules due to the greater area-to-mass ratio
   founding rounded nodules.

3. The selection of gravels and till should be consistent. This is can be
   confirmed by comparing the relative distribution of material types with the
   occurrence of gravels and till.

4. In the gravel/till situation, the most ubiquitous raw material should
demonstrate the least amount of reduction, retouch, and resharpening. In this
circumstance, the most common type of material is comparable to the lowest
quality of acceptable raw material while the most desirable raw material will
show a disproportionately high incident of general reduction, retouch and
resharpening.
5. Due to the extensiveness of this type of quarry deposits often cover miles of area making it difficult to determine the reuse rate. Populations taking advantage of this type of quarry gave less consideration to the placement of camp sites in proximity to the quarry than those who relied on mines. This also gives a greater distribution to workshop areas associated with other site types (Deaver, 1988: 2).

Archaeologists have identified sites that contain one or combinations of all quarry types in Southwestern Montana. Avon Valley appears to be a combination of quarry types 2 and 3 based on the variety of material types and the ubiquitous nature of the flake distribution and concentration. The outcrops that provide Avon Chert were mined while the basalts and other non-local cherts were found in the cobbles on the pediment.
Prehistoric Quarries in Southwest Montana

There are several documented lithic procurement and workshop sites in western Montana. It is important to acknowledge that lithic procurement, settlement and population movement patterns, and subsistence strategies over time are recognizable on a regional level. This allows a broad regional view of behavior by prehistoric indigenous cultures while at the same time recognizing greater detail of those behaviors within cultural groups.

Flying D Ranch

Mark Baumler and his team did a preliminary study of the Flying D Ranch located in the northern Madison Range 20 miles to the southwest of Bozeman in Southwestern Montana during the seasons of 1992-93. This project came about because studies conducted during the last decade suggest that the interpretations of upland and high altitude prehistoric occupation needed critical review and considerable revision. It was strongly felt that the foothills and mountains that surround valleys, basin, and plains deserve more credit for their complexity and variation than has been given in the past (Baumler et al, 1996: 41). The Flying D Ranch Archaeological Project was done in order to better understand how native people used this foothill-montane environment to procure plants and raw lithic materials. This area was also investigated as a well-known travel route as well (Baumler et al, 1996: 41-65).
As hold true with other sites in Southwestern Montana, Flying D Ranch is rich with Cambrian Age Meagher Formation and Mississippian Age Madison Formation, which contains chert, quartzite, chalcedony, and jasper. These raw materials are found not only in exposed outcrops but are found in cobble/nodule form in colluvial and alluvial deposits as well. Major source locations within the Flying D Ranch Project area are Pole Creek, Cherry Creek, and Spanish Creek Basin as well as Finnegan Ridge (Baumler et al, 1996, 1999, 2000; Passman, 1994).

Cashman Quarry

Dacite is the major raw material quarried at the Cashman Quarry. Dacite is fine grained non-obsidian volcanic rock material confused with basalt but, due to its higher silica content, is more suitable for tool making. The quarry is approximately one-acre in size with evidence of numerous pits and associated with dense flaking debris berms and fill, bifacial and blocks cores, and many hammerstones. Areas away from the main quarry produced artifacts such as bifaces in various stages of production, hammerstones and contain a small percentage of exotic stone including obsidian and chert (Baumler, 1999: 4). The site has a total of 16 features including the main quarry, several rock cairns and rock piles, two secondary workshop areas, and several raw material concentrations with flaking debris on the surrounding hills and alluvial fans. The investigators think the site, and the area in general, is likely to have had a regional importance in raw material procurement (Baumler, 1999: 3).
A team of geoarchaeologists from the University of Maine in cooperation with the Bureau of Land Management conducted research here in 1985-86 with the goal of producing data relevant to the peopling of the Americas. They chose an area located in southwestern Montana, the South Fork of Everson Creek, which is part of the Upper Missouri drainage. Geological investigations of the region suggest that this area has not been subject to glaciation in the past 100,000 years (Turner, et al, and 1988:96-98). Therefore, this location was particularly attractive to Paleoindian researchers because Pleistocene and Holocene environmental and archaeological data should be well preserved and exposed. The physical location is located at the base of the Beaverhead Mountains in the Bitterroot Range approximately 7 kilometers west of the Continental Divide at an elevation of 2076 meters (6800 feet) above sea level. Geologically, the area is located approximately 280 kilometers south of the southernmost extent of the Wisconsin-age glacial margin and immediately southeast of the area where the most severe mountain glaciation occurred (Bonnichsen, et al, 1992, 1987, 1986).

The research team visited and evaluated 19 different sites in order to choose a suitable research area. They chose the South Fork of Everson Creek due to the discovery of subsurface chalcedony deposits, which were quarried into pits of various sizes. The artifacts located near the pits had been processed into cores, flakes, and
preforms in nearby workshop sites (Deaver, 1988: 1). The team recognized 16
different surface types and conducted aerial mapping in the region. This led to the
discovery of another large quarry area 4.2 kilometers south the Everson Creek on the
north side of Black Canyon Creek in the next stream valley. Pedestrian survey and
additional aerial reconnaissance led to the discovery of more quarries located between
the two sites. The area is referred to collectively as the South Everson Creek and
Black Canyon Creek Quarry and Workshop Complex (ECBC) (Bonnichsen, et al,

The Schmitt Chert Mine

According to an article published by Leslie B. Davis of Montana State
University the Schmitt Chert Mine is located on the north side of the Three Forks
Basin just downstream from the headwaters of the Missouri River in southwestern
Montana (24BW559). This is a marvelous example of a specialized prehistoric
quarry. The site consists of an open pit that has be back filled, four tipi rings, and a
200+acre camp/workshop area north and down slope of the quarry as well as large
camp/workshop site on the west shore of the Missouri River near the town of Trident,
Montana. There are several other open-pit sites in the area of the Schmitt Mine
(Davis, 1983: 10).
The site is situated on a barren knoll of Mississippian Age Madison Limestone bedrock in Broadwater County at an elevation of 1360 meters. The upper levels of the Madison Limestone are pocked by caverns, created by karst processes during ancient and modern erosional cycles. The top of the limestone beds at Schmitt is an ancient erosional surface with highly fractured and weathered rock. The limestones are chert bearing. The cherts are white, light gray, dark gray, and red-brown in color with a mottled dendritic pattern. The desirable subsurface cherts are collected after the rock has been broken with concentrated percussion along naturally occurring fracture lines with hammerstone, bone and antler percussion (Davis, 1983: 10).

The mine itself had a chert-bearing exposure on the surface. The miners began to follow the chert beds into the bed at a dip of 15° west down into the bedrock. They continued mining downward following the chert beds using this technique, which is called “gophering” in mining nomenclature. The miners would follow the bed until such time as the overhanging rock became a danger. They would then back fill by collecting the tailings and debris that would then be stuffed into the overhang. The remaining overhang was then levered, wedged, and pried until blocks of several tons would fall forward exposing deeper limestone beds to further downward excavation. Cuts and fills resulted from lateral excavation, removal, and redeposition as well as changes in direction of the mining efforts created a central pit. One shaft remains in a karst cavity with the roof and sides intact that extends 12 meters into the overlying bedrock. It is been hypothesized that mined tailings and debris that had been thrown into the central pit was done in an attempt to reduce the
hazard of tons of overhanging bedrock beds collapsing, and thus closing and inhibiting the continuing excavation of the chert beds (Davis, 1983: 11).

The Schmitt Mine has had the good fortune to have 12 radiocarbon dates from wood charcoal and mammal bone and antler material found associated with buried artifacts. These dates indicate that miners began excavating raw material about 1350 BC and eventually abandoned the mine 350 AD. The diagnostic corner-notched projectile points are characteristic of the Pelican Lake Phase of the Late Middle Prehistoric tradition in this area, which indicates a chert mining operation lasting for 1700 years by people of a single cultural tradition. Clustered radiocarbon dates suggest intermittent, possibly seasonal, mining throughout this time (Davis, 1983: 11).

Presence of exotic stone such as obsidian, Knife River chalcedony, or porcellanite (many in the form of completed tools) suggest that these materials were brought in by the miners and used for trade and exchange and became incorporated into the mine fill. By direct access to mined exposures it is theorized that the mine was abandoned in 350 AD due to the exhaustion of accessible chert beds or too great a hazard in continuing the mining process. Whatever the case, the Pelican Lake lifeway disappeared about the same time as mining ceased (Davis, 1983: 12).
In 1980 Lynn B. Fredlund assessed the Palmer Quarry site (24JF 266) for the Maronick Construction Company the purpose of which was to determine the effects on the site by proposed mining of silica, which is used in the production of cement products. The site is located approximately 1 mile west of Montana City in Jefferson County. Significantly, the site is within 1 kilometer of the MacHaffie site (24JE4), an important prehistoric occupation site with great time depth and multiple occupations.

The site is in the area Fredlund calls the Southwest Montana Chert Area (Fredlund, 1980:3). The area from Helena-Montana City to the Flint Creek Valley has numerous recorded and unrecorded cryptocrystalline sites/outcrops that were mined in prehistoric time. Geologically, this area is the contact zone between Cambrian limestone/silica beds and the Boulder Batholith. This area has also produced precious metals in historic times with placer mining that quickly become a permanent mining operation.

Prehistoric mining took the form of pit excavation and lateral extraction from the main outcrop. The raw materials extracted were mostly chert with a wide spectrum of colors ranging from white to brown. Andesite cobbles were brought in from nearby drainages to use as hammerstones and exhibit patterns of heavy battering and wear. Eight separate areas of prehistoric pit excavation were noted. Other pits
were observed but erosional and depositional processes made temporal association unclear.

In conclusion, the mountains, valleys, and mountain-foothill environments of Southwestern Montana were sources of high quality raw lithic materials that were utilized by prehistoric people intermittently for 10,000 years. The studies noted above demonstrate the changes over time in hunter-gatherer lithic technologies, adaptation by prehistoric people to constantly changing environments and the complexity of long-term utilization of these areas by many groups.
Avon Valley Debitage

Theory

Traditional research of stone tools focuses on determining specific chipped stone tool tradition, the chronology of that tradition, and the fate of tools that will eventually become discarded after being used and reused for an undefined period of time to finally be dropped at an uncertain distance from the raw material source. But flaking debris provides a direct link to the tool manufacture, processes, and knapping behaviors at the source or in close proximity to the source. To better understand the Avon collection and glean the information the artifacts promise, it was necessary to find a theoretical perspective that would best address these issues. I have selected Mass Flake Analysis (Ahler, 1975) as the approach I would use.

Stanley A. Ahler, in a paper published in 1975, discusses two general methodologies that have been used to analysis flaking debris: 1) Individual flake analysis, and 2) Flake aggregate analysis:

*Individual Flake Analysis* (IFA) recognizes that details of shape, platform, and facial characteristics on the waste flake provide imprints of discrete knapping behavior techniques that are applied to a given tool/core. There are some drawbacks (Ahler, 1975: 86).
IFA is usually selectively applied only to complete flakes or flakes with a platform,

1. IFA can be very time consuming especially when flakes are small or the flake collection is large,

2. Technological biases are likely to occur due to short cuts taken to overcome time-consuming work, i.e. ignoring small flakes, which certain knapping techniques invariably produce,

3. Attributes of IFA are subjective, thus experiments are difficult to reproduce and data sets form study to study cannot be compared with any confidence,

Individual flake types and flake attributes are not good indicators of the variation of human behavior (Ahler, 1975: 86-87).

*Flake Aggregate Analysis* (FAA) shifts attention from observations of an individual flake to observations about a batch of flakes that have a predetermined set of variables i.e. material type, whether or not a flake has cortex, stratigraphic position, and flake size, within a single context. This procedure counters the major disadvantages of IFA, point for point, with major advantages.

1. FAA procedure can readily be applied to an entire debris collection of the same archaeological context without concern about flake fracture or the completeness of individual flakes. All knapping behaviors can be included eliminating potential bias from broken flake exclusion,
2. FAA is rapid and efficient, especially with large artifact samples that include many small flakes. This is due to the size grading that is the first step in the analysis,

3. Technological biases based on size are effectively eliminated because size grading takes the smallest flakes into account, and

4. FAA provides a relatively high level of replicability and objectivity due to the analytical procedures such as size grading and counting (Ahler, 1975: 87-88).

FAA has two potential flaws. 1) Similar to #4 in the IFA, there is still no clear linkage between the recorded data sets and human behavioral variation, and 2) the archaeological sample will reflect, more often than not, several episodes of knapping in the same archaeological sample wherein behavioral byproducts are a composite of behaviors rather than a discrete episode.

The theory behind Flake Aggregate Analysis is distinguished primarily by specific sets of analytical variables and their relationship to one another. In order to get the most out of the Avon Valley collection two of Ahler’s variables were used: progressive size reduction and progressive cortex removal. Because the working theory stipulates that a variable must be able to be duplicated, I will use two additional variations in this analysis, raw material type (because materials came from a number of sources, and stratigraphic context, which is important because it demonstrates a continuum through time.
Progressive Size Reduction: Tool manufacture by knapping is fundamentally a reductive technology with predictable and repetitive size constraints on byproducts produced. No flake produced by a reductive knapping behavior can be larger than the original size of the tool/core. As reduction continues, the core/tool becomes smaller and the average size of the byproduct flakes becomes progressively smaller as well (Ahler, 1975: 89).

Whatever the beginning size of the raw material, flakes produced early in the production process should have relatively greater numbers in the large size classes, while later stage flake removal produced from the same tool/core should have fewer or no flake representation in the large size classes and relatively greater numbers in the smaller size classes.

Progressive Cortex Removal: Cortex is defined as the outer rind or surface of a piece of raw material before the human modifications of flake removal or fracturing. Thus, in theory, many tool/cores are covered by cortex to some degree. As tool reduction continues the amount of cortex on the outer surface becomes less and less. The specific amount of cortical removal depends on the knapping techniques used and the raw material used, i.e. stone from a quarry bed with very little cortex to remove or a cobble in a stream bed that requires a great deal of cortex removal to reach the good quality stone. Because flake size can be expected to vary with techniques and reduction stage of production, it is more
important to record the presence or absence of cortex rather than the percentage of a flake that contains cortex because the amount of cortex on a tool/core is unpredictable (Ahler, 1975: 90).

*Raw Material Type:* Because we are analyzing flakes derived from a known quarry it would be expected that the greatest amount of debitage should be the locally derived “Avon Chert”. It is interesting to note that other raw material types present in the collection. Advances and retreats of the Flathead Glacier during Pleistocene-Holocene times contributed to the deposits of extensive moraines and associated outwash gravels (Choquette et al, 1981: 3-5; Fields, 1983: 1-5). These gravels composed much of the thick pediment deposits (cobbles of Precambrian Belt rock, andesite, basalt, rhyolite, and chert,) therefore flakes knapped from these materials are represented in the collection. Flakes knapped from materials other than those found in the valley are also at hand. Because all tools are knapped from some type of raw material, material type fits the criteria of a variable that can be duplicated under the criteria of Flake Aggregate Analysis

*Stratigraphic Context:* Not all archaeological sites have the luxury of a stratigraphic context. The excavators of the Avon Valley collection maintained a record of the stratigraphic horizon that provides a relative time depth. This affords a means by which we may be able to recognize changes in tool production behaviors across time. For that reason it is the last variable.
Flake Aggregate Analysis looks for the similarities and relationships between data sets that can be duplicated. Because the size of a flake, whether or not a flake has cortex, the type of raw materials used, and stratigraphic context are conditions of numerous collections of flake debitage, many archaeological data sets or collections will demonstrate these repetitive patterns and consistencies that confirm some of the basic premises of Flake Aggregate Analysis. The variables chosen provide confidence that the analytical procedure can provide a productive method of flake analysis in many archaeological contexts. The questions to be addressed from this analysis are related to how and why were the various raw materials used; were there refinements/changes in tool production technologies over time; and was quality of the raw material used important to the makers of the tools?
Method

I separated the flakes into the categories chosen as variables. First, I divided the flakes into size grades by putting them through nested geologic screens. The size grade screens correspond to the following screen mesh sizes: $G_1 = 1''$, $G_2 = \frac{1}{2}''$, $G_3 = \frac{1}{4}''$ and $G_4 = \frac{1}{8}''$ mesh.

Secondly, because the artifacts were taken from specific stratigraphic layers, I endeavored to maintain their original stratigraphic context. According to the journal by Mrs. Philip Hobler (Journal notes, 66-67), there are three general stratigraphic layers: 1) The topsoil or surface zone, which is approximately 18” deep, 2) the white calcareous zone, which is approximately 19” deep, and 3) the humic zone as the deepest strata, which is approximately 40” deep. These strata and associated depths are important because they demonstrate time depth.

Thirdly, the sorted size grades were separated by whether or not the flake had cortex present. This technique is much less time consuming than determining degrees of cortex removal. Further, because flake size can be expected to vary with techniques and reduction stage of production, it is more important to record the presence or absence of cortex rather than the percentage of a flake that contains cortex because the amount of cortex is on a tool/core is unpredictable.
Finally, each flake was sorted by the type of material from which it was produced (Basalt, silicified marl, or other stone types). Due to the variety of raw stone types and lack of finished tools found in the quarry and associated areas it may be inferred that the quarry was not just a raw material procurement area but a work and production area also (Hester et al, 1979).

Each flake was counted and noted on a spreadsheet according to its size, cortex or no cortex, material type, and stratigraphic context. The data were then analyzed using the Chi-squared statistical evaluation. According to the Chi-squared theory of an observed value under a hypothesis of independence, if an expected value greatly exceeds the observed value, the combination of attributes was preferred by the makers. Conversely, if an expected value is much smaller than the observed value, the value was avoided. The four variables chosen for this test were cross-tabulated producing six significant Chi squared values—some are stronger than others. A break down of the categories and the variations within each category are as follows:

- Context 1 is Surface Zone, top,
- Context 2 is White Calcareous Zone, middle,
- Context 3 is Humic Zone, lowest.
- Material 1 is Basalt,
- Material 2 is Silicified Marl,
- Material 3 is Other Stone.
- Size 1 is G1 (1’’),
- Size 2 is G2 (½’’),
- Size 3 is G3 (¼’’),
- Size 4 is G4 (½’’).
- Cortex 1 is without Cortex,
- Cortex 2 is with Cortex.
Analysis

The first analysis considers whether Stratigraphic Context is independent of Material Type. Table 1, rows 1-5 summarizes the results of the relationship of time depth (Context) to Material Type. The Chi-squared value for this test is 27.45, which exceeds a .05 level of significance and 4 degrees of freedom. Inspection of the table shows that Zone 1 has fewer flakes of Basalt observed than expected; there are fewer flakes of Avon Chert than expected; and more flakes of Other Materials than observed than if the materials were independent. Zone 2 shows a similar distribution of fewer flakes of Basalt that expected; more flakes of Avon Chert than expected; and significantly fewer flakes of Other Materials than expected. Zone 3 demonstrates that Basalt flakes are more than expected, Avon Chert was more than expected; and Other Materials are less than expected.

The number of flakes in each Zone indicates the material preferred by the makers of tools within that time frame. I believe that basalt cobbles were used opportunistically; Avon Chert was the material of choice, being used most often. All other materials were used incidentally, which suggests the degree to which mobility and transport were occurring. It may also suggest that Other Materials brought into the work areas were already in various stages of production. The rarity of Other Material flakes in Zone 2 (White Calcareous) and Zone 3 (Humic) suggests that mobility and transport were more limited
during earlier times while the Zone 1 (Surface) collection of Other Materials increases significantly. This suggests that people moving through the valley in a later time had a greater mobility perhaps due to the reintroduction of the horse in the Americas in the 16th century, which arguably brought about the greatest cultural change for peoples in the Northwestern mountains and plains (Frison, 1978: 122). With the exception of the greater amount of Other Materials used at the surface, raw tool material choices changed little over time.

The second analysis examines whether Material Type is independent of the presence of Cortex. Table 1, rows 7-12 summarizes the results of the relationship between Material Types and Cortex. The Chi-squared value of 18.83 exceeds a .05 level of significance with 2 degrees of freedom. Inspection of the Table shows that Basalt flakes without cortex are fewer than expected while flakes Basalt flakes observed with cortex are more frequent than expected under a hypothesis of independence. This suggests that once again the tool makers used basalt cobbles opportunistically, or as a second choice, reflected by the greater number of flakes with Cortex than without because Basalt cobbles are not as easily worked and tend to leave a greater amount of waste flakes with cortex (Deaver, 1988, Baumler et al, 1999). Avon Chert flakes observed without Cortex exceed those with Cortex. This is explained by the fact that Avon Chert was mined from the exposed beds of the silicified marl found in Avon Valley, and since they don’t come from cobblestone, this keeps cortex at a minimum. Other Materials observed show that flakes without Cortex exceed
those with Cortex. This may be due to pieces of raw material being brought into the Avon Valley with the cortex already removed. Avon Chert, as the most easily procured with the least need for cortex removal, was the material of choice in this area. It has the greatest amount of observed flakes without cortex and a least amount of flakes than expected with cortex. Avon Chert was worked in close proximity to the places of procurement with completed or partially completed pieces taken from the quarry area.

The third analysis states that Material Types are independent of Flake Size. Table 1, rows 13-18 summarizes the results of this relationship. The Chi-squared value of 20.64 exceeds a .05 level of significance and 6 degrees of freedom. An inspection of the table reveals that the size of the flake during the production stages not only demonstrates a preference by the tool makers for the Material Type used, but indirectly reveals the quality of the raw material.

Basalt shows the greatest discrepancy in number of observed G1 (largest) flakes to those expected. This would indicate that a great deal of material had to be removed to get to the useable portion of the basalt cobble. There are a greater number of observed flakes in the G2 category than expected. This would indicate that Basalt is fragile or of lesser quality and this was the optimum size Basalt cobbles could be made into flakes for usefulness. G3 shows the number of flakes as less than expected supporting the theory that basalt is somewhat fragile for small flakes. G4 also shows fewer observed flakes than expected.
This may be because these flakes are shatter from larger pieces broken off during use or during resharpening.

Avon Chert shows fewer observed than expected flakes for G1; slightly fewer G2 and G3 are observed than expected with proportions between the data being very small, and G4 shows the observed and the expected to be the same. Once again we see that Avon Chert is the raw material of choice and the reason people came to the area (Hester et al, 1977; Cameron, 1984). The material did not require a great deal of preparation to get to the useable portions of the rock. G2 and G3 indicate the greatest number of flakes with the least significant numeric difference between observed and expected, therefore these were the most usable size. G4, being the smallest flakes, might be interpreted as shatter or retouch.

Other Material in the size G1 indicates that the number of observed flakes are less than the expected under a hypothesis if independence. Size G2 shows fewer flakes observed to expected, while size G3 shows more observed flakes to expected. G4 shows more observed flakes than expected. This would indicate that Other Material was obtained through trade/exchange and was preprocessed in another location with very little large flake removal in the workshop area, while the medium sizes were being worked in the local workshop areas. The smallest G4 size indicates the retouching of the tools made from this highly desirable material was done.
The fourth analysis examines whether the presence of Cortex is independent of Size. Table 1, rows 19-23 summarizes the results of this relationship. The Chi-squared value of 20.32 exceeds a .05 level of significance with 3 degrees of freedom. Inspection of the Table suggests that Cortex was removed from raw materials in relation to the quality of material used during a specific stage of reduction.

G1 shows fewer observed flakes without cortex than expected under a hypothesis of independence while G1 with cortex shows a greater number of observed flakes to the number of flakes expected. We should assume that more of the largest flakes should have cortex since the first step of tool manufacture is to reduce the raw material to a usable form. Size G2 has slightly fewer flakes without Cortex and slightly more observed flakes with Cortex than expected. This suggests that some of the materials used were either of lesser quality than others or distinguishes between mined material and cobble material. Size G3 has more flakes without Cortex and fewer flakes observed with Cortex than expected. Size G4 has less observed flakes without cortex than expected and more observed flakes than expected with Cortex. This suggests either the finishing process by the removal of small bits of cortex during the completion of a tool, or environmental and erosional factors such as cryoturbation, bioturbation, weather and erosion patterns.
The fifth analysis examines whether Stratigraphic Context is independent of Size. Table 1, rows 24-29 summarizes the results of this relationship. The Chi-squared value of 10.89 for 6 degrees of freedom exceeds a .05 level of significance suggesting that the association is not as strong as the other relationships discussed above. Inspection of the Table suggests that on the Surface flakes classified as G1 occur slightly more than expected under a hypothesis of independence with very little difference in the figures. Flakes observed as G2 occur less than expected and there are more flakes observed as G3 than expected. Finally, G4 flakes are fewer than expected.

The White Calcareous Zone shows no great difference between observed and expected values for G1 flakes. There are slightly fewer G2 than expected and G3 are slightly more frequent than expected. Observed flakes for G4 are less than expected.

The Humic Zone shows fewer G1 and G3 than expected. G2 and G4 flakes occur more often than expected. When the differences between the Surface and the Humic Zone are taken into account, they seem to be opposite of each other with the White Calcareous Zone showing the least amount of difference between observed and expected. The actual number of flakes present in the collection demonstrates that flake sizes remain reasonably consistent within the Context Zones, showing very little change through time in reduction.
techniques. Differences may be related to conditions of the environmental and erosional patterns at the time of deposition.

Finally the sixth analysis investigates whether Stratigraphic Context is independent of the presence of Cortex. Table 1, rows 30-34 summarizes the results of this relationship. The Chi-squared value of 4.07 does not exceed a .05 level of significance with 2 degrees of freedom. This suggests that there is very little change in reduction technique through time.
Conclusion

Avon Valley was a branch of one of several major thoroughfares for early people moving from the mountains in the west to the plains in the east (Malouf, 1981; Cameron, 1984). Various studies suggest that although the climate in Avon Valley was harsh in the winter (Greiser et al, 2000 Choquette et al, 1981), the resource availability in the milder seasons was abundant. Therefore, it is suggested that people visited the valley seasonally, not only to replenish dwindling toolkits but as a stopping place for those traveling back and forth from the mountains in the west to the plains in the east (Hester, 1977; Cameron, 1984). The evidence further suggests that the quarry in Avon Valley was visited time and again for stone procurement and tool production by groups of indigenous people. The statistical analysis of the artifacts bear out that over time people took advantage of the raw toolstone materials at their disposal in the valley in various ways.

With the ease of access, availability, and procurement combined with desirable quality, the Avon Chert was a resource valued by Prehistoric and Protohistoric people. Raw material choices by indigenous groups in the area do not appear to have changed much over time. There is however, a trend from the earliest time depth in the Humic Zone, to move away from using basalt to using other materials that were not as easily obtained or were brought in during the latest time frame as suggested by the greatest amount of these artifacts being...
collected from the Surface Zone. Further, the expected and observed amounts of Avon Chert, with or without cortex and in the various sizes produced by flake reduction as discussed above, do not demonstrate a significant statistical difference in the production or use patterns even though the actual flake counts are extremely high.

The analysis does, however, demonstrate an opportunistic production of tools made from basalt as evidenced by the greater than expected number and size of flakes with cortex. Further, there is suggestion that tools produced from other materials are present due to the degree of mobility and transport available at in a later period of time, because the greatest numbers of flakes made from other materials are found in the Surface Zone. This may further suggest greater mobility of indigenous groups due to reintroduction of the horse to North America during Protohistoric times. Tool production techniques seem to have changed little over time; with the amount of cortex and the size of the debitage in relation to the stratigraphic context attesting to those small changes.

I would conclude that Avon Chert, being the most abundant raw material available, of predictable and consistent quality, and the most easily accessible raw toolstone was the preferred raw lithic material in the area. I agree with earlier researchers that Avon Valley is of great archaeological value that warrants additional and extensive study.
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Turner, Mort D., Joanne C. Turner, Robson Bonnichsen.  

White, Thain.  
Antelope Hill
Area of Avon Chert Quarry
Page 57
Figure 3

Powell County, Montana
Figure 4

Sketch Map of
24PW346 - North Avon Quarry
Cameron, 1984
Figure 5

Old Cabin Area (OCA), Heeter et al, 1977
### Avon Valley Variables Chart

**Table 1**

#### Case 1 - Context/Material

<table>
<thead>
<tr>
<th>Material</th>
<th>Surface Zone</th>
<th>1.</th>
<th>2.</th>
<th>3. Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basalt</td>
<td></td>
<td>233</td>
<td>107</td>
<td>332</td>
</tr>
<tr>
<td>Avon Chert</td>
<td></td>
<td>258.9</td>
<td>180.5</td>
<td>232.7</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>1648.3</td>
<td>1149.2</td>
<td>1575</td>
</tr>
<tr>
<td>Expected</td>
<td></td>
<td>576</td>
<td>68</td>
<td>690</td>
</tr>
<tr>
<td>#Expected</td>
<td></td>
<td>265.8</td>
<td>185.3</td>
<td>238.9</td>
</tr>
<tr>
<td></td>
<td><strong>Totals</strong></td>
<td><strong>672</strong></td>
<td><strong>265.8</strong></td>
<td><strong>690</strong></td>
</tr>
</tbody>
</table>

#### Case 2 - Material/Cortex

<table>
<thead>
<tr>
<th>Material</th>
<th>Without Cortex</th>
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<th>2.</th>
<th>3. Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basalt</td>
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<td>355</td>
<td>3418</td>
<td>4417</td>
</tr>
<tr>
<td>Avon Chert</td>
<td></td>
<td>526</td>
<td>3351</td>
<td>4417</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>317</td>
<td>861</td>
<td>1224</td>
</tr>
<tr>
<td>Expected</td>
<td></td>
<td>146</td>
<td>928</td>
<td>1224</td>
</tr>
<tr>
<td>#Expected</td>
<td></td>
<td>164</td>
<td>63</td>
<td>63.7</td>
</tr>
<tr>
<td></td>
<td><strong>Totals</strong></td>
<td><strong>4417</strong></td>
<td><strong>18.83</strong></td>
<td><strong>1224</strong></td>
</tr>
</tbody>
</table>

#### Case 3 - Material/Size

<table>
<thead>
<tr>
<th>Size</th>
<th>G1 # Expected</th>
<th>G2 # Expected</th>
<th>G3 # Expected</th>
<th>G4 # Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Basalt</td>
<td>139</td>
<td>34.9</td>
<td>356</td>
<td>337.5</td>
</tr>
<tr>
<td>2 Avon Chert</td>
<td>134</td>
<td>222.3</td>
<td>2178</td>
<td>2149</td>
</tr>
<tr>
<td>3 Other</td>
<td>20</td>
<td>35.8</td>
<td>299</td>
<td>346.5</td>
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<tr>
<td>Totals</td>
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<td>293</td>
<td>2833</td>
<td>2833</td>
</tr>
</tbody>
</table>

#### Case 4 - Cortex/Size

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<tr>
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<th>G1 # Expected</th>
<th>G2 # Expected</th>
<th>G3 # Expected</th>
<th>G4 # Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Without Cortex</td>
<td>121</td>
<td>229.4</td>
<td>2210</td>
<td>2218.3</td>
</tr>
<tr>
<td>2 With Cortex</td>
<td>172</td>
<td>63.6</td>
<td>623</td>
<td>614.7</td>
</tr>
<tr>
<td>Totals</td>
<td>293</td>
<td>293</td>
<td>2833</td>
<td>2833</td>
</tr>
</tbody>
</table>

#### Case 5 - Context/Size

<table>
<thead>
<tr>
<th>Size</th>
<th>G1 # Expected</th>
<th>G2 # Expected</th>
<th>G3 # Expected</th>
<th>G4 # Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Surface Zone</td>
<td>119</td>
<td>112.9</td>
<td>983</td>
<td>1091.3</td>
</tr>
<tr>
<td>2 White Calcareous Zone</td>
<td>75</td>
<td>78.7</td>
<td>746</td>
<td>760.9</td>
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<tr>
<td>3 Humic Zone</td>
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<td>101.4</td>
<td>1104</td>
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<tr>
<td>Totals</td>
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<td>2833</td>
<td>2833</td>
</tr>
</tbody>
</table>

#### Case 6 - Context/Cortex

<table>
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<tr>
<th>Material</th>
<th>Without Cortex</th>
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<th>2.</th>
<th>3. Total</th>
</tr>
</thead>
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<tr>
<td>Basalt</td>
<td></td>
<td>1663</td>
<td>1165</td>
<td>1589</td>
</tr>
<tr>
<td>Avon Chert</td>
<td></td>
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<tr>
<td>Other</td>
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<td>510</td>
<td>350</td>
<td>364</td>
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<tr>
<td>Expected</td>
<td></td>
<td>471.5</td>
<td>328.7</td>
<td>423.8</td>
</tr>
<tr>
<td>#Expected</td>
<td></td>
<td>471.5</td>
<td>328.7</td>
<td>423.8</td>
</tr>
<tr>
<td></td>
<td><strong>Totals</strong></td>
<td><strong>4417</strong></td>
<td><strong>1224</strong></td>
<td><strong>1224</strong></td>
</tr>
</tbody>
</table>

X=4.07