Chapter 12

Keatley Creek Lithic Strategies and Design

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Introduction

The purpose of this analysis is to identify the general strategies of lithic utilization employed for different activities carried out at the Keatley Creek site. It is important to understand the use-nature of specific types of tools in order to interpret the nature of tool patterning across living floors and thus infer the nature of activity areas and past socioeconomic organization in pithouses. However, it is also important to have a comprehensive understanding of the procurement, production, resharpening, and discard aspects of individual types of tools in order to create clear site formation models involving artifacts and different types of deposits. The goals of this chapter are therefore to generate models of lithic procurement, production, and use in order to understand why certain materials were brought to the site, why some tools but not others were manufactured or resharpened at the site, and why some tools but not others were abandoned or discarded at the site and in different proportional frequencies. This is an essential part of understanding the prehistoric economy of Keatley Creek.

The framework that we shall use to structure the presentation and analysis of data is based on design theory (Pye 1964, 1968; Horsfall 1987; Hayden et al. 1996). This approach emphasizes various constraints in the production of technological solutions to given problems. Our analysis centers on the identification of probable activities requiring technological solutions at the Keatley Creek site, as well as the identification of important constraints for those solutions. These are described in detail below. We then attempt to match the archaeological procurement of materials (detailed in the preceding chapter and in Vol. I, Chap. 16) and production of tools to the technological problems and limitations faced by the prehistoric residents of Keatley Creek in order to understand how tool characteristics make sense in terms of needs and constraints. Where solutions are distinctive enough in terms of basic procurement, reduction, and production, we refer to them as distinctive "strategies." At a somewhat lower conceptual level are concepts such as "specialization," "reliability," "portability," and other design features (Nelson 1991; Bleed 1986). Following Nelson (1991:66). We prefer to view these aspects in terms of decision criteria, or design considerations rather than strategies.

Having established what lithic materials were available in the vicinity of Keatley Creek in the preceding chapter, our major goal now is to understand why a specific tool was made of a particular material, on a particular kind of flake, and shaped or resharpened in a particular manner. We seek to understand the criteria that people used in making decisions about creating their tools: was economizing raw material most important, or ensuring reliable performance, or efficiency, or portability, or other considerations? It must be emphasized that this analysis is exploratory and heuristic in nature. We are not aware of any other analysis of a complete archaeological assemblage that has attempted to deal with tools in this fashion. Rather than being conclusive or definitive, this analysis is meant to create the framework for future analyses and the identification and testing of assumptions used. We have endeavored to include all the most numerically important and distinctive tool types except for projectile points, which we feel are very complex and warrant a separate analysis. See Volume III, Chapter 1 for detailed definitions of all tool types.

The activities carried out with individual classes of artifacts were inferred mainly from ethnoarchaeological and experimental information and/or the presence of use wear damage. The ethnographic information available for the Interior Plateau was also used to generate expectations concerning the activities most frequently performed in and around winter pithouses. These expectations were compared with archaeological materials in order to identify specific areas of analysis that require more intensive examination.

Ethnographic Data

The ethnographical information for the Mid-Fraser River Area has been summarized by Alexander (Vol. II, Chap. 2; and 1992). She indicates that inhabitants of the area moved to their winter pithouse dwellings on the river terraces in November. In the Chilcotin, while the winter houses were being prepared, people hunted and fished near the village at lower elevations (Lane in Alexander 1992). Alexander believes that this was probably also the case in the Lillooet region. In addition, David Low (personal communication) indicates that few animals would be found below 1,000 m altitude in the Keatley Creek vicinity during the late fall and early winter. Hunting was the dominant subsistence activity at this time, when animals were fat and had thick fur, and were moving out of the mountains to their wintering grounds at intermediate elevations (down to 1,000 m). Deer could be especially easy prey at this time of year since they gathered in large numbers and responded readily to hunting calls. Communal hunts were most frequent in the fall, but they may have taken place in any season. Other animals were hunted in smaller numbers including: sheep, elk, marmot, bear, and beaver, all of which could be found in the mountains. During December, January and February people stayed mainly indoors. The principal food was dried stored fish (primarily salmon), but men continued to hunt deer and other animals, especially in milder weather. Ice fishing was also pursued. Men spent part of the winter manufacturing spears, daggers, and weapons for warfare, while the women dressed hides (Teit in Alexander 1992).

January was the coldest month. Most activities were confined to the interior of winter dwellings. Hunting was rarely undertaken. Ungulates were lean and provided a poor return for the effort involved in procuring them. However, hare and grouse were available close to the village and could provide small supplements to the diet.

Late February and early March could be a critical period, when stored food might become limited or exhausted. If the warm weather was late, people could not hunt or fish (Lane in Alexander 1992). During this period, the extremely cold weather might force everyone to stay in their winter dwellings. At the end of February and the beginning of March people began to move away from their winter dwelling sites. Game was easier to run down and kill because the snow was melting. However animals were scarce and in poor condition. Plants available year round on the terraces, such as cactus leaves, could be gathered if food was short.

By late March most families had moved out of their winter houses and into summer dwelling lodges, but historically the winter village was used as a basecamp while picking berries. In the past, the Lillooet sometimes occupied their pithouses during the summer (Vol. II, Chap. 2; Kennedy and Bouchard 1978 in Alexander 1992), but the reasons for this are unclear. Alexander believes that the winter village was probably revisited frequently throughout the warmer months to store food and supplies, and that it could also have served as a residence for the elderly, the infirm, or children, while the others were in the mountains.

With these ethnographic data in mind, and assuming the activities carried on during ethnographic and archaeological times were similar, it is possible to develop some general expectations concerning the activities which should be most represented at the Keatley Creek site (see Vol. II, Chap. 2 for detailed documentation of the following activities).

1) Since hunting was undertaken during part of the winter occupation, residents undoubtedly prepared the necessary tools at the site. Thus, broken and/or unfinished preforms and projectile points should occur in the pithouses. They could have been abandoned or lost during the manufacturing process or be brought into the site for repair and resharpening. In the case of tools abandoned during the manufacturing process, fractures difficult to deal with or internal flaws might be common. Loss might also be relatively frequent due to poor lighting and the small size and dark color of most Kamloops projectile points. Assuming arrows were used, residents would also have needed to prepare shafts and bows. Hunting should have also involved cut-

ting activities related to butchering or filleting the parts of animals brought into the site (or into hunting camps) for consumption or drying (Alexander 1992; Romanoff 1992).

2) Weapons. Tools for warfare were prepared in winter dwellings. The most labor intensive of these tools (e.g., carved clubs) would probably be removed from the site. Other tools used to make weapons are probably indistinguishable from tools used to make hunting paraphernalia.

3) Hide preparation. Tools related to hide preparation are also expected to occur, especially those used for dry skin scraping and softening in the manufacture of buckskin. Winter would have also been a good period for making buckskin clothing, since many hours were undoubtedly necessary for tailoring and sewing buckskin. Thus, evidence for sewing, hide cutting and puncturing should also occur.

4) Plant gathering. Some plant gathering activities would become important if the winter was long. Preparation of plant gathering tools and receptacles for the spring could be expected to occur in winter dwellings. Thus, baskets and digging sticks would be repaired or manufactured. For these tasks, we assume that scrapers and utilized flakes would be used.

5) Prestige and Ritual items. Because of the labor intensive nature of making ceremonial or status items and the abundant "down time" during winter residence in pithouses, it seems likely that most of the manufacturing of these items took place in pithouses. The presence of tools related to carving may be the only indicators of these activities, including: beaver incisors, drills, and different classes of utilized flakes. These tools can also be used for decorating bone objects (Teit 1900:183).

6) Dwelling preparation. Preparation of the winter dwellings would also involve the use of some tools such as those related to heavy wood working. Making posts, racks or shelves; making or repairing sleeping platforms and storage platforms; and digging out storage pits are activities that would require tools such as hammers, digging sticks, adzes, axes, and chisels. The tools used in these tasks were probably ground stone adzes or flaked quartzite celts, mauls (hammers), and antler wedges (Teit 1909:715; 1912:349; 1917:29) since no other type of heavy wood working tools have been found at the site.

7) Ice fishing. Evidence for the preparation of wood and bone fishing gear (e.g., hooks and leisters) may be difficult to isolate from other activities in which utilized flakes, scrapers, and notches were also prominent parts of the tool kit (e.g., arrow and basketry making). The low frequency of making leisters and fish hooks might make such activities even harder to detect. Their presence is therefore somewhat hypothetical.

8) Storage. In base camps of collectors, both food and artifacts should be stored for future use (Binford 1980). Cores, bifaces, weapons, site furniture, flakes of raw materials not available in the area, and valuables can all be expected to be stored in pithouses or nearby. Accordingly, Teit (1900:199) mentions the presence of an underground cache pit and of an elevated cache (both for food). Since most of the lithic sources for artifacts found at the site are in the mountains, storage of lithic materials in pithouses was probably one solution for winter needs when raw material sources were frozen in the ground or buried under snow cover.

In summary, on the basis of the ethnographic data, we expect the artifacts most frequently recovered in the Keatley Creek housepit assemblage to be those related to secondary butchering and filleting, hide working, tailoring activities, and preparation of hunting and gathering equipment (Table 1). Although there are only limited use-wear data as yet, analysis indicates that the working of hides, plant materials, and minerals took place in HP 7 (Vol. II, Chap. 3). For heuristic purposes we have constructed a model to explain general assemblage characteristics by examining the most important tool classes recovered at the site in order to determine whether a reasonable correspondence exists with the activities expected in pithouses and to see if the design and materials of the tools can be explained in terms of the constraints and task requirements that we presume to have existed during the occupation of the site.

In order to structure the analysis of the Keatley Creek assemblage in terms of technological problems and solutions, we have tentatively assigned tool types to specific tasks. According to local and comparative ethnographic data (mainly Teit 1900, 1906, 1909—see Vol. II, Chap. 2, Appendix B), the following tools could have been used in the following activities:

A composite inventory of all tool types and their relative frequencies from all excavations at the site is presented in the Appendix. Tool frequencies from individual housepits or other excavations are provided in Volume I, Chapters 14 and 15; Volume II, Chapters 11–14; and Volume III, Chapters 1, 10–11. With these preliminary considerations in mind, we can now examine some specific tool types, the constraints most likely associated with them, and the strategies apparently used in fabricating and using them.

Table 1: Activities and Tools Expected in Housepits

Wood working	**heavy**	adzes axes hammerstones or mauls bifaces?
	shaving	right angle flakes "knives" (Teit 1900:183) utilized flakes with acute to semi-abrupt angles scrapers (Hayden 1979a) notches (Hayden 1979a) core planes
	drilling	perforators borers drills
Meat procurement and processing (hunted game)	**hunting**	broken and unfinished preforms and projectile points
	skinning	scrapers bifacial knives
	cutting hide	"knives" flakes with acute angles and invasive retouch (retouched or utilized)
	disjointing	bifaces (Jones 1980) "knives" chopper or unmodified cores or blocks (Hayden 1979a) spall tools
	cutting tendons	bifaces (Jones 1980) any "sharp" acute angle tool (Jones 1980)
	cutting meat in heavy butchering	bifaces (Jones 1980) cleavers (Jones 1980) flakes with acute angles (retouched or utilized) (Frison 1989) scrapers unifacial knives
	filleting	knives ? flakes with acute angles and invasive retouch (retouched or utilized)
	cutting or carving of bone	flakes with semi-abrupt angles (retouched or utilized)
Preparation of skin		end scrapers (Hayden 1990) spall tools side scrapers (Cantwell 1979)
Making buckskin clothing		flakes with acute angles and invasive retouch piercers stone wedges (pièces esquillées) used to make bone awls
Basketry		"knives" flakes with acute angles (retouched or utilized) scrapers? expedient scrapers small notches?
Bark cutting (for baskets, etc.)		acute edged utilized flakes

Parameters to be Examined

According to design theory, a number of constraints can play important roles in solving technological problems. We have identified the problems most likely to be dealt with in winter pithouses. At the most basic level, the constraints that we will consider are:

- *suitable raw materials* for the successful and relatively efficient solving of specific technological problems;
- relative *availability* of the various suitable raw materials, including procurement costs (*travel time, transport costs, search time, exchange costs, seasonal changes*) and the *size range* of available materials;
- *cost and difficulty of manufacturing* tools for given solutions including producing the flake types necessary;
- *volume of materials to be processed and frequency of processing events;* these factors have been related to the degree of specialization and resharpening strategies used in tool designs (Hayden 1987; Hayden and Gargett 1988);
- *longevity* of given tool solutions and replacement rates;
- *time constraints* associated with specific tasks (Torrence 1982);

- *need to transport* tools as well as other materials.

In addition to these relatively basic constraints, we will also examine the potential roles of several "design criteria" that have been proposed as important for explaining tool characteristics. While they seem to emerge as a result of basic constraints, they are not clearly "strategies" in the usual sense of the term. These design criteria include concepts such as hafted versus unhafted, generalized versus specialized designs, and choices of resharpening techniques (Hayden 1987, 1989). The role of other, more abstract, qualities such as reliability, maintainability, flexibility, and versatility have been examined in detail in a previous publication (Hayden et al. 1996).

The resulting strategies that can be identified after examining all of the above factors will be discussed in terms of strategies of raw material procurement, use, reduction, and resharpening. The tools we discuss will be grouped according to their similarities in terms of these strategies. Because lithic raw-material plays such a central role in the following discussions, a major component of the research at Keatley Creek involved the identification of raw material stone sources as documented by Mike Rousseau in the preceding chapter.

Most of the raw material utilized at the Keatley Creek site is trachydacite probably from the upper Hat Creek drainage. Though it is located between 15 and 20 kilometers in a straight line from the site, the topography is very rugged and the "effective" distance is considerably greater. The sources of chert are located at the same range of distances. Although some closer potential sources have been located, their quality is inferior, and there is almost no raw material from these sources at the site. Quartzite and some other metamorphic and igneous rocks could have been obtained in the river or till gravels within of 1–2 km of the site. Bedrock sources for nephrite have not been located although isolated cobbles and boulders occur in the gravels of the Fraser and Bridge Rivers near Lillooet.

The introduction of raw materials into the site should have been limited because of the need to transport food and gear from mountain sources to the Keatley Creek winter village which served as a base camp for storing food and gear for the winter (Alexander 1992). Without travel aids prehistorically, the addition of lithic raw material to food and gear would have been very burdensome, and we thus expect minimal amounts to have been transported to the Keatley Creek site. It is also important to emphasize that the main sources of trachydacite and chert would have been totally inaccessible in the winter due to snow cover and frozen ground conditions. Therefore, lithic raw material was probably relatively costly to obtain and scarce at this winter village site.

I. Expedient, Block Core Strategy

In this strategy, cores are kept at the habitation site. Flakes are removed and modified according to immediate needs, and usually discarded after the immediate task is completed unless large, still-usable flakes are involved. Material is obtained from the most easily available sources, and there is generally no need for especially durable materials. Types included in this strategy are: expedient knives, scrapers, utilized flakes, notches, denticulates, borers, piercers and perforators.

1. Expedient Knives and Scrapers: Unifacial Knives, Retouched and Unretouched Flakes With Acute Angles (Types 170, 70, 140, 144, 74).

Constraints

Task Constraints. Unifacial knives and retouched and unretouched flakes with acute angles were probably used in some part of the butchering activities thought to be represented at the site (cutting meat, hide, tendons, or filleting) or in cutting rawhide thongs or buckskin for making clothes. Because of the complementary distributions of utilized flakes (which lack invasive retouch) versus expedient knives (with invasive retouch) on housepit floors (Vol. II, Chap. 11; Spafford 1991), utilized flakes appear to have been primarily used in other activities, perhaps such as basket making. Thus, we will not treat utilized flakes as part of the expedient knife activity complex, but as part of the scraper complex in the following section. Given the concentration of expedient knives close to the walls, these tools were probably not used in heavy butchering, but instead in light tasks such as cutting off pieces of jerked meat or cutting up hides for thongs, clothes or other purposes. These kinds of tools should be very frequent at the site due to: their expedient nature, the limited number of resharpenings involved (because many successive resharpenings would increase edge angles more than desired), short use-lives with consequently high discard rates, and the use of these tools in infrequently or sporadically occurring activities.

Time. Only if butchering fresh meat was involved would there be possible light to moderate time constraints in the use of these tools. Even then, because most fresh meat brought back to the winter village for butchering would probably not represent more than a single deer at any one time, time constraints were probably not very significant, especially under cool winter conditions. However, it does not seem likely that most of these tools were used for cutting fresh meat, given their occurrence near walls.

Material Constraints. The only requirements should be the use of fine-grained raw material.

Wear Rate. Cutting hide results in a very high wear rate (Frison 1989) with edges lasting only a few minutes. Cutting meat, however, results in very low wear rates.

Manufacturing Time/Effort. Minor or insignificant manufacturing times characterize all of these tool types although it would be necessary to procure or manufacture a pressure flaking tool in order to keep edge angles acute by removing invasive resharpening flakes. Although billet flakes were frequently used for all these tools, we view this as a matter of convenient and effective use of byproduct biface waste flakes rather than an essential aspect of these tools.

Frequency and Intensity of Use (Processing Volumes). At best, 1 deer or hide per month per housepit would have been processed, representing a very low volume.

Socioeconomic Constraints (Transport). There are no constraints involving the tools themselves since these tools do not need to be transported away from the site.

Constraints do occur in the transport of raw material to the site. In this case, the transport constraints would be significant since people would also be carrying as much food as they could to be stored and gear from the mountain lithic sources to Keatley Creek during the fall seasonal movements. Because of this, people could probably only carry minimal quantities of stone.

Flake Type. There are no special needs concerning flake types. Any kind of flake with acute angles and a straight edge would be adequate: hard hammer flakes, billet flakes, blades, and bipolar flakes. However, producing blades can be a technique wasteful of raw material. Systematic blade production requires the preparation of cores and the removal of many preparation flakes. Moreover, considerable skill, training, and time are necessary to systematically produce blades (see Nelson 1991:68). The risk of ruining blade cores, and therefore wasting a large amount of raw material plague the flintknapper at every step in the reduction process. Finally, blade cores require much more specific sizes and shapes of raw materials, as well as high quality materials, thus increasing procurement costs considerably wherever the optimal size and shape raw material is difficult to find, which was probably the case in the Lillooet and neighboring regions. For all these reasons, systematic production of blades for butchering at winter villages would not be a good design solution. In fact, as Parry and Kelly (1987) and Johnson (1987) have argued, the high investment and risks associated with blade production may only make sense under high mobility circumstances when at least one part of the seasonal round intersects abundant high quality sources of raw material of suitable size and shape, since blades clearly do provide more cutting edge per weight of *successfully* processed stone material. Another reduction strategy, bipolar reduction, produces a great deal of shatter and small flakes and would be wasteful of larger core material.

Billet flakes conserve raw material and they produce acute angles more consistently. Some researchers argue that thin biface reduction flakes are even better than bifaces for cutting hide in skinning (Frison 1989). The ratio of utilized billet flakes versus non-utilized ones can provide a general indication of the degree to which biface flakes were used for tools. If a high percentage of billet flakes are utilized, it can be tentatively inferred that billet flakes were often saved or even produced for use as cutting tools. If billet flakes do not show traces of utilization very often, they were probably simply a by-product of the resharpening or manufacturing of bifaces. However, use-wear analysis is required to fully evaluate this hypothesis. Examining the proportion of billet flakes with use retouch can provide an initial indication (Table 2). With the exception of size 2 flakes, billet flakes were frequently being selected for use. Size 2 is too small in general for this work.

Table 2. Utilized Billet Flakes

	Size 2 (1–2 cm)	Size 3 (2–5 cm)	Size 4 (> 5 cm)
Total billet flakes	1563	658	7
Billet flakes with utilization retouch	21 (1.3%)	230 (35.0%)	6 (85.7%)

What can be said about billet flakes utilized for producing retouched tools? For expedient knives, many of the flakes were originally billet produced (44.7% of those identifiable). The same is true of low angled utilized flakes (35.6% made on billet flakes) and bifacial expedient knives (45.1%).

Given the much more abundant occurrence of block core flakes in the assemblage, this seems to indicate a preference for the use of billet flakes over hard hammer flakes for expedient knives. This preference is probably related to the more acute edge angles of most billet flakes and to the desirability of acute edge angles for some kinds of activities (e.g., cutting hide). When dull, and given continued use in an activity, some of the billet flakes could be resharpened by pressure flaking into expedient knives.

Although the production of billet flakes may not have been the main reason for bringing bifaces to the site, it is clear that the convenient availability of flakes from biface manufacture and resharpening played an important role in the strategy of tool production and butchering or hide cutting activities. When billet flakes were not available, flakes from block cores were used.

Strategies and Design

Raw Material Strategies. Given the need for fine-grained materials, people could be expected to have used the closest available source (trachydacite and chert: 15–20 km away). Given the low constraints on flake types, any shape and most sizes of raw material could be used. In addition, we suggest that the more wear-resistant cherts and chalcedonies would be saved for tasks involving greater requirements of durability and longevity. Consequently, the main material expected to be used for butchering and tailoring at winter villages is trachydacite. In fact, the percentages of all types of expedient knives made of this material varies between 91–96%.

Acquisition/Procurement Strategies. The trachydacite utilized was not available through the winter occupation. However, it could easily have been directly acquired during fall hunts and spring plant gathering in the neighboring Hat Creek Valley. Caching raw material before winter time in the housepit village could therefore be expected.

Reduction Strategies. As previously discussed, the best strategy would involve the reduction of block cores from which a large range of flakes could be obtained (cf. Stiner and Kuhn 1992).

Tool Form and Resharpening. There are only minor constraints concerning form: adequate low angles and straight edges, plus the need to be held comfortably (tools needed to be more than 2 cm long). Thus, tool design simply involves selection of straight acute-edged flakes with edges longer than 1–2 cm as well as the use of the most appropriate resharpening technique. The minimal size for the utilized flakes is less than that of other types. This could indicate, perhaps, a range of sizes below which flakes are not retouched and are simply used in small short tasks if the edge angle is appropriate.

The sizes for all these tools, as for the assemblage in general, were relatively small with a mean of 3.3 cm and a standard deviation of 0.9 cm (Table 3). There is a general correspondence between these measures and the small size of the block (multidirectional) cores found at the site.

Longevity. The small size and thinness of most flakes used in this activity would have made it difficult to resharpen most of these tools extensively. In many cases this provides good use of flakes that would otherwise be discarded. In other cases, it is clear that large thin flakes were being carefully kept or produced for future purposes, and were often more intensively resharpened by invasive retouching.

Table 3. Minimum and Mean Dimensions of Expedient Knives and Scrapers

Type	N	Minimum	Mean (cm)	S. Dev.
170	340	1.1	3.31	0.97
140	89	1.3	3.62	1.34
74	144	1.1	2.98	0.78
70	139	0.8	3.29	0.091

The extent of resharpening varies widely from a fraction of a millimeter (type 74) to bifacial retouch that covers much of both faces (type 140). This indicates that many tools were only used for brief periods before being discarded or abandoned. Although the more extensively retouched pieces may have been curated between tasks.

Other Variables of Design. Maintainability was probably emphasized, because all of these tools can be easily replaced with other similar examples. All these tools can also be easily and quickly resharpened.

Multifunctionality. Larger flakes, in particular, could be used on more than one edge (either in the same task or different ones). Although there is no evidence for creating multifunctional tool designs, a surprising 48% of expedient knives exhibited additional types of retouch seeming to indicate alternative functions. This unusually high percentage is also reflected in other tool types produced with this strategy such as notches (44%) and piercers (46%), although utilized flakes (29–35%) and scrapers (26%) exhibited less frequent alternative uses. For a strategy used in a non-mobile context, these extreme high rates of multifunctionality accord poorly with Shott's (1986) postulated relationship between mobility and multifunctionality. We suspect raw material availability and transport constraints play a more basic role in this case.

Frequency. The frequency of these kinds of tools is relatively high when compared with the rest of the assemblage. This is especially the case of type 170.

Type	Count	Percentage
70	212	3.6%
74	187	3.2%
140	168	2.9%
170	577	9.8%

The high frequency of these tools is undoubtedly related to the recurring need for butchering and hide cutting tools, plus their short use lives and expedient nature, as well as the infrequent performance of other activities requiring tools.

Specialization. Due to the lack of time constraints, the episodic and relatively moderate volume of material being processed, as well as the relatively simple nature of the task, there is clearly no unusual need to develop any specialized or extra-efficient tool for butchering and hide cutting. Therefore, the simplest, lowest-cost, effective design solution was employed. In this case, the nature and frequency of the task as well as limits on raw materials made it desirable to use billet flakes from bifaces whenever possible, and to sharpen them using invasive pressure retouch. The result was small, easily maintainable and replaceable expedient tools used and retouched to varying extents under conditions where few time or risk constraints existed.

2. General Scraping Tools: Scrapers, Utilized Flakes, Notches, Denticulates (Types 150, 156, 163, 154, 54, 71, 72, 73)

Constraints

Task. All of these tool types were probably used primarily for shaving wood (Hayden 1979a). Some scrapers and utilized flakes may also have been used in hide working (Cantwell 1979), working bone and antler (Cantwell 1979), cutting meat in heavy butchering, and possibly basket making. However, such tools cannot be distinguished from the majority at this point. There would have been a need for moderately robust edges for working hard surfaces and/or in order to avoid damaging hide or skin.

Time. Low time constraints characterize the presumed use of all these tools, e.g., in relation to basketry, wood, and bone working.

Material. Fine grained material would have been preferred for effective and efficient task performance in all of the above undertakings, although less effective coarser grained materials might be used on occasion. There would have been no special requirements for long use life materials, due to the low frequency and intensity of tasks and their performance at sedentary home bases where raw material was cached.

Wear Rates. On the basis of ethnographic observations (Hayden 1979a), wear rates for most semi-abrupt woodworking tools were probably moderate, on the order of 5-20 minutes of use before significant dulling.

Manufacturing Time/Effort. Minor or insignificant requirements characterize all these tool types.

Frequency and Intensity of Use. These kinds of tools could be used in many of the activities thought to be represented at the site such as the preparation of hunting, fishing, plant collecting gear and the making of prestige items. We expect sporadic but relatively frequent use of short to moderate duration.

Transport. There are no requirements related to the transport of these tools. Once raw material was brought to the site, the tools could be manufactured and abandoned at the site, especially given the low investment in manufacturing time/effort. Raw material would be replenished as required the following year. As with expedient knives, there would be considerable constraints on the quantity of raw material transported from the mountain areas to the site due to the need to carry as much food as possible to be used for the winter plus necessary gear.

Flake Type. Like expedient knives, there is no need for special types of flakes. Any kind of flake with semi-abrupt angles would be adequate, including most hard hammer flakes. Assuming that semi-abrupt angles were important, most billet flakes could probably not be used without substantial retouch. Blades would not have been used in these tasks because of the same factors discussed under expedient knives.

Strategies and Design

Raw Material Strategies. Given low constraints on flake types, any shape and most sizes of raw material could have been used. People should have used the closest available sources of trachydacite or chert. Since there was no need for long use-lives most of these tools would probably be manufactured on trachydacite which did not last as long as cherts. As an example, 91% of all notches were made on trachydacite.

Acquisition/Procurement Strategies. These would be essentially the same as the strategies used for expedient knives, i.e., acquisition during foraging trips to Hat Creek in the spring and fall.

Reduction Strategies. These strategies are also the same as expedient knives, i.e., block core reduction (with little or no use of billet flakes in this case).

Tool Form. There are very few constraints concerning the form of tools used in these woodworking tasks: adequate angles, straight edges (except notches and denticulates used on shafts or strips), the need to be held comfortably (i.e., generally sizes greater than 2 cm—Table 4), and relatively smooth ventral surfaces. There is no apparent benefit in hafting these tools given their short use-lives.

Resharpening. Hard hammer percussion would provide the easiest means of resharpening any of these flake tools since no special resharpening equipment is required and the semi-abrupt retouch that hard hammer retouch generally produces would have been optimal for most of the tasks in which these tools are assumed to have been used. Occasional use of billets for resharpening might be expected on the basis of convenience, or perhaps intentionally to create lower edge angles for meat cutting. On the other hand, large notches (type 154) and denticulates were probably created specifically for shaving hard wood or bone shafts and tips (see Hayden 1979) and these edge forms could only be produced by hard hammer retouching. The smaller, more delicate notches (type 54) that we suspect may have been used primarily in shaping basketry elements, could have been produced by pressure flaking thin flake edges in some cases, (or even by use), or by delicate hard hammer percussion using small pebbles.

Table 4. Dimension of General Scraping Tools (Whole and Chipped only)

Type	N	Min. Size (cm)	Mean Size	S. Dev.
71 (Utilized flake on break)	44	1.6	2.91	0.94
72 (Utilized flake on acute edge)	443	1.2	3.02	0.90
73 (Utilized flake on semi-abrupt edge)	154	1.6	3.33	1.00
150 (Scraper)	248	1.3	3.58	1.26
154 (Notch or Multinotch)	196	1.2	3.44	1.23
156 (Inverse Scraper)	62	1.5	3.83	1.26
163 (Double Scraper)	98	1.8	3.50	0.97

Longevity. Due to the scarcity of raw material and the size of most woodworking projects, we expect there to be considerable indications of repeated resharpening and/or the use of multiple edges. Double scrapers represent 30.6% of all scrapers, which supports expectations about the intensive use of raw material. In addition, although some of the scrapers are relatively unused, most of them (60.5%) were worn, retouched, exhausted, or useless. The fact that of all scrapers (types 150, 154, 156, 163) the most heavily used examples were located near the wall of HP 7 may indicate that they were usually stored or curated for future use. On the other hand, the abundant occurrence of much more lightly use-retouched flakes (types 72, 73, 74) scattered over the center of the floor indicates that a large proportion of this tool class was expediently produced, used, and discarded.

Other Variables of Design (Recycling, Multifunctionality). These are again similar to design considerations discussed for expedient knives, i.e., they are maintainable. Given the small size of many of these tools and their relatively robust edge angles, there seems to have been little scope for recycling. Given the wide range of potential uses for many of these types, especially scrapers, their multifunctionality is an open question at this point.

Frequency. Due to their high discard rate and to their frequent expedient nature, we expect to find a relatively high percentage of this kind of tool. In fact, scrapers constitute 12.4% of the excavated assemblage. Utilized flakes on acute edges (type 72) and on strong flake edges (type 73) constitute 9.9% and 3.4% of the assemblage respectively. Notches and denticulates represent 5.6 and 0.2% of the assemblage.

In sum, general scraping tools are largely expedient tools (with unusually good or resharpenable flakes being saved and reused) occurring in a wide size range of flakes from block cores. The nature of the tasks and their frequency as well as the difficulty of obtaining stone material, were the main reasons for the use of unspecialized, largely expediently produced flakes from block cores. Lack of time or risk constraints contributed to the "maintainable" design of these tools.

3. Perforators, Borers, Piercers

These tools represent the same basic constraints and strategies that typify other tools in the Expedient, Block Core, strategy. They are relatively low frequency, limited use tools that can be made on many different kinds of flakes with few constraints. The only major differences with the other tools included in this major strategy are related to task constraints involving the piercing of skin (the need for sharp pointed projections); perforating (the need for slightly more robust projections capable of sustaining greater pressure on the tool); and boring (the need for much more robust projections capable of sustaining much higher loads as well as rotary movements without fracturing).

II. Biface Strategies

The bifacial strategy makes most sense in the context of high mobility (as tools used in traveling to seasonal camps) and high constraints on the amount of stone material that can be transported on such trips. The advantages of bifaces include their presumed multifunctionality, their economy of raw material use, and the potential utility of resharpening flakes. It is important to note that some authors like Shott refer to all bifacially retouched pieces (including flakes, projectile points, and handaxes) as "bifaces." In contrast to this excessively general use of the term, we use the term, "biface," *only* to refer to relatively large, bifacially *reduced* tools which are clearly not projectiles, drills, or other specialized flake tools.

Constraints

Biface Task Constraints. Bifaces are usually considered multifunctional tools (cf. Winters 1969; Ahler and McMillan 1976; Nelson 1991, Bamforth 1991:230; Johnson 1987). Because of this, they are often viewed as useful tools when there are strong constraints in the quantity of tools that can be transported. They thus make most sense in high mobility situations (see Bamforth 1991:226–229; Sassaman 1992:256–257) such as at seasonal hunting camps and when collector strategies involve the transport of large amounts of food for storage, thus reducing the ability to carry tools or raw materials. "Disk or bifacial cores maximize tool material; they provide a variety of flake forms for use as tools, yet they can be thin while having extensive, usable edge length (high edge-to-weight ratio) . . . In addition, the biface can be changed to a variety of forms and resharpened with minimal reduction of the stone; therefore, few need to be carried . . . " (Nelson 1991:74).

The use of bifaces could have had other advantages. They could have been used at sites as sources of raw material (Kelly 1988; Ingbar 1990; Nelson 1991). At Keatley Creek, for instance, billet flakes from bifaces were probably used as expedient knives for butchering or hide cutting. Nearly exhausted bifaces could also be sharpened into more specialized bifacial knives (Morrow 1987:141). In addition broken bifaces could be recycled as small cores to obtain a few more flakes or as wedges (pièces esquillées). They were sometimes intentionally further broken up, undoubtedly to obtain useful right angle edges. This was also true of many other large tools.

Bifaces could also have been useful in activities carried on at seasonally sedentary sites, like the Keatley Creek winter village. Activities may have included woodworking (e.g., work on arrows, leisters, net hooks) and butchering. The occurrence of broken bifaces in the center areas of housepits (Vol. II, Chap. 11), indicates that they were probably used in activities requiring considerable space or producing copious debris. Jones (1980) considers bifaces to be effective tools for butchering animals. He has efficiently used handaxes (which we consider functionally equivalent to bifaces) made on quartzite, phonolite, and basalt or trachyandesite for skin-cutting, skin removal and meat-cutting. He believes that these tools are more effective, longer-lasting and more comfortable to hold than simple acute-edged flakes (except for the initial cutting of the hide on medium size animals).

Time and Mobility Constraints. There would only have been light time-constraints in using bifaces within winter villages since most accounts indicate that people lived off of stored foods and had abundant time. None of the assumed tasks associated with bifaces would have had significant time constraints. While hunting, the time constraints associated with the use of bifaces would have been higher but so would mobility requirements. Theoretically, time constraints should lead to specialized tools, while mobility constraints should lead to multifunctional, recyclable tools (Shott 1986). At present, we cannot determine empirically how specialized versus multifunctional Keatley Creek bifaces were. We suspect they were multifunctional as others have suggested (Odell 1993:111; Winters 1969; Ahler and McMillan 1976), and as ethnographic observations seem to indicate (e.g., as butchering tools, woodworking tools, fish knives, making basket elements, and cutting buckskin—Fowler and Liljeblad 1986; Steward 1933:261, 277; Krocker and Barrett 1960; Gould 1966:57; Volgelin 1938:28).

Material Constraints. Fine-grained raw material would be easier to manufacture into a biface and would provide better cutting edges for butchering and wood working. Trachydacite and chert (and chalcedony) would consequently be the best materials for use. Table 5 displays the different manufacturing stages, the quantities, and percentages of raw materials employed for bifaces. The data clearly show that the vast majority of bifaces were made of trachydacite (especially the fine-grained variety), chert and chalcedony.

Flake Type. Most bifaces were probably produced via direct cobble reduction or from very large flakes. Flake sizes needed to be large and thin enough to be able to be reduced afterwards. No bipolar flakes, no blades, no billet flakes would be suitable.

Table 5. Raw Materials Used in Biface Manufacturing

	Stage 4 (Type 131)		*Stage 3* (Type 134)		*Stage 2* (Type 193)		*Stage 1* (Type 192)	
Fine-grain trachydacite	83	(82.2%)	27	(75.0)	31	(73.8)	11	(91.7)
Coarse-grain trachydacite	10	(9.9%)	3	(8.3)	3	(7.1)	1	(8.3)
Chert	3	(1.0%)	3	(8.3)	1	(2.4)	0	(14.3)
Chalcedony	4	(4.0%)	3	(8.3)	4	(11.9)	0	
Quartzite	1	(0.1%)	0		1	(2.4)	0	
Totals	101	(100.0%)	36	(100%)	42	(100%)	12	(100%)

Wear Rate. No estimates are available for wear rates of bifaces.

Technological Constraints. The manufacturing time and effort and skill required for bifaces is probably the highest of any chipped stone artifact type in the assemblage.

Frequency or Intensity of Use (Processing Volume). We do not expect high amounts of meat processing or work on wooden tools to have been undertaken at winter pithouse sites. Moreover, other kinds of tools could have been used in these tasks. On the other hand, it is clear that bifaces *were* used inside pithouses, because of the many broken fragments that occur in the centers of the floors. Interestingly, bifaces seem to have been resharpened in the sleeping areas between the hearths and the pithouse walls, (where billet flakes of all sizes concentrate), whereas the bifaces seem to have been used in the center floor area where broken biface fragments concentrate (Vol. I, Chap. 13; Vol. II, Chap. 11). However, as previously noted, bifaces could have been used as raw material sources for making other kinds of tools such as expedient knives made from resharpening flakes.

Socioeconomic Constraints (Transport and Mobility). In general, complex hunter-gatherers and collectors using logistical settlement patterns have high constraints on tool transport due to the need to transport food in bulk as well as carrying increased amounts of technological gear. There are, consequently, constraints on the weight and bulk of individual tools carried to sites, especially if food necessary for survival during the winter was also being transported. Bifaces might be especially important tools in early spring for foraging before lithic resources could be replenished. Other mobility constraints were discussed above under time considerations.

Strategies and Design

Raw Material Strategies. Fine-grained materials are best for controlled flaking and sharp, acute edge angles. Chert and chalcedony may have been most sought after because they are more wear resistant. However, the size of the nodules available may have been critical. Large chert nodules are probably rarer than large trachydacite nodules.

Acquisition/Procurement Strategies. Due to possibilities of breakage of bifaces during the manufacturing process (Johnson 1989) and/or the existence of internal flaws, it would make most sense to perform the initial stages of reduction (stages 1 and 2) at or near the quarry (except perhaps for the small thick variety of bifaces). Roughed out bifaces were probably taken to Keatley Creek at the beginning of the winter occupation or cached there previously. Because of the effort and skill required in the manufacture of thin bifaces, because of the high risk of breakage (especially during resharpening), and because of their suitability to be used in different tasks, they probably constitute personal gear carried by individuals. In fact, this constitutes the best case that can be made for a personally owned tool in the entire chipped stone assemblage, and it is unlikely that thin bifaces would have been generally lent to other people given their costs and risk of breakage. Sassaman (1992:257) explicitly relates the use of bifaces to hunting activities and therefore views them as men's tools.

Most of the bifaces (72% of *all* bifaces in the sample) recovered at the site represent the last manufacturing stages (types 131 and 134; Callahan's stages 3 and 4). This supports the idea of tools with very high longevity adapted to conditions of transport constraints on stone materials.

Reduction Strategies. These would consist of the removal of bifacial billet flakes to avoid rapid consumption of raw material, to minimize the weight of raw material in transport, and to maintain adequate low edge angles on tools.

Tool Form and Resharpening. The mean maximal dimension for *whole* and chipped primary thinned and edged bifaces is 5.1 cm, with a standard deviation of 1.2. These relatively small dimensions undoubtedly reflect the fact that all whole specimens of bifaces are the small, thick variety. Larger varieties are inevitably broken.

It is necessary to indicate that the bifaces in the Keatley Creek assemblage can be divided into two distinctive classes (Vol. III, Chap. 1). The first class is composed of bifaces or fragments that conform to the standard image of Callahan's stage 3 or 4 bifaces: they are thin, relatively straight edged, relatively wide, and medium or large in size. There are no whole examples of this class probably due to their relatively high value, their thinness, and their fragility.

The second class of biface, in contrast, is small, thick, and does not display the fine craftsmanship found so frequently in the larger class. Edges are generally irregular and sinuous. While these two classes of bifaces can be readily distinguished, it is not clear what the differences represent. The thin bifaces clearly correspond to the tasks and design problems we have been discussing. They are also by far the most numerous. The small class of thick bifaces may represent "learning" products similar to those produced by beginning university students, or very rough preforms for projectile points that were abandoned, or they may represent a different tool type used for different tasks or under different conditions. Small thick bifaces are relatively infrequent, although there are a number of whole examples. Due to the uncertainty concerning the use and role of small thick bifaces, we will concentrate exclusively on the large thin variety in this analysis.

Design

In design terms, the resharpening mode using billets, largely determines the overall shape of the tool, except for the proximal and distal ends. Hayden (1987, 1989) argued that thin biface morphology and billet flaking make sense primarily in terms of tactics to conserve low edge angles on tools while maximizing the number of resharpenings (in contrast to hard hammer resharpening). In this sense they are a maintainable tool. This design and resharpening strategy, although costly in terms of manufacturing time, effort, skill, and materials, provides important benefits where there are significant constraints on the transport of tools or on raw material availability, together with moderate or high processing requirements. The size of the tool is potentially important in understanding its role in butchering. Bifaces would be better for primary butchering than flake tools due to their larger size and greater weight (Jones 1980).

The distal tips theoretically could be shaped in any fashion, although most examples from Keatley Creek appear to be pointed. Pointed tips may have been useful for tasks requiring gouging tools, such as the hollowing out of indentations for the placement of fire drills, thus adding to the versatility of bifaces.

The proximal ends were probably shaped to facilitate holding or hafting, although this has not been studied in detail. Hafting would have extended the use-life even further by enabling relatively small stubs to be used. It would also have increased the weight and ease of manipulating the tool in butchering tasks—attributes emphasized as important by Jones (1980).

Longevity. Bifaces were clearly designed for prolonged use and many resharpenings.

Other Variables of Design. It is probable that one of the main design characteristics emphasized was multifunctionality although there are no morphological features *per se* that would lead one to postulate this. The inference of multifunctionality derives primarily from comparative use-wear (Lawrence Keeley, personal communication) and contextual or theoretical considerations. Thin bifaces are certainly not reliable tools given their high rate of breakage and their fragility although the gearing up investment and manufacturing effort might be considered as typical of reliable tools, as well as their assumed context of use (time constrained hunting). Although Bamforth (1991:230) has argued that bifaces are maintainable tools, it is questionable as to whether they should be considered maintainable since it is not clear what comparable alternatives would have been employed if a biface broke and there is no reason to believe that extra biface blades were carried by individual hunters while hunting or that such spare blades could have been quickly or easily inserted into hafts (contra Keeley 1982). On the other hand, bifaces are clearly made for multiple resharpenings and are portable. Thus, whether bifaces should be considered as unusually reliable or maintainable tools—or whether these distinctions are meaningful in this case—is open to debate. Bifaces obviously have considerable potential for recycling, however, this is primarily a function of their size. It is doubtful that recycling (flexibility) considerations played much role in the actual tool design, and there is certainly no operational way to demonstrate such an assumption at this point. Recycling of bifaces could easily have been an opportunistic afterthought.

Frequency. There are only 205 bifaces or fragments in the sample (3.4% of identifiable tools). Frequencies are expected to be low given long use-lives and use away from village sites. On the other hand, recycling and breakage into small fragments probably artificially elevates these frequencies.

Specialization. Jones (1980) thinks bifaces make excellent butchering tools due to their weight and holding characteristics. They may thus be considered specialized tools in this regard, although their potential for multifunctional roles is great, it is difficult to assess their status as specialized tools at this time. Certainly, the degree of investment of time, energy, and skill in their production is characteristic of specialized tools, but this relationship may be more complex than is often assumed. See the previous discussion of possible multifunctionality under Time Constraints.

Bifacial knives (type 130) are very similar to bifaces in that they are presumed to have been used for butchering activities. However, given their rarity, their thin and sometimes sinuous shape, they appear to be specialized and fragile tools, or perhaps high status items. Due to their rare (N=52), but usually complete occurrence, it seems likely that they were only stored (and occasionally lost or forgotten) at winter villages. Most of their constraints and design elements appear basically similar to bifaces.

III. Portable Flake Tool Strategies

The goal in this strategy is to carry specialized tools in high mobility contexts that will last as long as possible and thus avoid the need to carry excess stone weight. Thus, the most durable materials with high resharpening potential are often reserved for these tools. Because of their specialized nature and resharpening requirements, we suspect they were probably most often produced near quarry sites since a large proportion of the core reduction would not be suitable for making these tools. This is especially true of trachydacite cores which often contain stress planes often resulting in broken flakes. In the Keatley Creek assemblage, tools made according to this strategy include: end scrapers, "key shaped" scrapers, and drills. Projectile points can also be considered a special case of using this strategy.

1. End Scrapers (type 162)

Constraints

Task. There is good ethnographic, experimental, and use-wear data to indicate that end scrapers were used primarily to scrape off the epidermis (including hair follicles) and endodermis (the inner membrane) of skins as well as to thin the dermis if necessary (Hayden 1979b, 1990). Semi-abrupt or abrupt angles are necessary as is a smooth convex working edge. Tools must also be easily hand-held or hafted. Edges must be sharp in order to effectively remove dermis layers.

Time. There would only be light to moderate time constraints, especially if skins were scraped in a dry state.

Material. Fine-grained stone material is required to shave fine layers off skins.

Manufacturing Time/Effort. Manufacturing effort for the stone part was probably minor or insignificant assuming adequate raw material was available; however the manufacture of hafts could have entailed more time and effort.

Frequency and Intensity of Use. According to ethnographic data, preparation of hides occurred primarily at base camps during the winter and was a very time-consuming activity (ca. 2–3 hours of scraping per hide) involving the highly intensive use of end scrapers. However, the generally low number of deer available, indicates that, at most, only a few hides would be processed per family per year on average.

Wear Rate. Experiments by Hayden indicate that wear rates depend on the moisture content and the part of the dermis being scraped. Wear rates can range from low (one resharpening every hour or more) to very high (one resharpening every 5–10 minutes). Ethnographic accounts by Mason also indicate high wear rates for some facets of hideworking (see Hayden 1979b:225).

Transport. Tools could have been left as site gear at the winter village site if people were moving to areas where raw materials were available or if the activities that were going to take place on seasonal moves were not related to hide processing. Alternatively, it would be a minor cost to carry several endscraper bits to autumn hunting camps.

Flake Type. To the extent that this activity could consume large amounts of stone material due to its long duration and the rapid wearing out of working edges (see Hayden 1979b:225), the ability to repeatedly resharpen flakes would be desirable. Given the need for a small working edge, this would make blade-like flake forms a very good design solution. In contrast, bipolar and billet flakes would generally be too thin to support the contact pressures involved or to be repeatedly resharpened, or to be comfortably held or hafted in this task. We expect to find mostly heavily used short end scrapers at winter villages. The mean for the maximum dimension for whole or chipped end scrapers is 4.0 cm and the standard deviation is 1.1. Thus, they are relatively small.

Strategies and Design

Raw Material Strategies and Acquisition/Procurement Strategies. As chert dulls less quickly than trachydacite, some selection for chert should be evident where this material is available.

Reduction Strategies. If hide processing occurred on a frequent basis with each family processing many hides during a year, we would expect some effort to be made to systematically produce blades for hide working tools. However, given the scarcity of ungulates in the Keatley Creek catchment area, it seems unlikely that most families would process more than one or two hides per year. Consumption of hide scrapers was probably correspondingly low and non-specialized block core reduction of raw material could have been relied upon to produce the few blade-like flakes that were desired for use as end scrapers. The variable technical attributes of end scraper flakes at Keatley Creek indicates that this was, in fact, the strategy employed. Reduction of cores and selection of these flakes could have occurred either at quarry sites or at the winter village. Bifacial billet flakes would not be suitable in general because of their thin cross-sections and edges.

Tool Form and Resharpening. Blade-like flakes would be the most effective for shaving hides given the need for frequent resharpening and the required edge characteristics noted previously.

Other Characteristics of Design. End scrapers are clearly highly maintainable tools since they appear to be designed for resharpening and easy replacement in hafts. While this corresponds to Bleed's suggestions that maintainable tools should occur under conditions of low risk and time-pressure, we suspect that these features are much more the products of simple economy of effort under conditions of high material attrition (see Hayden 1987) and convenience rather than any consideration of risk or time pressures. While end scrapers can probably also be considered very reliable tools, there is no indication of overdesigned elements. Indeed, operationally, it is difficult to imagine how such tools could be overdesigned or more specialized other than by increasing their robustness.

There are no indications that recycling potential or multifunctionality played any significant role in the morphology, design, or manufacturing of these tools, although in other assemblages such as Eskimo and Upper Paleolithic assemblages, end scrapers are sometimes reshaped or recycled and appear to have been used for several different purposes but perhaps opportunistically rather than as the result of intentional design (Hayden 1979b). Thus, 30% of end scrapers in the assemblage appear to have several different uses.

Frequency. We expect a relatively low proportion of end scrapers, due to the low number of deer hides processed per year as well as the extended use-lives of these tools. End scrapers constitute 1.5% of the sample (plus thumbnail scrapers at 0.3%); 53.8% of them display heavy resharpening. Only 6.3% of the sample can be considered completely exhausted. Although this is not as high a proportion as we expected, some of them could have been stored for future use or transported to the mountains and lost or left at the village. In general, these data match expectations concerning the relative frequency of the task in which end scrapers were employed.

Specialization. This is clearly one of the most specialized tools in the assemblage. Whereas skin scraping can probably be performed with ordinary flakes (Kamminga 1982), the investment of time and effort in the manufacture of blade-like hafted skin scrapers for use during extended periods of time provides savings in efficiency that far outweigh the initial manufacturing costs of end scrapers. While end scrapers may have been used for other tasks as a matter of convenience (Hayden 1979b), it is clear that they were above all a tool designed and manufactured for a single, specialized, time consuming activity: hide scraping.

2. Key-Shaped Scrapers

Constraints

Task. According to Rousseau's analysis (1992), the primary function of key-shaped scrapers involved working stems and branches of woody shrubs and trees (especially Saskatoon berry branches), with specific tasks including bark stripping, removal of secondary branch nodes, smoothing, and significantly altering the primary branch shafts by scraping, shaving, planing, whittling, carving and/or engraving actions. They could have also been occasionally used to scrape soaked or boiled deer antler.

Time. Slight to moderate time constraints would normally characterize the above tasks. However, if these tools were carried on hunting trips to repair or replace hunting equipment (e.g., arrows, darts, snares)—as Rousseau postulates—time constraints involved in the tasks might be significantly greater.

Material. Any kind of fine-grained raw material could have been used for the above tasks. However, most key-shaped scrapers are made from hard, resilient and tough cryptocrystalline silicates (chalcedony and chert). For Rousseau, this indicates that they were designed to be highly efficient and they were intended to have long use-lives. Trachydacite has less hardness and durability, and also dulls rapidly compared to other silicates when used on moderately hard and hard contact materials. According to Rousseau, trachydacite is also quite brittle, and so it is more prone to breaking while being used or resharpened.

Manufacturing Time/Effort. There are moderate amounts of time invested in the production of the stone elements of these tools. Many of them appear to have been hafted, which would have considerably increased the manufacturing time and effort involved.

Frequency and Intensity of Use. Although these tools may have been used primarily on hunting trips and only infrequently at village sites, they could have been employed for relatively long periods for working on wood shafts at lookout sites or hunting camps.

Wear rate. Given the nature of the woody contact materials, the high edge angles, and the hard, tough, stone materials involved, wear rates must have been low to moderate and use-lives correspondingly long.

Transportability. Key-shaped scrapers constitute a larger proportion of mountain lithic assemblages than winter village assemblages (Rousseau 1992), indicating that they were used primarily in mobile contexts. The preference for longer lasting materials makes sense primarily under more mobile conditions. Moreover, they are relatively small and several stone bits could have been carried by an individual without adding excessive weight or bulk to their load.

Flake Type. Probably only hard hammer flakes big enough, thick enough and long enough (rectangular in form) could have been used to make key shaped scrapers. Most bifacial billet flakes would not have been suitable because of their acute angles and general thinness. Bipolar flakes from small cores were probably not large or thick enough. Bipolar flaking of large cores would be wasteful of material given the large amount of shatter produced. The intensity of use of these tools would probably not be great enough to warrant specialized blade production, although blade-like flakes would be suitable blanks.

Strategies and Design

Raw Material Strategies. Given the desirability of hard and durable raw materials in the above contexts, most of these tools should be made on chert or chalcedony or similarly hard materials. In fact, key-shaped scrapers made on these raw materials constitutes 81.8% of the sample (N=22).

Acquisition/Procurement Strategies. Since this kind of tool required a special size and shape of flake blank, it may well have been manufactured near quarries in the major hunting areas.

Reduction Strategies. Given the thickness and strength desired, the best strategy would probably have involved the utilization of hard hammer flakes.

Tool Design and Resharpening. Initially, it would seem that a simple scraper or adze such as those observed by Hayden in Australia would be adequate for performing the tasks attributed to key-shaped scrapers by Rousseau. Thus, the unusual shape of these tools must be attributed to other factors such as a) specialized bark stripping from branches in which the "hook" of the scraper serves to guide the tool along the branch shaft, or b) a desire to maintain the projecting part of the scraper for other specialized functions, such as gouging wood. Given Rousseau's observations on wear and damage to the tips of these tools, the argument that the unusual shape was for multi-functional purposes seems strongest.

For working wood, especially hard woods, edge angles between 65 and 85° are best according to ethnoarchaeological observations (e.g., Hayden 1979a; Gould, Koster and Sontz 1971), and this is the range of edge angles that characterizes most of these tools. The steep edge angles also reflect intensive and repeated resharpenings similar to hafted Australian chipped stone adzes. The inference for hafting is also supported by an unusual degree of standardization for the maximum widths of these tools (mean = 18.0 mm, s.d. = 2.4 mm; see also Rousseau 1992) and occasional resin deposits on proximal ends. Hafting would increase the amount of effective pressure that could be applied through the tool and facilitate tasks that had to be completed under time constraints or which lasted substantial lengths of time. Hafting would also make it possible to use smaller stone bits, thereby reducing the amount of stone required in transport. Evidence for hafting indicates these were probably personal gear tools. Resharpening retouch would have been achieved with hard hammers or batons to create semi-abrupt edges.

Other Design Variables. On the basis of morphological characteristics, key-shaped scrapers can probably be described as reliable and maintainable tools. There is a selective preference for particularly hard and durable materials, which enhanced tool longevity and efficiency and decreased the possibility of accidental breakage. They are relatively thick and robust, and they were clearly manufactured in advance for use. According to Rousseau (1992) they were designed to deal with a specific anticipated, important and recurrent task. Thus, they exhibit all the characteristics and proposed conditions of "reliable" tools. On the other hand, it is difficult to determine whether this emphasis on more durable material was motivated by concerns about the risk of tool failure, or simply by concerns for getting as much use out of a single flake as possible. These tools were also certainly made to be maintainable. Their composite (hafted) nature would make it easy to replace any stone bits that broke, while the ones that lasted could be and clearly were repeatedly resharpened many times. An important part of the design seems to emphasize multiple resharpenings.

Given the small size of these tools and the lack of evidence for recycling, we infer that this was not an important design consideration. On the other hand the morphology and the use-wear of the distal ends indicate that multifunctionality may have been an important design consideration, probably related in a general fashion to mobility and transport constraints. However, only 8% of key shaped scrapers display clear indications of multifunctionality.

Frequency. Because of their long use-lives, and because they were probably part of personal gear in storage (rather than being actively used) at winter villages, we do not expect these tools to occur in high frequencies in the assemblage. In fact, they constitute only 0.4% of the sample.

Specialization. This appears to be a highly specialized tool for use in a specific set of related tasks in a manufacturing operational sequence. Although it may be a multifunctional tool, each part seems highly specialized and inter-related in terms of tasks. It seems that time or mobility constraints rather than volume of material processed probably made the extra effort of hafting and specialized morphology worth the effort invested in them.

3. Drills

Constraints

Task Constraints. In order to be able to bore small deep holes in moderate to hard materials with reasonable efficiency, tools must be narrow, have a tip that will cut or abrade, and be capable of relatively fast rotation.

Time Constraints. Unfortunately, we do not know whether drilling small holes would have been part of practical technological gear or only prestige gear, and thus it is difficult to determine if there might have been time constraints involved in the repair of some practical items with drills. However, in general, most ethnographic drilling appears to have taken place during down times when there was abundant time for manufacturing with few time constraints.

Material Constraints. Optimal materials would be those that were tough, durable, finegrained, and easily flaked. Trachydacite or chert/chalcedony would be the best choice, with chert and chalcedony having more advantages in terms of toughness, non-brittleness, and durability.

Technological Constraints. Relatively large, long, thin, straight flakes would be required for making drills. Due to the elongated, narrow bit with a sub-circular cross-section, and due to the hafted nature of drills, these must have been some of the most time consuming and difficult chipped-stone tools to manufacture.

Frequency and Intensity of Use. Although these tools were probably infrequently used, the high rates of rotation associated with them meant that they were intensively used for varying periods of time possibly extending up to several hours per event.

Wear Rate. Wear rates were probably unusually high due to the small working edges, high pressures, and highly auto-abrasive environments. Frequent resharpenings must have been required although experiments are required to verify this.

Socioeconomic Constraints (Transport). Unfortunately, we do not know if drills were used exclusively at winter village sites, or whether they might have also been carried about on seasonal rounds and used at hunting or fishing sites. It would certainly have been a minor transport cost to carry the drill bit during seasonal moves, but whether there would have been a need for drills (e.g., in repairing fish net frames, snowshoes, or other items) is unknown. Nevertheless, transport constraints do not seem as though they would have had any great influence on tool design. Drills are highly portable and may well have been transported as part of personal gear.

Strategies and Design

Raw Material and Procurement Strategies. There would have been a clear selection for chert/chalcedony and perhaps extra efforts to procure this material, either by traveling farther, searching for suitable raw material longer, or via exchange. In fact 24% (N=33) were made of chert or chalcedony.

Reduction Strategies. Bifacial thinning flakes generally provide thinner flakes, however, these tend to have greater curvature than hard hammer flakes. Nevertheless, if relatively large, straight billet flakes did occur, they probably would have been selected as blanks for drills or projectile points. Relatively thin, straight hard hammer flakes could probably be produced more easily and more frequently. Most drills have been so extensively modified that it is impossible to determine the type of flake from which they were made. The infrequent use and manufacture of drills would not warrant the development of a specialized blade technology.

Tool Design and Resharpening. Clearly, the task constraints impose fairly narrow limits on the morphology of the bit. In order to facilitate rapid rotation, it would obviously be advantageous, if not necessary, to haft drill bits. Moreover, either due to the need to drill deep holes and/or the desire to prolong the use-lives of these tools, drill bits were relatively long. Resharpening would have been performed by pressure flaking due to the delicate nature of resharpening these tools.

Other Design Variables. Clearly, drills must be viewed as highly maintainable tools since they are designed for repeated resharpening and replacement and since they are not particularly robust or overdesigned. Indeed, given the task constraints, it is difficult to see how drills could be overdesigned or more specialized. Although risk and time constraints are not significant, it is difficult to imagine how drill morphology might change even if risk and time became important considerations. Thus, it is not clear that these conceptual constructs help in understanding tool morphology in this case. Other factors such as task constraints, amounts of drilling involved, and rate of material consumption seem far more important. Similarly, recycling and multifunctionality considerations do not advance understanding of drill morphology. In fact, there are no examples of multifunctional drills in the assemblage.

Frequency. Due to the infrequent need for drilling small deep holes, as well as their long-lived, resharpenable status, drills should be relatively rare in winter village assemblages. In fact, they represent only 0.6% (N=38).

Specialization. It is difficult to imagine a more specialized chipped stone tool. The high degree of specialization in this case probably does not stem from very high processing volumes, but from narrow task constraints.

IV. Quarried Bipolar Strategies

The intentional procurement of pebbles or cobbles from the outside environment for bipolar reduction is a strategy oriented to the special needs for large, coarse-grained, spall tools in the assemblage which could be left as site furniture or discarded after use.

1. Spall Tools

Constraints

Task Constraints. spall tools found at the site are generally similar to hafted ethnographic specimens recorded by Teit (1900, 1906) and Albright (1984). These ethnographers report that spall tools of coarse grained rock were used in order to stretch hides in the tanning process. Coarse grained stone is desirable for the final softening procedure in making buckskin because it will not cut through hides with the application of the very high pressures required to stretch the skins in order to break down the lignin fibers. Some of the larger spall tools also appear to have been used as beamers to remove endoderm membranes from wet skins. These beamers will not be dealt with in this analysis until further studies on them have been conducted.

Frequency and Intensity of Use. High intensity, but sporadic and low frequency use probably characterized these tools involving the same considerations as end scrapers, i.e., scarcity of deer and hides.

Time Constraints. There are moderate time constraints related to completing the stretching process before the skins become dry and such constraints do not affect the use or maintenance of these tools except to the extent that replacement due to tool failure would adversely affect the tanning process.

Material Constraints. As already noted, coarse grained stone is desirable for this task. Coarse stone also grips any remaining wet endoderm for its removal. Quartzite has coarse grain, does not crumble, and is flakable. These qualities are important for hafting and use. Few stone types in the area have similar characteristics, although some other coarse grained igneous and metamorphic rock types were also used. Quartzite was probably the best available raw material.

Technological Constraints. Little time or effort were required for the manufacturing of the stone component, although proper hafting involves substantially more time and effort. There is difficulty involved in shaping hafts to fit specific flakes and in binding flakes to withstand high stresses. Retouch would have been needed only if the original edge was too sharp or jagged, or for hafting modification. According to ethnographic information, the use-life of this kind of tool was very long, extending over generations (Albright 1984), thus minimizing average manufacturing time per year.

Flake Type. Large flakes are required to maximize the effect of stretching on skins. The main source of coarse grained materials large enough to produce these flakes is rounded quartzite river cobbles. Bipolar splitting is the most effective and perhaps the only means of producing large flakes from these relatively tough quartzite cobbles although occasional flakes produced by direct hard hammer percussion might also be suitable. In terms of beaming tools, large spalls useful for removing the endodermis membrane and hair layer are better to grip and can be used efficiently when a hide is draped over a log.

Wear Rate. Wear formation is very slow for these tools and is in any event an almost insignificant consideration.

Socioeconomic Constraints (Transport). There are a number of indications that spall tools were highly curated (Albright 1984) and were probably treated as site furniture rather than transported on seasonal moves. The unusual weight and size of the spalls, not to mention their long stout hafts, would have been an unusual burden to carry. Since these tools were only used in winter villages and perhaps at fall mountain hunting camps, and since they had very long use-lives, it would make far more sense to cache spall tools at the sites of their use. In fact, excavations at Keatley Creek revealed a number of clearly cached spall tools in Housepit 7. The high percentage of *whole* spall tools (N=41, i.e., 0.7% of the sample) supports this suggestion since there are no obvious reasons to abandon whole and still usable tools at the site. Alternative tool solutions such as pointed sticks (Teit 1900) could even be used for stretching hides in mountain locations.

Strategies and Design

Raw Material Strategies. Since coarse grained flakeable material would be most effective, quartzite should be most favored. In fact 41.5% of the sample is quartzite, 19.5% is fine and coarse grained trachydacite, 9.8% is coarse grained andesite, 4.9% is olivine, 2.2% is shale, and 22.9% is indeterminate material.

Acquisition/Procurement Strategies. Quartzite raw material could have been obtained in the form of river cobbles near the Fraser River. However, there would have been some restrictions in the availability of the quartzite, especially during the coldest part of the winter season due to frozen ground and snowcover. Therefore people would need to procure quartzite materials in advance or keep tools from previous seasons. One may wonder why this type of tool was kept if the procurement cost was low. In addition to the difficulty of obtaining raw material in the winter, and the difficulty involved in shaping hafts to fit specific large flakes, there was simply no reason to discard these tools from one year to another just as anvils and abraders were kept.

Trachydacite was not locally available near Keatley Creek. Spall tools could have been brought into the site as finished tools, or they could have been manufactured from cobbles that were brought to the site as cores. Some of the trachydacite utilized was fine-grained (12.2% of the sample). As this does not seem to be the preferred material for this type of tool, it may have been utilized because there was no better material immediately available at some times.

Reduction Strategies. There was a need to split cobbles in order to obtain the largest possible flakes. Because of this, and because of the round shape of river cobbles and the toughness of quartzite, bipolar reduction was probably the best reduction strategy, although direct percussion may also have been used in some cases. No other reduction strategies are capable of producing suitable flakes.

Tool Design and Resharpening. There is a need for dull edges or edges that grip slippery surfaces. Long handled hafted tools are much more efficient for "staking" (stretching) skins because much more pressure can be applied in this fashion. This pressure is critical for stretching skins and making buckskin. In addition, large broad edges are important for softening large areas at once. Thus, large broad flakes of coarse grained material, suitable for lashing to long wood hafts constitute the main tool design, although other technological solutions made entirely of wood could also be used.

Other Variables of Design. Reliable designs have strengthened parts, are overdesigned, have a sturdy construction and careful fitting of the parts. In the case of spall tools, there was a high investment in the shaping of the hafts to adequately fit the tools. Hafting use wear is frequently very evident on spall tools. The tools were specialized and robustly designed, apparently due to the nature of the task and the high pressures exerted. There was virtually no maintenance involved for the stone parts of these tools and they are probably the most cumbersome chipped stone tool to transport in the entire assemblage. The impression that spall tools were designed with reliability in mind is strengthened by the lack of indications that spall tools were maintainable. Many were never retouched or rarely needed resharpening. Nor was breakage frequent. There is no indication that recycling potential (flexibility) or multifunctionality (versatility) played any significant role in tool design or use. Only 9% show any other possible signs of alternative use, probably due to the specialized nature of the material and the tool itself.

While all of these characteristics have been suggested as typifying "reliable" designs, there is little correspondence to the risk factors that Bleed (1988) Torrence (1989) and Nelson (1991) suggest produces reliable designs. Thus, the reliability in this case was probably incidental to the basic task mechanics, or *de facto*. Reliable designs are supposed to be more suitable when there is a premium on resource capture and processing time. This is clearly not the case for spall tools. Any need for emergency tool replacements might have been achieved simply by keeping extra parts in storage or by using alternative solutions such as plain wooden sticks. However, this cannot be determined from tool morphology. On the other hand, Bleed (1988:741) also argues that reliable designs are optimal when there are predictable times of need and downtime as well as in situations where bulk and weight are not critical. This corresponds more closely to the use context of spall tools.

Specialization. Hafted spall tools are among the most specialized and non-versatile tools in the assemblage. However, this specialization does not appear to be due to risk considerations or time constraints, but to basic task mechanics.

Frequency. Due to moderate to low processing volumes, very low attrition rates, and extremely long use-lives, spall scrapers are expected to be rare, and they are (N=41; 0.7% of the assemblage).

2. Quartzite Spall Adzes

Spall adzes appear to constitute another tool type belonging to this lithic strategy. However, they are so rare and under-reported elsewhere that further analysis is required before discussing them in this context.

V. Scavenged Bipolar Strategy

This recycling of exhausted tools by using bipolar percussion to further reduce them makes most sense as a recycling strategy used when residents were faced with very low reserves of new material.

Although clearly present in the Keatley Creek assemblage, our original research design did not provide for the quantitative collection of data on this aspect of lithic related behavior. However, subjectively, it can be stated that large tools and flakes as well as bifaces and residual block cores often seem to have been "recycled" via simple intentional breakage (in order to use break edges) or via bipolar reduction to create new flakes. This strategy is obviously related to Nelson's (1991) "flexibility." Unfortunately, we cannot provide a detailed analysis of this strategy at this time. The importance of this strategy is expected to increase as lithic reserves decreased during the seasonal occupation of the pithouses at Keatley Creek.

VI. Ground Stone Cutting Tool Strategy

The creation and maintenance of cutting edges by grinding is used under conditions of high processing volumes and/or to display control of wealth and power.

1. Nephrite Adzes

Constraints

Nephrite Adze Task Constraints. The ethnographic information for the area mentions the utilization of ground stone adzes for heavy woodworking (Teit 1900). This kind of tool could conceivably have also been used for heavy butchering, and appears to have been used to shape antler prehistorically on the basis of adze marks found on large pieces of antler at Keatley Creek.

Adzes were probably used in the construction of the pithouse wooden roof superstructures, as well as interior planking for sleeping platforms, and other furniture. On the basis of Teit's accounts and drawings, the number of logs needed in the construction of a medium sized housepit can be estimated to have been about 312 (24 large logs, 44 medium logs, and 244 smaller poles). High, heavy duty cutting requirements might also be involved during the year in building deer fences in the mountains, removing large amounts of bark for cambium, canoes, baskets, roofing, and constructing drying racks, net frames, bows, log ladders and the log or plank sculptures documented by Teit (1906) and others. Thus, very large quantities of wood would have been episodically processed. Ground stone adzes may not always be more efficient in cutting wood than chipped stone equivalents (Hayden 1987); however, where cutting requirements were extremely high, it would have been more costly in terms of effort, time and scheduling to return to quarry sites at short intervals to replace exhausted tools or materials. In this respect ground stone cutting tools had major advantages over chipped stone tools. The cutting tasks themselves simply required sharp, semi-abrupt edges with considerable mass in order to render penetration effective.

Time Constraints. If the inhabitants of the site had to use late autumn for intensive procurement of the food necessary for the winter (hunting and fishing), and if food resources could be scarce if the winter lasted too long, the need for using a kind of tool that minimized replacement effort and time so that as much critical time could be spent in subsistence activities would be particularly important. In this respect, the use of ground stone tools for heavy wood working would make very good practical sense especially since the replacement of decayed pithouse roofs would also have had to be completed in a relatively short time during the fall, before severe winter weather set in. Therefore, efficiency and saving time were undoubtedly considerations in the design of these tools.

Material Constraints. A durable, tough, raw material with sharp cutting edges would be optimal. At Keatley Creek nephrite was utilized. Other igneous and metamorphic rock types in the area were also used and would have been easier to manufacture, although few would produce as effective and strong a cutting edge as nephrite (Darwent 1998). Smaller, chipped stone quartzite adzes, bifacial quartzite core adzes, and antler wedges may also have been used as an alternative tool by poorer families for some wood working or barking activities. Figure 1 shows one clear example of a groundstone adze made from igneous rock as well as a very probable chipped quartzite adze and a number of other possible chipped stone adzes, all from Keatley Creek. In addition, Teit (1900:183; 1909:644, 709, 715) refers a number of times to people using antler chisels or wedges for wood working. Thus, more than simple practicality may have played a role in the use of nephrite for adzes. The use of nephrite may well have been a sign of status or wealth (Darwent 1998).

Technological Constraints. By all measures, it would have been exceedingly time consuming to manufacture ground stone adzes, especially using nephrite. To cut 1 mm of nephrite with traditional techniques requires an hour of work (Darwent 1998). In addition, the maintenance of cutting tools by edge-grinding involves a considerable amount of work (cf., ethnographic data in Hayden 1979, 1987). However, other chipped stone alternatives may have involved greater total costs. Nephrite is extremely tough and durable, and would be unusually long lasting with low wear rates and low resharpening requirements thereby reducing average yearly costs.

Prestige and Ideological Constraints. Hayden (1987) initially related the importance of edge-grinding adzes or axes to high wood cutting requirements. In some instances, such as with the high manufacturing time involved in making nephrite adzes, the edge grinding may also be related to the existence of free time or to the control over others' labor in the form of slavery or the ability to commission work. The goal of prestige technologies is to use control over labor to produce desirable items that are too labor-costly for most people to be able to afford, thus displaying individual power and wealth. Given the inordinate amount of labor involved in producing nephrite adzes, they are prime candidates for

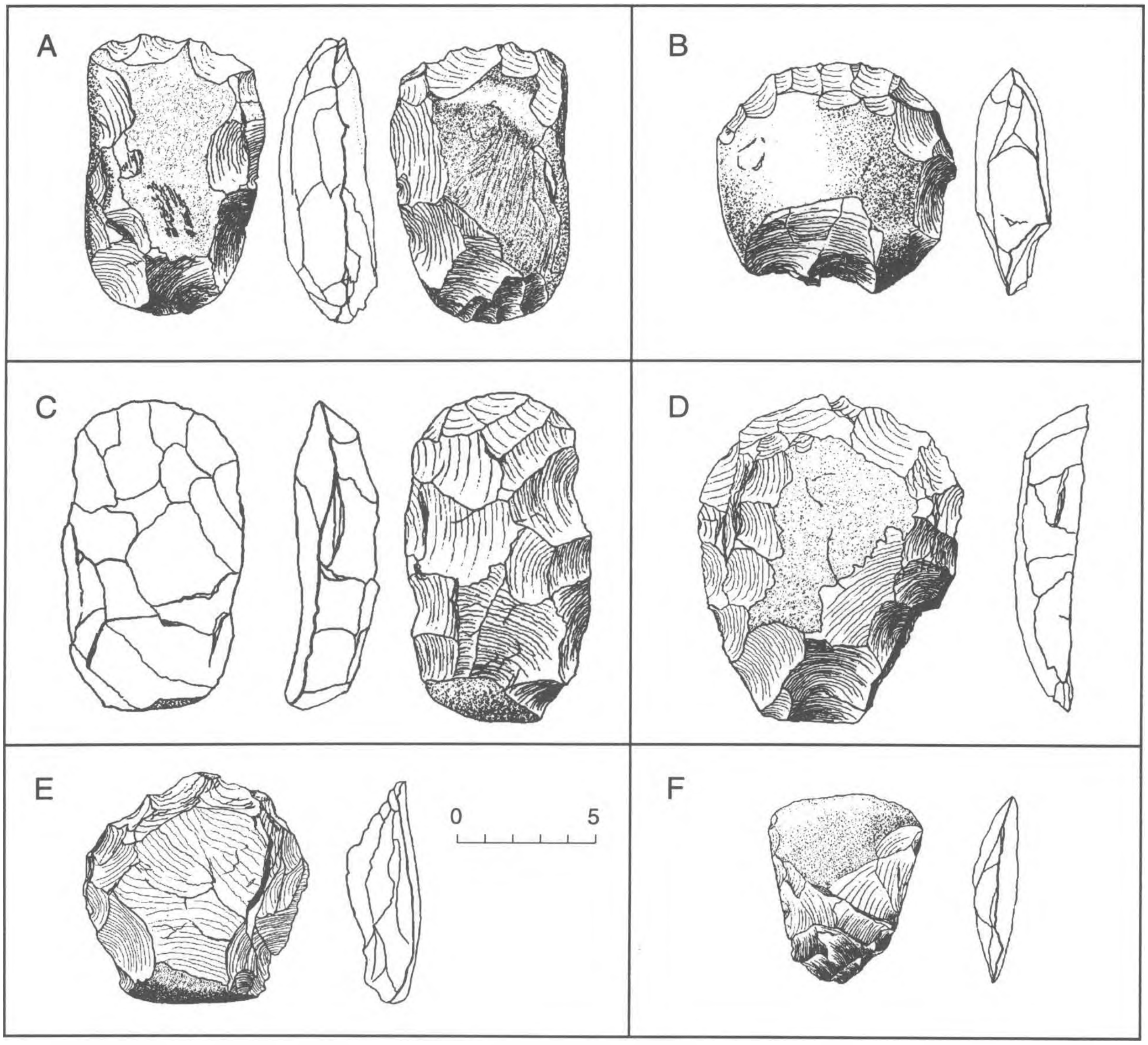

Figure 1. Examples of design solutions for heavy woodworking besides the ground stone nephrite solution. These include the use of ground or chipped igneous rocks and chipped quartzite adzes. A (Cat. no. 7312) is a basalt adze from HP 7; it has been fully ground on both faces and subsequently re-chipped on some edges. C (Cat. no. 6741 from HP 47) is a well formed quartzite adze. Other possible examples of chipped stone adzes include several examples of quartzite spall tools: B (Cat. no. 2238) and D (Cat. no. 7291) both are from HP 7; E is a surface find of andesite. A small version of these spall tools could also have been used for light woodworking. Several examples of this latter type were recovered from Keatley Creek including F (Cat. no. 3633) from HP 7.

prestige artifacts. Other types of stone may have been nearly as effective and involved much lower production costs, but would not have had as much prestige display value. In the Lillooet region, the existence of social hierarchies including slave labor was documented ethnographically (Teit 1906) as was the existence of some occupational specialization (Romanoff 1992), while unusually long nephrite adzes were clearly used as wealth and prestige display items (Smith 1900; Emmons 1923:26–27).

The use of some nephrite adzes by women (Teit 1917:11) is probably related to their high status role and the use of such adzes in marriage payments in high status marriages, even if women only used adzes for splitting up dead trees as opposed to men's use of adzes to cut up living trees (as is the pattern in New Guinea—Petrequin and Petrequin 1993:387).

Frequency and Intensity of Use. Very large quantities of wood would have been intensively processed at infrequent intervals (see Task Constraints).

Socioeconomic Constraints (Transport). Nephrite adzes were probably not left at winter village sites (in contrast to spall tools) because of their high procurement and manufacturing costs and the need for cutting tools at other seasonal locations. Given their very high value, they were probably part of personal gear. Ground stone adzes are good solutions to transport constraints because their replacement rate is far lower than that of chipped stone heavy woodworking tools. On the other hand, they might add significantly to the weight and bulk of items that an individual would have to carry on camp moves, especially if hafted.

Flake Type. The only requirements would be the need for raw material large enough to manufacture into an adze through grinding. Nephrite does not "flake," but must be reduced by grinding and sawing from a parent cobble.

Strategies and Design

Raw Material and Procurement Strategies. At the Keatley Creek site, several fragments of adzes made of nephrite were recovered. The source of this raw material was probably the Fraser and Bridge River lag deposits, where nephrite cobbles and boulders are found today. Thus raw material could have been obtained while other activities, such as fishing, were carried out. However, if more material was required than could be found opportunistically, it would have been time consuming to search for and to obtain due to its rarity.

In addition, the use life of ground nephrite adzes is very long (probably spanning more than one generation), thereby minimizing the average yearly procurement cost.

Tool Design and Resharpening. Due to the intensive and long duration of processing numerous logs, hafting provides critical advantages in easing the fatigue as well as the trauma to hands in contrast to hand held chopping tools. The manufacturing and maintenance costs of the haft are more than offset by savings in fatigue and perhaps an increased efficiency involved in processing large quantities of wood. Resharpening the cutting edge would require a non-permanent type of haft. The most practical would probably be a friction fit accompanied with binding. Smooth surfaces provide far superior friction fit hafts than irregular surfaces such as those typical of chipped stone tools. Thus, in addition to edge-grinding to prolong use-life (and reduce consumption of raw material), surfaces could also be expected to be ground. Sizes (width) should be a function of the size of the wood or antler being worked and the mass required to penetrate wood effectively. Initial lengths would probably have been as long as possible without creating loading conditions leading to breakage. Long adzes would maximize the resharpening potential and use-life of the tool.

Reduction Strategies. Grinding, using sands (preferably garnet sands), sandstone, water and wood or cord is the only effective traditional technique for shaping nephrite (Darwent 1998).

Other Design Variables. Nephrite adzes appear to be highly reliable on the basis of morphological criteria. They are made of much tougher materials than strictly necessary, they were robust, required elaborate advance manufacturing time and effort, specialized repair and resharpening, and appear to have been used under conditions of some time constraints. Nevertheless, it is not clear how intensive actual time constraints were, and there was also a strong maintainability element to nephrite adzes. Breakage would have to be dealt with by replacement (a very difficult, long-term process), or borrowing. However, there is a more fundamental question involved in understanding strategies behind the manufacture of nephrite adzes; notably whether the apparent "reliable" character of these tools was only incidental to, or a by-product of, a more basic concern with material conservation strategies used in the face of large processing requirements, or even more importantly, of a basic concern with displaying wealth and power.

Although ground adzes may have been multifunctional, this is difficult to demonstrate. Moreover, there are few arguments that support the idea that multifunctionality played any significant role in tool design or manufacture. Any adze multifunctionality appears to be strictly the result of *ad hoc* or opportunistic use of adzes. Nor does potential for recycling appear to have had any influence on raw material choice or tool design.

Frequency. Aside from loss, discard of this kind of tool at the site is probably due to breakage and abandonment of small or flawed pieces that could not be easily reshaped to form smaller adzes. Because nephrite adzes were by far the most costly tool to make, had high longevity, and were almost certainly unique items of personal or family gear, they should be very rare in winter village assemblages.

Specialization. Although ground stone adzes could be used for cutting many things, they were probably developed for a very specialized task: procuring and processing large amounts of timber. Since highly specialized materials were used, and since a great deal more time and effort and specialized hafting designs were involved in the manufacture of these tools (in contrast to more generalized forms of wood chopping tools), they must be considered highly specialized tool types.

Discussion

The technological organization of a group responds to different environmental conditions such as the distribution and predictability of resources, their periodicity, productivity, patchiness and mobility. It involves resource acquisition, manufacture, manipulation, and discard or loss (Nelson 1991, 1992). Our focus in this discussion will be on the acquisition, manufacture and manipulation of stone resources and the evaluation of basic strategies in these domains.

The groups that have inhabited the Lillooet region probably acquired most of the stone raw material they needed for their tasks during their seasonal round. Trachydacite, the raw material utilized for the manufacture of most of the tools, is not available near the site. However, most of the block cores found at the site are trachydacite (81 out of 106, or 79.4%). Since this raw material is not locally available, there should be a high percentage (91.1%) of exhausted block cores. In addition, cores should be small in size. The mean size for all the core types is small: 3.2 cm for bipolar cores; 5.2 cm for the multidirectional cores and 4.5 cm for flake cores. Flake cores are often made from larger flakes but are reduced to small sizes and are sometimes made on broken biface fragments, apparently as a way of saving raw materials. Chert, chalcedony, and obsidian should also occur primarily in exhausted states or bipolar forms. This is in fact the case.

Bipolar cores constitute 73.6% of all cores, matching expectations for the intensive use of raw materials. The percentage of completely exhausted or useless cores from which *no* further flakes could be removed (in all classes of cores) is only 20.3%, which is lower than might be expected, but still significant and probably reflects conservation of unexhausted cores as well as the inclusion of unsnapped bipolar cores.

We believe different core strategies were emphasized at Keatley Creek in order to manage the problem of limited raw material availability according to the minimal requirements of various classes of tasks involved.

Block (Multidirectional) Cores

Block cores were probably introduced into the site in order to obtain blanks for a broad range of tools, especially those for which very acute angles were not needed.

Block cores would have provided some large and suitable flakes for non-butchering tasks. This was probably the case for end scrapers, scrapers, notches, perforators, borers, drills, and acute, semi-abrupt, or obtuse utilized flakes. Blocks cores would have also provided many small flakes with a range of edge angles for a variety of expedient tasks.

Bifaces

Bifaces were probably introduced into the site primarily to store them for use on hunting forays and incidentally as a way of saving raw material. They were also undoubtedly used for some activities inside pithouses. Bifacial billet flakes obtained as byproducts of resharpening or for the purpose of obtaining thin flakes, were suitable for tasks requiring very acute angles, such as those related to butchering.

Quarried Bipolar Cores

Quartzite cobbles were readily available in the river terraces and shores. Therefore, they could be easily procured for bipolar reduction in the making of spall tools for hideworking and perhaps other activities.

Scavenged Bipolar Cores

Flakes could be obtained from exhausted block cores, bifaces, and large flakes or tools using the bipolar technique. Exhausted cores of trachydacite, chert, chalcedony and obsidian were probably frequently reduced further using bipolar techniques. This strategy could not be identified as having been used for the manufacture of any specific tool types. However, the scavenged bipolar strategy was certainly used for some tasks as indicated by the concentrations of bipolar cores in the southwest part of the Housepit 3 roof and around the hearth in the west sector of Housepit 7. We do not yet have any clear indications as to what those tasks were but the small size of the flakes involved and comparative ethnographic accounts (MacCallman and Groebelar 1965; Fidel Masao, personal communication) make it seem likely that scarification or cutting animal hide was involved.

Blade Cores

Blade cores do not occur at the site, except for bladelet cores from pre-housepit components. We propose that most prepared cores such as Levallois cores, and especially blade cores, are actually wasteful of raw material (contra Sheets and Muto 1972; Clark 1987; Nelson 1991:68) because of the high risk of failure at all stages, the initial need to shape cores, and the need for specific sizes, shapes, and high quality of raw material. These factors also increase search and procurement times and the investment in training required for successful blade production. On the other hand, once produced, blades have the advantages of having relatively long, sharp cutting edges per unit weight with little unusable edge, of being relatively thin and straight, and of facilitating multiple resharpenings for tools made on distal or proximal ends such as burins, end scrapers, borers, piercers, drills, and points.

Therefore, we suggest that blade technologies should occur: a) where processing large volumes of material involve distal-end tools such as those just mentioned; b) where there is an unusual need for large numbers of straight, thin, long flakes as in high volume butchering and filleting; and c) where high mobility places a premium on edge:weight ratios *and* where this coincides with seasonal visits to high quality lithic sources with abundant suitably sized nodules for blade making.

In the Keatley Creek case, none of these conditions seem to have existed in the Late Prehistoric (pithouse) tradition. The most sensible use of the generally small to medium sized blocks of raw material available within the seasonal round would have been as block cores from which almost all flakes larger than 2 cm could have been used. This reduction strategy relying on block cores would have provided maximum flexibility in terms of the production of different sizes and shapes of blanks for small expedient knives, drills, notches, and end scrapers and other small tools. The production of highly varied types of flakes depending on situational needs cannot be achieved with blade cores. It is therefore not surprising to find that block core reduction was the dominant strategy used at the site. The overall small size of tools also supports this interpretation. Whether it would have been most economical to reduce cores at quarries and simply carry away suitable flakes to the winter village or to carry cores to winter villages to maintain flexibility of blank production according to need and to ensure maximum sharpness of flakes, is unclear. Both strategies were probably used with an emphasis on quarry production of blanks with the greatest size and shape constraints (end scrapers, drills, key-shaped scrapers, bifaces) while production of flakes at pithouses was probably principally for tools with fewer shape constraints (utilized flakes, scrapers, notches). In fact, while cores occur at the site, refitting attempts so far have failed to produce a single conjoinable pair, indicating substantial off-site flake production (as well as substantial clean-up of debris for outside discard). At this point, however, we have not been able to distinguish expedient tool production at the site from the introduction of flake blanks from quarries.

Major Strategies

The term, "strategy" can be used at a detailed level (the resharpening or procurement strategy) as well as a broader, more encompassing level. This results in some confusion, and perhaps different terms ought to be applied to the different levels of intentional problem-solving approaches (e.g., minor vs. major strategies, or tactics vs. strategies). In the preceding pages, we have described six of the broader intentional problem-solving approaches that appear to be structuring the Keatley Creek assemblage. In sum, these major strategies are:

- The expedient, block core reduction and tool manufacturing strategy.
- The bifacial strategy.
- The portable flake tool strategy.
- The quarried bipolar strategy.
- The scavenged bipolar strategy.
- The groundstone strategy.

There are additional types of major strategies that occur in other assemblages elsewhere in the world (e.g., prepared blade strategies), or involving some of the other types in the Keatley Creek assemblage including granite anvils, sandstone abrading tools and saws, fire-cracked rock, pigments, crystals, and copper. However, we feel that the identification of the major types of strategies discussed in the preceding pages is a reasonable initial step in the systematic analysis of assemblages for our heuristic, exploratory goals.

It is clear from the tool and debitage analyses (see the following chapter and Vol. II, Chap. 11) that the housepit assemblages at Keatley Creek are dominated by the expedient block core and tool strategy. As others have suggested, this may be due to the lack of time stresses (Torrence 1982) when living off stored foods; or to relatively sedentary occupations involving the stock-piling and constant availability of raw material (Parry and Kelly 1987, Johnson 1987). We suggest that the expedient reduction of block cores is also the most efficient use of raw material in terms of procurement, reduction, and the use of minimal amounts of raw material in a wide array of tasks. We argue that there would have been considerable constraints on the amount of raw material that could have been brought to the winter villages and that it was used in an extremely economical fashion. This is indicated by numerous factors: 1) the unusually small size of the tool assemblage as a whole and the remarkably small size of many of the expedient tools; 2) the high rate of breakage (frequently intentional) and re-use of edges formed by breaks (detailed in the next chapter); 3) the high degree of culling of all usable flakes (also documented in the following chapter); 4) the high frequency of multiple edge use; 5) the high ratio of tools to debitage; 6) the great variability in the size range of tools and the extent of their resharpening; and 7) the frequent recycling of broken bifaces and exhausted cores through bipolar reduction. While the original research design used to record our data did not anticipate all of these variables, many of them became clearly evident during analysis and we can make relatively confident statements about them on a subjective basis.

The next most common strategy is the intensive use of bifacial reduction flakes as expedient tools, and this, too, makes sense primarily in terms of conditions where raw material is scarce. Although it is clear that bifaces were used in specific activities in the center of the large housepits during the winter occupations, the overall design of biface tools makes most sense in terms of high mobility (see Sassaman 1992). Bamforth (1991) has shown that in California there was a clear emphasis on bifaces in hunting campsites with a complementary emphasis on expedient "utilized flakes" (probably including types similar to the expedient knives at Keatley Creek) at the larger, more sedentary sites. This certainly fits our view of how lithic technology was used in the Keatley Creek case. The use of bifaces within pithouses may represent the incidental use of a handy and convenient tool for butchering, woodworking, or some related activity, rather than the condition under which bifaces could be expected to be adaptive , i.e., high mobility.

Clearly, the type of analysis which we have attempted here is still in its development phase. Yet the results seem promising enough for the explanation of tool forms and materials to warrant more detailed experiments, comparisons, analyses, and data gathering that could transform our initial formulations into much more robust conclusions about the organization of lithic technology and the strategies used prehistorically to deal with technological problems.

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Appendix:
Composite Frequencies of All Lithic Types from All Excavations at Keatley Creek — Artifact Totals from Keatley Creek (EeRl7)

Type	Abbreviation	Code	Frequency	Percent
UNIFACIALLY RETOUCHED ARTIFACTS				
Scraper retouch flake with hide polish	Scraper 1	143	42	0.63
Single scraper	Scraper 2	150	472	7.09
Keeled scraper	Scraper 3	155	2	0.03
Alternate scraper	Scraper 4	156	100	1.50
"Key-shaped" unifacial scraper	Scraper 5	158	39	0.59
Inverse scraper	Scraper 6	163	162	2.43
Double scraper	Scraper 7	164	74	1.11
Convergent scraper	Scraper 8	165	33	0.50
Expedient knife, inversely retouched	Flake 1	70	224	3.37
Lightly retouched expedient knife, utilized flake	Flake 2	74	183	2.75
Flake with polish sheen	Flake 3	148	9	0.14
Expedient knife, normal retouched	Flake 4	170	558	8.38
Flake with abrupt (trampling) retouch	Flake 5	171	85	1.28
Utilized flake (General)	Ut.flk 1	180	542	8.14
Utilized flake on break	Ut.flk 2	71	83	1.25
Utilized flake on thin flake edge	Ut.flk 3	72	583	8.76
Utilized flake on strong flake edge	Ut.flk 4	73	207	3.11
Miscellaneous uniface	Misc.Unif.	157	112	1.68
"Thumbnail" scraper: classified as endscrapers in this analysis (see type 162)	Thumb scraper	161	20	0.30
Endscraper	End scraper	162	104	1.56
Piercer	Piercer	153	135	2.03
Unifacial borer	Unif.borer	152	18	0.27
Unifacial denticulate	Unif.dentic.	160	13	0.20
Unifacial knife	Unif.knife	159	2	0.03
Unifacial perforator	Unif.perfo.	151	22	0.33
Blade with one retouched edge	Blade	188	1	0.02
Notch	Notch	154	331	4.97
Small notch	Sm.notch	54	130	1.95
Dufour bladelet	Dufour	88	2	0.03
Spall tool	Spall 1	183	22	0.33
Retouched spall tool	Spall 2	184	42	0.63
Miscellaneous	Misc.	1	32	0.48
BIFACIAL ARTIFACTS				
Stage 2 biface	Biface 2	192	17	0.26
Stage 3 biface	Biface 3	193	68	1.02
Biface: Stage 4	Biface 4	131	188	2.83
Fan-tailed biface	Biface 5	139	6	0.09
Knife-like biface	Biface 6	140	167	2.51
Scraper-like biface	Biface 7	141	45	0.68
Convergent knife-like biface	Biface 8	144	16	0.24
Bifacial fragment	Bif.frag.	6	69	1.04
Distal tip of biface	Bif.tip	135	2	0.03
Biface retouch flake with hide polish	Bif.flk 1	4	3	0.05
Bifacial knife	Bif.knife	130	62	0.93
Large biface reduction flake	Bif.flk 2	8	2	0.03
Bifacial perforator	Bif.perfo.	132	11	0.17
Bifacial drill	Bif.drill	133	23	0.35
Pièce esquillée	Pièce esquillée	145	43	0.65
Miscellaneous biface	Misc.Biface	2	115	1.73
POINTS				
Preform	Preform	134	52	0.78
Point fragment	Pt.frag.	36 & 100	94	1.41
Point tip	Pt.tip	35	3	0.05
Miscellaneous points	Misc.Pts	99	2	0.03

Appendix (*continued*)

Type	Abbreviation	Code	Frequency	Percent
Side-notched point no base	Side-notch	109	146	2.19
Lehman point	Lehman	102	3	0.05
Lochnore point	Lochnore	101	16	0.24
Kamloops preform	Kamloops 0	137	66	0.99
Kamloops Side-notched point concave base	Kamloops 1	110	85	1.28
Kamloops Side-notched point straight base	Kamloops 2	111	5	0.08
Kamloops Side-notched point convex base	Kamloops 3	112	51	0.77
Kamloops Multi-notched	Kamloops 4	113	3	0.05
Kamloops Stemmed	Kamloops 5	114	7	0.11
Plateau preform	Plateau 0	136	3	0.05
Plateau Corner-notched point concave base	Plateau 1	115	18	0.27
Plateau Corner-notched point straight base	Plateau 2	116	19	0.29
Plateau Corner-notched point convex base	Plateau 3	117	19	0.29
Plateau Corner-notched point no base	Plateau 4	118	12	0.18
Plateau Basally-notched straight base	Plateau 5	119	6	0.09
Late Plateau point	Late Plat.	19	41	0.62
Shuswap base	Shuswap 1	120	5	0.08
Shuswap Contracting stem slight shoulders	Shuswap 2	121	1	0.02
Shuswap Contracting stem pronounced shoulders	Shuswap 3	122	1	0.02
Shuswap Parallel stem slight shoulders	Shuswap 4	123	5	0.08
Shuswap Parallel stem pronounced shoulders	Shuswap 5	124	1	0.02
Shuswap Corner removed concave base	Shuswap 6	125	1	0.02
Shuswap Corner removed "eared"	Shuswap 7	126	2	0.03
Shuswap Stemmed single basal notch	Shuswap 8	127	4	0.06
Shuswap Shallow side notched straight basal margin	Shuswap 9	128	4	0.06
Shuswap Shallow side notched concave basal margin	Shuswap X	129	9	0.14
CORES				
Multidirectional core	Core 1	186	88	1.32
Small flake core	Core 2	187	42	0.63
Unidirectional core	Core 3	189	2	0.03
Bipolar core	Bip.Core	146	339	5.09
Microblade core	Micro.Core	149	8	0.12
Microblade	Microblade	147	52	0.78
Core rejuvenation flake	Rejuven.	182	16	0.24
GROUND STONE				
Celt	Celt	218	5	0.08
Ornamental ground nephrite	Grnd nef.	209	1	0.02
Ground slate	Grnd slate	203	3	0.05
Groundstone maul	Maul	219	3	0.05
Grinding stone mortar	Mortar	211	1	0.02
Hammerstone	Hammerstone	190	37	0.56
Steatite tubular pipe	Pipe	204	15	0.23
Sandstone saw	Sandstn saw	202	7	0.11
Miscellaneous ground stone	Grnd stone	200	4	0.06
Abraded cobble or block	Abraded 1	207	15	0.23
Abrader	Abrader	201	61	0.92
Wedge-shaped bifacial adze	Adze	185	1	0.02
Anvil stone	Anvil stone	206	3	0.05
ORNAMENTS				
Copper artifact	Cu art.	217	2	0.03
Mica	Mica	212	12	0.18
Stone bead	Stone bead	214	2	0.03
Ochre	Ochre	210	6	0.09
Stone pendant or eccentric	Stone pend.	215	19	0.29
OTHER				
Metal artifact	Metal art.	213	5	0.08
Glass artifact	Glass art.	220	2	0.03
Ochre palette	Palette	221	3	0.05
	Total		6,659	100.00%