Mass and Attribute Analysis of the Quartz Lithic Assemblage from the Grandfather Quarry (HbMd-4), near Granville Lake, Northern Manitoba

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by

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Abstract

Quarries are fixed locationally, whereas most seasonally abundant food resources in northern latitudes are not. Toolstone procurement must therefore be 'factored in' to other resource procurement strategies. As sources of useable toolstone, quarries are the logical starting point for the study of how stone tool-using societies organized their technologies in accordance with their subsistence and social needs. Yet they have often been ignored by archaeologists because of the logistical problems presented by their typically enormous and variable assemblages.

Quartz differs from more common, crypto-crystalline raw materials such as chert, flint or chalcedony. It is harder, more brittle, and has different fracture properties. It is less common archaeologically than crypto-crystalline toolstone, and archaeologists tend to either avoid quartz assemblages altogether, or to automatically and uncritically analyze them in the same manner as crypto-crystalline toolstones without considering their different properties.

The Grandfather Quarry (HbMd-4) offers an opportunity to address these problems at once. Using Lithic Technological Organization theory, a mass analysis (after Ahler 1989), modified and combined with an attribute analysis, demonstrates that this method is a useful tool for examining large, complex assemblages such as those found in quarry sites. While more time-consuming and labour-intensive than a standard mass analysis, the modified version allows for the collection of a large number of attribute data that lend robusticity to the results and provide academic rigour. This research also demonstrates that quartz assemblages can indeed be examined using the same methods as for other raw materials, provided the unique properties of quartz as a toolstone are considered. It is shown that although the overall quality of toolstone from this source is quite poor, the Grandfather Quarry was likely the only reliable source, or at least one of a very few reliable sources, of quartz toolstone in the Churchill River Basin. All useable toolstone was intensively exploited, but rare nodules of higher quality quartz were set aside for in situ reduction into cores, tools and bifaces.

Lastly, the unexpected discovery of microblade technology at the quarry opens new avenues for future research in the northern Manitoba Boreal Forest.

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Kinana’skomitina’wa’w

With heartfelt thanks…

Every human endeavour ultimately derives from the efforts of many, and this dissertation is no exception. I would like to thank the following people, without whose support, assistance and encouragement, this dissertation would never have been written:

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Special thanks to advisory and examining committee member Dr. Jill Oakes (and her husband Dr. Rick Riewe), Professor in the Department of Geography and at the Centre for Earth Observation Science, who in addition to serving on my committee, also provided me with a place to stay in Winnipeg during the defence and final submission process!); to my other committee member, Dr. William “Skip” Koolage, Professor Emeritus of Anthropology at the University of Manitoba; and to my external examiner, Dr. Chris Ellis, Professor of Anthropology, University of Western Ontario.

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Any effort to adequately thank the above, is doomed to woeful inadequacy, because I simply do not have the words; and so to each and every one of them, a humble yet heartfelt ***kinanawskomitinow*** will have to suffice.

Dedication

***Janet Lynne Reid*, B.A. (UBC, 1966), M.L.S. (UBC, 1974)**

1944 – 2012

My aunt, Janet Reid, financed my first three years of post-secondary education and thus gave me my start in academia. Were it not for her generosity and encouragement, I might never have come to the point of writing this dissertation.

Although she proudly saw me complete my B.A. (UVic 1988) and my M.A. (UVic 1991), she sadly did not live to witness the completion of my doctorate: "Auntie Janet" died peacefully on the night of February 9, 2012 after a brief but courageous battle with cancer, three months short of her 68th birthday. In keeping with her generosity of spirit, she left me a small sum that enabled me to finance the completion of this degree. It is to her memory that this dissertation is dedicated with fondness and gratitude, and above all, with love.

"Don't cry because it's over; smile because it happened!"

-- Dr. Suess

Table of Contents

List of Tables

List of Figures

List of Equations

List of Copyrighted Material

Chapter 1:
Introduction and Overview

Research Objectives

Statement of the problem

This dissertation addresses three issues that are frequently faced by archaeologists conducting lithic analyses. The first is methodological and relates to the fact that archaeologists have yet to devise an efficient, replicable, and statistically sound approach to analyze large, complex lithic assemblages, resulting in perceived analytical problems that may account for the lack of archaeological treatment of quarry sites (Ericson 1984: 2). The second issue is contextual; specifically, while quarries or lithic source areas are considered as important as exploitable resources like plants and animals (see Beck et al. 2002:482; Daniel 2001:261), they have been largely ignored by archaeologists (see Bamforth 2006). This avoidance is typically related to the logistical problems of excavating them given their size, the curatorial challenges of housing the large assemblages they yield, and the analytical problems they present because quarries tend to be used repeatedly for long periods of time creating a palimpsest effect of human activity. This makes it difficult to isolate stratigraphic layers relating to specific occupations and time periods. The final issue is technical and relates to quartz as a useable toolstone for lithic technology. Arguably, archaeologists avoid analyzing quartz assemblages because of the stone's physical properties, unusual fracturing patterns, and undeserved characterization as an inferior material compared to other siliceous toolstones, namely chert (e.g. Tallavaara et al. 2010). While these issues are more often addressed separately by archaeologists, this study tackles all three of them through the analysis of a large quartz quarry assemblage excavated from the Grandfather Quarry Site (HbMd-4) located in the boreal forest region of northern Manitoba.

Statement of goals

This study has three goals:

1. To make a methodological contribution to the field of lithic analysis. Specifically, I will demonstrate that quarry assemblages can be analyzed using a combined approach of mass analysis and individual attribute analysis, and that the daunting size of many quarry assemblages can be managed by drawing from them smaller study samples using a statistically rigorous method (Milne 2003).
2. To demonstrate the importance of quarry studies by highlighting the essential information they provide in the reconstruction of ancient lithic technological organization.
3. To demonstrate that quartz as a lithic raw material, can be studied despite the inherent difficulties this stone poses due to its internal

> structure, high degree of reflectivity, and presumed inferiority as a useable toolstone. Quartz is one of the most abundant types of stone available geologically throughout the world and people have used it extensively for toolmaking purposes (Ballin 2004, 2008, Barber 1981a, 1981c, 1981b, Bisson 1990, Callanan 1981, Cornelissen 2003, Driscoll 2010, Flenniken 1981, Holen 1991, Kozlowski 1991, Nicholas 1981, Orton 2002, Powell 1965, Ritchie 1981, Rusak 1989, Seligmann 1908, Seong 2004, ten Bruggencate, et al. 2013, Wenzel 1972). As such, it is essential to understand how past populations exploited this stone (ten Bruggencate, et al. 2013: 2703).

To meet these goals, I use a combined analytical approach drawing on two widely used methods known as mass analysis (after Ahler 1989) and individual attribute analysis (see Andrefsky 2001: 9-12, Odell 2003: 125-129). Because the Grandfather Quarry assemblage is composed entirely of quartz, my methodology is geared specifically to address the analytical challenges this stone presents (e.g. Ballin 2004, 2008, Broadbent and Knutsson 1975, Knutsson 1988a, Knutsson and Lindgren 2009, Seong 2004). Data generated through the analysis of 31,438 lithic debitage and tool artifacts, are analyzed using descriptive statistics, measures of dispersion, and multivariate methods. The patterns identified are interpreted within a technological organizational theoretical framework (Binford 1973, 1977, Kelly 1988, Nelson 1991, Shott 1986).

Context of Research

The Granville Lake Project

The Granville Lake Research Project grew out of a desire on the part of the Okawamithikani (Pickerel Narrows) Cree Nation and the community of Granville Lake, Manitoba, to develop a heritage project that would advance their local tourism strategies. Aboriginal communities nationwide have long recognized the potential of cultural heritage knowledge and ecological tourism as economically viable resources.

The project was funded by a three-year (2007-2010) Standard Research Grant through the Social Sciences and Humanities Research Council of Canada (SSHRC), and preliminary research conducted by the community in 2006 focused on the documentation of oral histories, cultural landscapes, and the ancient heritage in the traditional territory of the Asiniskaw Ithiniwak (Rock Cree) in the Granville Lake region of the central Churchill River Drainage Basin. Several culturally significant heritage sites were documented through this work including three major quartz quarries – of which the Grandfather Quarry is one. All of the sites have remained culturally significant to the community as indicated through local oral histories. These pre-European quartz quarries are the largest recorded in Manitoba and the western boreal forest of Canada, and they appear to have been consistently exploited for millennia.

An interdisciplinary research team was assembled to assist local Aboriginal communities along the central Churchill River Drainage Basin to develop heritage policies to protect, and preserve culturally significant Aboriginal landscapes, and to provide knowledge to advance the tourism strategy of Okawamithikani First Nation. This research had four principal objectives (Brownlee, et al. 2007-2010):

1. To examine how Aboriginal people can play active roles in the management and development of policies governing Aboriginal cultural heritage resources
2. To develop an interpretive research framework that integrates local traditional knowledge with historical, archaeological, and geological perspectives
3. To understand how traditional lands that have existed for thousands of years were utilized by the ancestors of the Cree communities situated in the central Churchill River Basin in Saskatchewan and Manitoba.
4. To work with the Cree communities across the central Churchill River Basin to preserve and promote their heritage by recording their local knowledge and stories of culturally significant landscapes.

In the pursuit of these research goals, four graduate students and two undergraduate students were recruited. This study was initiated by Milne, who is a co-investigator on the SSHRC-supported initiative in the area. Her role was to examine the lithic artifacts excavated from the area to understand how past populations were using the local quartz sources for tool making purposes. I was recruited by Milne to conduct the analysis of the material that was excavated from the Grandfather Quarry site in 2008, and my research addresses the third stated objective. This aspect of the project seeks to investigate the upstream areas of the Churchill River in the Granville Lake and Pukatawagan regions, and examines the procurement of quartz as a raw material used in tool production in the northern boreal forest of Western Canada.

Quarry sites were extremely important to pre-European Aboriginal populations inhabiting the northern Boreal forest of western Canada, because as the raw material for the production of tools that were used in almost every aspect of life from food processing, clothing manufacture, hunting equipment, and woodworking, toolstone was a resource every bit as important as food resources. Researching these quarry sites is therefore fundamental to understanding ancient lifeways.

In the summers of 2008 and 2009, excavation work was conducted at the Grandfather Quarry under the direction of Kevin Brownlee, Principal Investigator for the project. Materials recovered became the subject of my research and analysis, which has direct bearing on residential and subsistence strategies, and thereby on land use strategies, for the area now inhabited by the Okawamithikani Cree.

The Site

The Grandfather Quarry is a quartz toolstone procurement site in the northern boreal forest of Manitoba, Canada (see Figure 1). Apart from a few pecking-stones of sandstone, the assemblage is entirely of quartz and is extremely large, comprising an estimated 200,000 pieces of debitage along with a number of formal and informal tools. Given the composition of the assemblage, it embodies all three of the issues outlined above: it is massive in size; analysis of it requires the use of an effective, replicable method that is statistically sound; it is from a quarry site that has the potential to offer insights into the ways in which its users organized their lithic technology in relation to their other activities; and it is almost entirely of quartz.

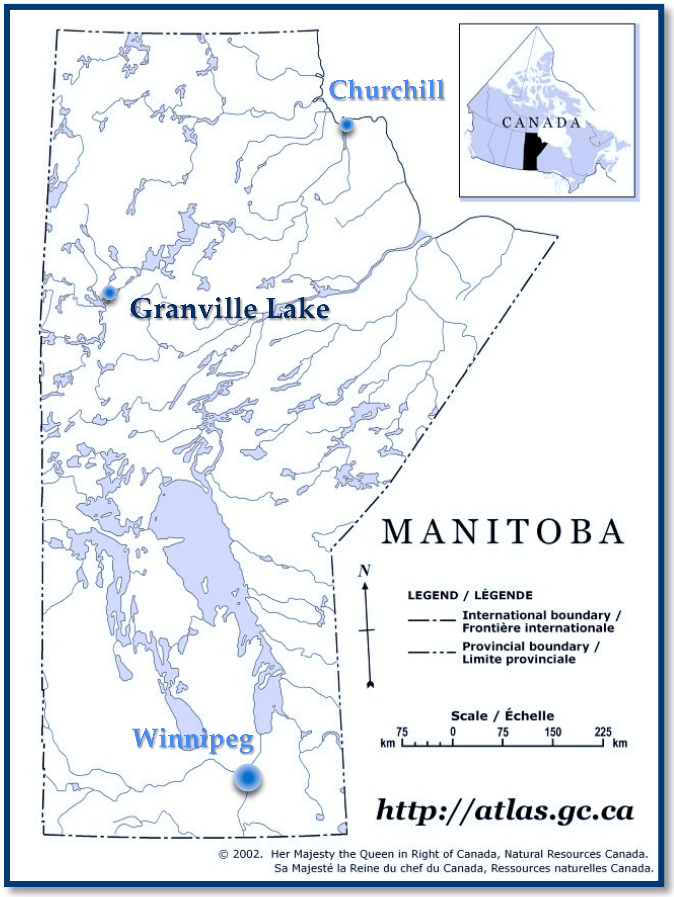


Figure 1: Map of Manitoba showing the location of Granville Lake. Copyright © 2002 by Her Majesty the Queen in Right of Canada.

Significance of Research

This study represents the first intensive lithic analysis to be performed on a Boreal Forest quartz quarry assemblage. It makes a methodological contribution to lithic analysis, particularly in the case of quarry assemblages, which can be problematic for archaeologists, by demonstrating the efficacy of mass and attribute analyses, conducted simultaneously, on the debitage and tool assemblages of the Grandfather Quarry, in the northern Boreal Forest of Manitoba. In so doing, it adds to the growing body of research beginning to address the dearth of quarry studies; and in addition, it informs our understanding of lithic raw material procurement and technological organization within the context of the northern Boreal Forest of Manitoba. In turn, the results of this study will expand our knowledge of how past boreal forest populations utilized lithic resource sites and how trips to these locales may have further structured mobility and subsistence strategies.

Lastly, the results of this study will point the way to future research at other quarry sites throughout the boreal forest and neighbouring regions, and may ultimately permit the identification of, and distinction between, cultural identities and behaviour patterns through time at the super-regional level.

Organizational Framework

Chapter 2 places the research area within the context of the culture history of Northern and Central Manitoba. I provide a literature review of the cultural phases of the northern Boreal Forest, and move on to discuss the Grandfather Quarry site itself. In Chapter 3, I discuss the theoretical framework within which my data are interpreted, and review the literature pertaining to Lithic Technological Organization and the archaeological study of quarry sites.

Chapter 4 provides a literature review of analytical methods in lithic analysis and discusses the physics behind lithic fracture mechanics, the principle behind the manufacture of chipped stone tools. In Chapter 5, I introduce the three research hypotheses to be tested against the data generated by this study and describe the procedure by which I conducted the analysis. I discuss my rationale for selecting mass analysis and attribute analysis to generate my data, and describe the statistical methods used.

Chapter 6 presents my study data. These consist largely of debitage frequency distributions for weight, size grade, dorsal scar count, and raw material quality, which are the metrics that proved to be the most useful in making inferences about the lithic reduction strategies employed by the quarry's users. The non-debitage artifacts are also described and where appropriate, stylistic similarities with cultural affiliations are pointed out.

In Chapter 7, I test the research hypotheses constructed in Chapter 3, and offer my interpretation of what the results mean in terms of the overall culture history of the northern Boreal Forest. Finally, in Chapter 8. I summarize the results of this study and its contribution to Boreal Forest research, pointing out possible avenues for future research. Ultimately, through the results of this analysis, I have been able to identify the range of reduction activities performed at the quarry site, which, in turn, permits me to make inferences about the technological organization of those populations that exploited the quartz and how these activities were integrated into their broader subsistence and settlement strategies in the region.

Chapter 2:
the Research Area in Context

The culture-history of the Manitoba Boreal Forest

Introduction

The pre-contact culture history of Manitoba shows a broad range of culturally diverse peoples. It is intimately linked to the environmental changes brought about by a series of climatic episodes throughout the Holocene. Eleven thousand years ago, ecotones of Canada – particularly those found in the central plains and Canadian Shield – were to be found well to the south of their present locations; but the retreat of the Laurentide Ice Sheet (approx. 10,500 through 6,000 BP) was followed by a northerly movement of both grasslands and boreal forest (Wendland 1978). This is supported by a number of climatic and vegetation studies (e.g. Shay 1967, Sorenson, et al. 1971); and Mayer-Oakes (1967b) has investigated archaeologically the population history of the basin of Glacial Lake Agassiz, the massive body of meltwater left in the wake of the retreating Laurentide ice sheet.

Chapter 2

The Research Area in Context

Because northern Manitoba was under ice for so much longer than the southern part of the province, it is not surprising that the archaeological record of northern Manitoba is relatively sparse compared with that of the south. Nonetheless, from about 8,500 BP the region could possibly have been inhabited and/or visited by Paleo-Indian groups (Brownlee 2011).

The Grandfather Quarry (HbMd-4) is an archaeological site that lies within this region. It is located near the present-day village of Granville Lake in the northwestern part of the Manitoba boreal forest. According to Kevin Brownlee (Personal Communication, 2010, 2011), preliminary radiocarbon dates suggest the site may have been in use for up to 6,300 years; however, the recovery context of the materials that were dated is difficult to control for since the site was backfilled by its users over time. Therefore, stratigraphic control is not absolute making the obtained dates speculative at best.

The lithic assemblage recovered from the Grandfather Quarry Site is almost exclusively quartz and consists near-exclusively of debitage. There is a proportionately small number of formal tool types, including bifaces and scrapers, along with a range of informal tools consisting mostly of retouched flakes. The only non-quartz artifacts recovered were anvil-like features, sandstone pecking stones, and one possible abrader, also of sandstone.

Chapter 2

The Research Area in Context

In this chapter I discuss the Grandfather Quarry and its assemblage within the context of the prehistory of the northern Boreal Forest of Manitoba. I begin with a review of the culture history of the northern Boreal Forest and adjacent regions. I then describe the Grandfather Quarry in the context of its location within the Boreal Forest and relate its assemblage to the culture history of the region.

The Culture History of Northern and Central Manitoba

Archaeological research since 1990 has brought to 39 the total number of distinct cultural groups identified in Northern Manitoba (Malasiuk 1993: 18). More broadly, Malasiuk (1993: 10) lists a much smaller number of chronologically ordered culture complexes found archaeologically throughout Manitoba. Each of these occurred within roughly defined regions in Manitoba, although there are areas of overlap. Of these, culture complexes relevant to an emphasis on the early-to-middle prehistoric cultures of central and northern Manitoba include: the Central Manitoba Shield Archaic; the McKean culture; the Oxbow Culture; and two cultures of the Arctic Small Tool tradition (ASTt), the Pre-Dorset and the Dorset.

Central Manitoba Shield Archaic (4500 BC – AD 1)

The Archaic period developed out of the big-game hunting Northern Plano (10,500 – 6,500 BP) cultures of the Paleo-Indian period. The term "Shield Archaic" was initially coined by James V. Wright in the 1960s as a catch-all to describe "the pre-ceramic remains of Ontario and Northern Quebec" (Wright 1972: 2). As the concept developed and the work of other researchers was included (e.g. Byers 1959a, 1959b, Harp 1958, 1959, 1961, Ridley 1954, Ritchie 1938, 1944, Rogers and Bradley 1953, Rogers and Rogers 1948, 1950), the Shield Archaic complex came to represent a regional culture characterized by strategic adaptation to the boreal forest of Manitoba and adjacent provinces, extending from Quebec to the Keewatin district of the Northwest Territories (see Figure 2. Also: Wright 1970, 1972, 1976, 1981). The vast expanse of territory inhabited by the Shield Archaic people is hardly surprising given the nature of the boreal forest environment: the extensive network of rivers and lakes forms a natural system of Archaic "highways," enabling travel by boat during the spring and summer, and by snowshoe and sled over the ice during the winter months.

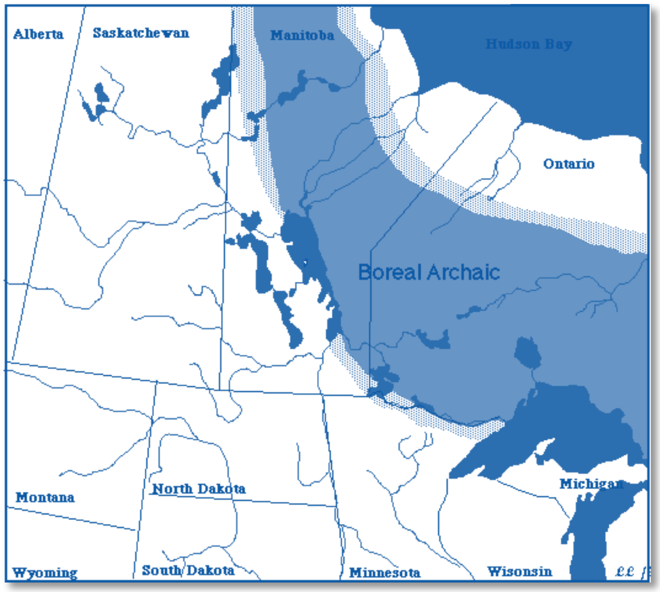


Figure 2: Map showing the area covered by the Boreal (Shield) Archaic culture tradition. From Petch, et al. (1998). Image Copyright © 1998 by the Manitoba Archaeological Society. Used by permission.

Although the Archaic period in North America is generally associated with a shift to the exploitation of a wider variety of resources and increased sedentism (Milner 2005, Petch, et al. 1998), Shield Archaic assemblages nonetheless indicate a continuation of a mobile hunting and gathering subsistence strategy, albeit with the same shift of emphasis to broad-spectrum food collection that is typical of Archaic cultures. This wide range of food resources represents a departure from the plains cultures owing to the availability of different animals (e.g. woodland caribou, moose, elk, rabbit, fox and wolf all form part of the faunal assemblage), and fishing appears to have been especially important (Wright 1971: 22).

The boreal forest environment and hunting and gathering lifestyle are reflected in the toolkit, which consists of chipped stone tools similar to those of contemporary cultures of the plains to the south (e.g. points, scrapers, knives), as well as tools suitable for working wood (e.g. adzes) which are not found outside the boreal forest (Wright 1972: 92-157, Petch, et al. 1998). Additionally, evidence for ritual is seen in the Shield Archaic in the form of finely made wood, bone, and antler tools that were included as grave goods in an elaborate burial at the Victoria Day Site, dated ca. 4300 BP (Petch, et al. 1998, Pilon 2001: 271-272).

McKean Culture (3000BC - 1000 BC)

The McKean culture complex is primarily "a plains and mountain culture which did not occupy much of the woodland area of northern Manitoba" (Hlady 1970a: 103). Named for the type-site in Wyoming (Mulloy 1954), the McKean complex is characterized by three distinct projectile point forms: McKean Lanceolate, Duncan, and Hanna (see Figure 3). It is possible that these points may have belonged to different yet mutually interacting ethnic groups: explorer Henry Kelsey noted in 1690 that the Assiniboine, Cree and Blackfoot, all three of whom interacted with one another and shared common hunting grounds, could distinguish their arrows from one another (Kelsey 2002 [1690]).

Figure 3: Projectile points of the McKean complex: (l to r) Duncan, Hanna and McKean (Saskatchewan Heritage Online 2005). Images Copyright © 2005 Saskatchewan Heritage Online and used by permission.

The McKean complex occurs over a broad area encompassing Saskatchewan, Alberta, Montana, Wyoming, and parts of Colorado, Nebraska and North and South Dakota (Hlady 1970a: 103). It is also found in Manitoba west of the Winnipeg river, where it is most common in the Swan River Valley (Syms 1969: 175). Mayer-Oakes (1967a: 355) estimates the date of projectile points found at Tailrace Bay (Grand Rapids Survey) at approximately 4,500 BP.

McKean subsistence on the Western grassland appears to have been centered on the exploitation of bison, although bison appears to become secondary to other resources east of the Winnipeg River; it is further evident from the number of grinding stones (manos and metates) found in McKean assemblages that plant foods formed a very large part of the McKean diet, although surprisingly only three sites have yielded preserved plant-food remains (Keyser 1986: 233). Grinding stones are notably rare in McKean assemblages found in Manitoba (Petch, et al. 1998), suggesting that plant-foods may have been of less importance here; however, Syms (1970: 136) cautions that "[w]e must be careful not to assume that hunting and fishing were the only food sources because of lack of preservation and absence of grinding stones." He goes on to argue that as the McKean people advanced into other environments,

> …they appear to adapt their tool inventory and food sources to the changing conditions. Even during the driest periods, their subsistence patterns were probably sufficiently flexible to enable them to exist in most of the Northern Plains, particularly in Manitoba where there is a higher rainfall and greater variety of ecological zones than in the southern part of the Northern or Central Plains (Syms 1970: 136).

In any case, broad-spectrum food-collecting is indicated by the great variety of bird, small and medium-sized mammal, and fish recovered (e.g. MacNeish and Capes 1958: 147).

Oxbow Culture (3300 BC – 1000 BC)

In Manitoba, McKean points are often found together with a short, wide, side-notched and “eared” form of point (see Figure 4) variously referred to as “Oxbow,” “Parkdale Eared” or “Powers-Yonker Eared” (Syms 1970: 125). These represent a plains culture concentrated north of the Missouri River (i.e. Northern Montana, Alberta, Saskatchewan). In Manitoba, Oxbow is primarily found in the southwest (Buchner 1981, Miller 1981), but specimens have been found as far north as Southern Indian Lake (Petch, et al. 1998).

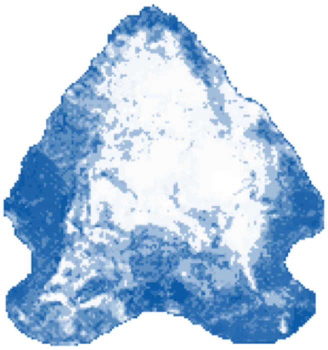


Figure 4: An Oxbow projectile point, From Petch, et al. (1998). Image Copyright © 1998 by the Manitoba Archaeological Society. Used by permission.

Other items associated include oval bifacial knives, end-scrapers, perforators, drills, crude choppers, anvil stones and fire-cracked rock. This last item is strongly associated with a method of preparing bison whereby the meat is boiled in water heated by red-hot stones (Bryan 1991: 80); and indeed, Oxbow sites are associated with bison especially in grassland locations. In 2006, I observed similar patterns firsthand when I worked on the Wright Site (EaLg-9) as a teaching assistant for the Manitoba Universities Summer Archaeological Field School; the site is located approximately 6 km north of Winnipeg on Highway 9. Here bison remains were found in large quantities; and fire-cracked rock was ubiquitous throughout the site. At least two projectile points with attributes characteristic of Oxbow were also found.

Richard MacNeish (1958) classified these points along with the McKean types as "Whiteshell Focus." Most Canadian scholars regard Oxbow as preceding the McKean complex, although there is little doubt that the makers of both types overlapped both geographically and chronologically (Syms 1970: 125-127), given that they are commonly found together.

Of particular note with regard to the Oxbow people is their well-developed sense of spirituality. Burials dating as early as 5,000 BP have been found throughout the plains, including the Gray Site in Saskatchewan, an

Oxbow cemetery used for more than 2,000 years (Millar 1981, Petch, et al. 1998, Wade 1981). Petch, et al. (1998) note that no Oxbow burials have yet been found in Manitoba; but more recently, Hoppa et al. (2005) have analyzed two elaborate burials at the Eriksdale Site (EfLl-1) that could possibly be attributable to the Oxbow complex; and Nicholson and Nicholson (2007) have recently detailed evidence for the ceremonial/ritual treatment of a bison skull in southwestern Manitoba.

Pre-Dorset culture (1500- 500 BC)

With the retreat of the Laurentide ice sheet around 8,000 BP, the climate was generally warmer than it is now; however, between about 3500-2500 BP the northern subarctic experienced colder and more variable climatic conditions, and in response to this, the northern treeline of the boreal forest retreated to a point some 300km to the south of its present location (Wendland 1978: 276, Sorenson, et al. 1971). In response to these changes, the Shield Archaic hunters also moved southward. At approximately the same time, members of the Arctic-adapted, Pre-Dorset culture, moved southward in response to increasingly colder conditions found in the Arctic proper (Maxwell 1985). Small groups of Pre-Dorset hunters thus moved into these newly abandoned areas, penetrating into the boreal forest (Nash 1969, 1970: 82-90, Wright 1970: 44).

The Pre-Dorset are members of the Arctic Small Tool tradition (ASTt). Remains of their sites are typically found south of the Perry Channel in the eastern Low Arctic; however, their remains have more recently been found in a limited number of High Arctic locations (Maxwell 1985, Milne and Park In Press, McGhee 1996). The ASTt originated in Siberia and then spread across the Bering Strait via the Seaward Peninsula into Northern Alaska (McGhee 1996, Milne and Park In Press). Once there, small groups of ASTt hunters began moving into the eastern Arctic via the Arctic coast and islands, and, "when maritime hunting was adversely affected by prolonged cold" (Gordon 1996: 149, see also Nash 1969: 148-151, Nash 1970: 89-90), eventually into the inland tundra and down to the treeline, where they adapted to local environments and available resources (Maxwell 1985, Milne and Park In Press). Over time, minor variations in material culture led archaeologists to identify regional manifestations of ASTt populations. Pre-Dorset sites characterize those ASTt occupations found throughout the eastern Low Arctic archipelago and mainland regions, including northern Manitoba.

Characteristic of the Pre-Dorset lithic assemblage are burins, burin-spalls (often chipped for use at one end), side-blades in either a regular or crescented outline, and microblades (Anderson and Hodgetts 2007, Bielawski 1988, Gordon 1974, 1975, 1976, 1996, McGhee 1975, 1976, 1979, Meyer 1977, Nash 1969, 1970, 1975, Wenzel and Shelley 2001).

There are three major Pre-Dorset sites in Manitoba, all belonging to the late phase of the Pre-Dorset and dating between about 1500-500 BC (3500-2500 BP). Of these, the oldest is Thyazzi (Nash 1970: 86), meaning "sandy" in Chipewyan (Giddings 1956: 258). It is located on a sandy ridge near the north Knife River and was likely visited seasonally by small groups between about 1500 – 1300 BC (3500-3300 BP). By this time, barrenland Pre-Dorset had adapted to a purely interior (i.e. non-maritime) way of life (McGhee 1975: 64), and indeed the points discovered at Thyazzi suggest an emphasis on caribou hunting as the main pursuit as it was for the Chipewyan of more recent times (Nash 1969: 51, Giddings 1964: 240-242, Nash 1975). Elsewhere in the barrenlands, Pre-Dorset faunal assemblages suggest the exploitation of mixed smaller game such as arctic fox (Ellis 2008: 305), as well as avian resources such as ducks and geese (Milne and Donnelly 2004). The other sites of Seahorse Gully and Twin Lakes, both nearer to Hudson Bay than Thyazzi, are more recent (ca. 2500-3000 BP) and more maritime-oriented in terms of their assemblages, suggesting a focus on sea mammal exploitation (Nash 1970). In addition to the three major Pre-Dorset sites in Manitoba, Arctic Small Tool tradition material has been reported from a number of smaller sites within the Boreal Forest, including the north end of Southern Indian Lake (Kroker 1990) and Rock Lake, approximately 32 km north of Thompson, Manitoba (Dickson 1980). Kroker also points to three sites tentatively assigned to the ASTt, in the vicinity of the Limestone area of the Lower Nelson River which flows into Hudson Bay. Although they are considerably inland at the present time, Kroker (1990: 152) is quick to point out that at the time of occupation these sites would have been no more than 40 km inland from the coast of a Hudson Bay swollen with glacial meltwater.

Although during the Pre-Dorset occupations of Northern Manitoba there may have been the potential for interaction between the Pre-Dorset and the Shield Archaic hunters, it is not known with certainty whether they occupied the same regions simultaneously or at different seasons. Artifacts of both complexes have been found in mixed contexts (Dickson 1980), but it is now believed by most researchers that these collections reflect physical mixing after the fact rather than trade or diffusion, and that "alternating occupations between Indians [sic] and Eskimos appear to have been temporally distinct" (Noble 1971).

Dorset Culture (900 BC – AD ~1000)

The Dorset are the direct descendants of the Pre-Dorset in the eastern Arctic (Maxwell 1985, Milne, et al. 2013, Milne and Park In Press). Dorset sites are found widely distributed throughout the eastern Arctic (Milne, et al. 2013). They are more typically interpreted as an Arctic adapted population given that the first remains of their sites found in the archaeological record coincides with a period of intense cold in the Arctic proper. However, two sites located near Churchill, on the coast of Hudson Bay, have yielded Dorset assemblages. Subsistence pursuits at these sites appear to have been similar to that of other groups living on the coast during the post-contact period: faunal remains such as seal predominated, with polar bear, musk-ox and caribou also exploited (Dumond 1979: 10) along with eider, duck and Arctic tern (Nash 1972). Artifacts found in and around the remains of five houses include long, thin microblades, burin-like tools, small harpoon heads, notched and triangular points, notched knife blades and larger biface blades, along with large, rectangular soapstone vessels likely used for cooking or as lamps (Nash 1970: 90).

The Study Area

The Grandfather Quarry site (HbMd-4) is located near Granville Lake, at the western end of the Churchill River system in northern Manitoba. At the request of the Okawamithikani Cree Nation, the precise coordinates have been withheld in order to protect the site from deliberate or accidental damage.

Ecology

Ecologically, the region is a woodland environment consisting largely of spruce, jackpine, poplar, birch, willow, tamarack and smaller brush. Wild berries abound, including wild strawberries, blueberries, raspberries, gooseberries, chokecherries, saskatoons and cranberries, to name but a few. A wide variety of animal life provides ample game resources, including migratory bison (Park and Stenton 1998a: 110), moose (*Alces americanus*), deer (*Odocoileus virginianus borealis*), woodland caribou (*Rangifer tarandus*), barrenland caribou (*Rangifer groenlandicius*), and bear (*Ursus americanus*). Smaller animal resources include various species of weasel (genus *Putorius*), beaver (*Castor canadensis*), muskrat (*Fiber zibethicus*), lynx (*Lynx canadensis*), several species of fox (genus *Vulpes*), squirrel, rabbit (*Lepas americanus*), otter (*Lutra canadensis*), fisher (*Mustela pennauti*), marten (*Mustela abietecola*), and mink (*Putorius vison*). Fish are abundant, and include whitefish (*Coregonus clupeaformis*), pickerel (*Esox americanus*), jackfish (*Esox lucius*), sturgeon (*Acipenser fulvescens*), mullet (*Catostomus commersonii*), goldeye (*Hiodon alosoides*), tullibee (*Coregonus artedi*), perch (*Perca flavescens*), ling (*Lota lota*), as well as both lake and speckled trout (*Salvelinus namaycush* and *Salvelinus fontinalis* respectively). Waterfowl, particularly geese and ducks (family *Anatidae*), are present, along with such game birds as ruffed grouse (*Bonasa umbellus*), spruce grouse (*Falcipennis canadensis*) and ptarmigan (*Lagopus sp.*) (Hlady 1970a: 94).

Geology

The local geology consists essentially of a host metasedimentary rock surrounding a number of pegmatite deposits of feldspar, mica, and of course, quartz. This has resulted in several quartz deposits that have been used as toolstone quarries, of which the Grandfather Quarry is one (ten Bruggencate, et al. 2013).

In terms of suitability as toolstone, the overall quality of the quartz is quite poor, although there are occasional, relatively small veins of very high-quality raw material present. Although chert tools have been found throughout the Churchill River Basin, deposits of naturally-occurring chert are rare (ten Bruggencate, et al. 2013: 2703). Chert was therefore not available to stone tool-using groups, and local quartz would have to have been used despite its poor quality, and indeed “quartz tools and debitage make up the bulk of most lithic classes in stone tool assemblages from archaeological sites in this region” (ten Bruggencate, et al. 2013: 2703).

The Archaeology

Throughout the research area, lithic artifacts attributable to the northern Plano (Paleo-Indian) cultures that pre-dated the Shield Archaic, have been found, along with higher densities of Shield Archaic lithics, and later Woodland lithics and ceramic assemblages, indicating a continual occupation and utilization of the area for approximately the past 6,000 years (Dickson 1975, 1977, Hlady 1970a, 1971, Jones and Jones 1978, Kroker 1990, Nash 1970, 1975, Syms and McKinley 2002, ten Bruggencate, et al. 2013: 2703).

There are five purported pre-contact quarries in the Granville Lake district: Grandfather Quarry, Little Grandfather Quarry, Mimikweapisk Quarry, Wheatcroft Quarry, and Smoky Quartz Quarry. Of these, only the Grandfather Quarry (HbMd-4) has been the subject of intensive archaeological investigation, having been tested and surveyed during the summer of 2008, and excavated more thoroughly in the summer of 2009 (ten Bruggencate, et al. 2013: 2703).

The Grandfather Quarry is a 12m × 4m × 2m pit excavated into the metasediment-hosted pegmatite bedrock, "surrounded on all sides by extensive scatters of quartz debris, debitage, and tool fragments. The quarry has been infilled with a mixture of soil, debitage, and other debris" (ten Bruggencate, et al. 2013: 2703). The excavated assemblage consists almost exclusively of quartz debitage, with a few formal and informal tools, bifaces and cores present as well. Other than a few sandstone pecking stones and one abrader, the assemblage is exclusively quartz.

Excavation

Excavation (see Figure 5) work was carried out by Kevin Brownlee (Curator of Archaeology at the Manitoba Museum and Principal Investigator of the Granville Lake Project) and a field crew that included representatives of the *Okawamithikani* (Pickerel Narrows) Cree Nation and three graduate students, Rachel ten Bruggencate (Ph.D. program, University of Manitoba), Myra Sitchon (Ph.D. Program, University of Manitoba) and Holly Cote (M.A. Program, Lakehead University).

Figure 5: Excavation at the Grandfather Quarry. Photo Copyright © 2008 the Manitoba Museum. Used by permission.

The material recovered from the Grandfather Quarry consists of an estimated 150,000 – 200,000 pieces (Beardsell and Milne 2011b) removed in the summers of 2008 and 2009 from two 1x1m excavation units (Units 1 and 5), one small 1m x 30cm excavation unit (Unit 11) and seven 50x50cm test pits (2, 3, 4, 6, 7, 8, 9 and 10; see Figure 6). Arbitrary levels of 5cm were designated, beginning at an arbitrary vertical datum of 50m above sea level.

Material was excavated from Units 1, 5 and 11 and was screened using nested ¼″ and 1/8″ hardware cloth. Material from Unit (Test Pit) 3 was not screened.

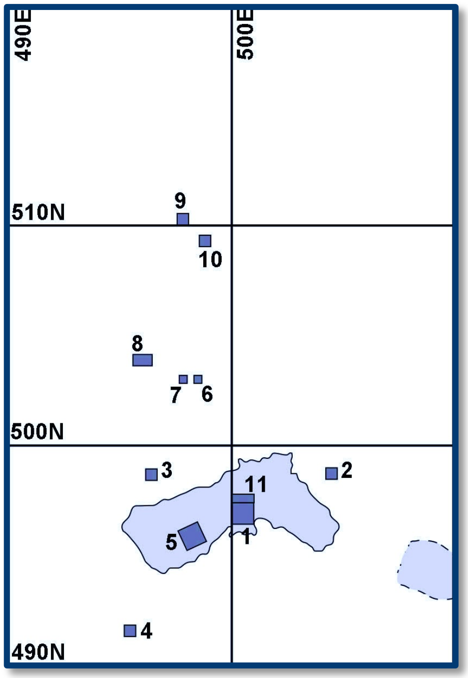


Figure 6: Map of the Grandfather Quarry site, showing the locations of all excavation units and test pits. Map by Scott Hamilton and Copyright © 2008 the Manitoba Museum. Used by permission.

Other than some feldspar detritus, mica fragments, and a few pecking stones fashioned from sandstone, the lithic material recovered is predominantly quartz, and is almost exclusively debitage. Formal tool types including the pecking stones, bifaces, and scrapers, among others as well as a range of informal tools consisting largely of retouched flakes, were also recovered (see Chapter 6). All recovered material was bagged and boxed by unit and level, and was delivered to the University of Manitoba archaeology laboratory for analysis (see Figure 7). As a token of respect for the heritage of those who left this material behind, and for the current stewards of the land on which Grandfather Quarry is found, a beaker of tobacco was kept in the laboratory with this archaeological material.

This investigation was conducted under an Aboriginal Research Program Grant through the Social Sciences and Humanities Research Council of Canada (Brownlee, Principal Investigator; Fayek and Milne, Co-Investigators; Hanna, Collaborator), and has resulted in several journal and conference papers (e.g. Beardsell and Milne 2011a, 2011b, Brownlee 2011, ten Bruggencate and Fayek 2009, ten Bruggencate, et al. 2013), one Master's thesis, and two doctoral dissertations, of which this is one.

Figure 7: Cabinets containing the excavated material from the Grandfather Quarry. The tubs used to transport material from each unit and level are stacked atop the cabinets.

The other doctoral dissertation (ten Bruggencate In Preparation) is an attempt to differentiate quartz artifacts from discrete source areas using a technique that combines qualitative visual categorization with lead (Pb) isotope analysis and the quantification of titanium (Ti), uranium (U) and thorium (Th) using a Secondary Ion Mass Spectrometer (SIMS). The technique can successfully differentiate between quartz samples from seven pre-contact quarry sites in northern Manitoba and Saskatchewan (ten Bruggencate, et al. 2013: 2703). ten Bruggencate's research is crucial to archaeological studies in the area given the scarcity of chert and other cryptocrystalline toolstones, and the commensurate importance of quartz as a raw material to the stone tool-using populations of the Churchill River Basin.

The master's thesis (Cote 2012) is an attempt to record oral histories of the region as they pertain to places (such as the Grandfather Quarry, for example) in the landscape. Similar work has been done elsewhere (e.g. Oetelaar and Meyer 2006, Oetelaar and Oetelaar 2006) in order to help researchers view the landscape from the perspective of the people who utilized it.

My study focuses exclusively on the Grandfather Quarry and aims to examine debitage assemblage variability using two methods of analysis: mass analysis and individual attribute analysis. The results of this study will provide important information on the kinds of reduction strategies undertaken by toolmakers while at the quarry, which, in turn, will help reconstruct corollary cultural phenomena like mobility, land use, and seasonal resource exploitation. When integrated, all three avenues of investigation – geochemical sourcing of lithic artifacts, oral histories, and lithic analysis, will provide multiple lines of evidence (Anderson and Hodgetts 2007: 231, Bradbury and Carr 1995, Magne 2001: 23, Morrow 1997) or "cabled" arguments (after Wylie 1989, see also Lewis-Williams 2002: 102) that will help accurately reconstruct how people in this region used the landscape over time.

Summary

In this chapter I have discussed the Grandfather Quarry (HbMd-4) in the context of the culture history of northern Manitoba. Approximately 6,500 years ago, the Shield Archaic grew out of the big game-hunting cultures of the Paleo-Indian period. Although the Archaic characterized a gradual shift throughout the continent toward a more sedentary way of life, hunting and gathering persisted in the Boreal Forest, albeit with the same shift toward the exploitation of a broader spectrum of food resources. These Shield Archaic cultures ultimately spanned the entire Boreal Forest, from what is now Quebec and Ontario, around Hudson Bay and into the Keewatin district of the Northwest Territories.

Approximately 3,500 years ago, a cooling trend caused the northern treeline to retreat southward to a point some 500 km south of its present location, and the forest-adapted Shield Archaic peoples abandoned the northernmost territories and moved southward with the treeline. At roughly the same time, the Pre-Dorset bearers of the Arctic Small Tool tradition moved into some of these newly abandoned areas and even penetrated the Boreal Forest, exploiting new resources as unfavourable conditions caused their Arctic marine-adapted subsistence strategy to falter.

The Grandfather Quarry is uniquely situated in the midst of this arena of climatic and cultural change during the Shield Archaic, and is therefore of interest to archaeologists. In the next chapter I discuss the theoretical framework within which my research into the Grandfather Quarry was conducted.

Chapter 3: Theoretical Framework

Quarry Sites and the Organization of Lithic Technology

Introduction

As sources of lithic raw material (toolstone), quarries represent a resource every bit as important as food to most foraging societies (Beck, et al. 2002: 482, Milne 2003: 70-71). Past studies (e.g. Taçon 1991) as well as emerging ones (e.g. Hanna 2009) also suggest a spiritual and/or cosmological significance to quarry sites, in addition to the implications they hold for prehistoric land use and adaptation (Beck, et al. 2002: 482, Bamforth 2006: 512). One would therefore expect quarries to be a primary target of study for the archaeologist interested in the life-ways of past hunting and gathering populations.

Paradoxically, though, while quarries may be of interest to the archaeologist (Gramly and Cox 1976, Gramly 1980a), even dating back more than a century (e.g. Holmes 1890, 1891a, 1894a, 1897, 1919, Phillips 1899, 1900), there has been little treatment of quarries by archaeologists, relative to other types of sites (Purdy 1984: 119, Pedrick 1985: 5). Indeed, in his data-collection preparatory to publishing his work on the Shield Archaic (Wright 1970, 1972), Wright purposely excluded quarry site materials, feeling that as ‘special purpose’ sites they introduce an unwarranted dimension of complexity:

> Quarry sites have not been used for comparisons in the Shield Archaic monograph since their specialized function introduces a factor that is disruptive to a scheme attempting to outline the temporal and spatial variations as expressed by habitation sites. This is not to say that the quarry sites do not contribute information vital to our understanding of the Shield Archaic but simply that for the purposes of the major study such sites have been purposefully separated from the habitation sites in order to maintain comparative continuity (Wright 1970: 30-31).

Those publications on quarry sites that do exist are largely descriptive (Bamforth 2006: 511-512). More recently, however, quarries have been examined in greater detail by archaeologists and have expanded to encompass a broader picture of the lives of prehistoric hunter-gatherers (Pedrick 1985: 6, Bamforth

2006: 512). In this chapter, I examine the way in which quarry studies can inform archaeologists as to peoples' technological organization vis-à-vis settlement and mobility, which in turn are largely influenced by subsistence strategies and resource procurement.

I begin with a discussion of lithic technical organization in general, as any discussion of the broader implications of quarry studies must necessarily consider such contexts as tool form and function, concepts of curation, resource procurement (i.e. subsistence) strategies, and settlement and mobility patterns. I then outline the development of quarry studies and give examples illustrating how quarry sites and the reduction activities associated with them can inform archaeologists about people's technological organization within the context of settlement and mobility. Finally, I discuss some of the analytical challenges presented by quarry sites in addressing these human phenomena.

Lithic Technological Organization

Continuous vs. Staged Reduction

Whether it is debitage, cores and bifaces, or finished tools being analyzed, there has been a prevailing tendency to conceive of lithic reduction as a staged process: "[t]ypically, lithic analysts view reduction as a process that unfolds in essentially discrete stages" (Shott 2004: 224). This propensity to automatically view artifacts as unchanging snapshots in time should come as no surprise in light of Ruth Benedict's (1934: 2) famous observation that even researchers are inherently biased by their own cultural milieu: in our own Western, post-Industrial Revolution world, a factory mass-produced tool is essentially static – that is, it maintains its form and function throughout its use-life. A hammer is always a hammer; a plane blade a plane blade, a chisel a chisel and a saw a saw. Even when they show signs of wear, they maintain their original function and basic shape from manufacture through eventual discard.

This cannot be said of stone tools, however, and many researchers do not distinguish the actual stages of lithic reduction. Instead, they view it "as a continuum from raw-material acquisition to a final product" (Andrefsky 2005: 187, Sullivan and Rozen 1985, Rozen and Sullivan 1989, see also: Bradbury and Carr 1999, Shott 1996b). This understanding of the *dynamic* nature of stone tools was a direct outgrowth of the 1964 publication in English of Semenov's work on the microwear pattern analysis of tool edges (Andrefsky 2005: 5), and is of critical importance to the archaeologist if tool types are to be useful as temporal, spatial or functional indicators (Frison 1968: 154), not to mention indicators of human behaviour.

If, then, stone tool types are to be useful as temporal, spatial or functional indicators, the dynamic nature of stone tools throughout their use-lives *must* be considered (Frison 1968: 154). The first implication here is that the tools themselves will ultimately wear out and have to be discarded when the "stub" or remainder is too small and worn to be of any further use, making a continuing supply of fresh toolstone a *necessity*, not a luxury nor an optional commodity. Simply stated, it is an essential resource.

If one starts from this primary assumption, it follows that lithic raw materials are subject to the same sorts of procurement costs in terms of time and energy. Just as with food resources, therefore, effective strategies must be employed to mitigate the costs of toolstone procurement; moreover, the situation is further complicated "[b]ecause there is no necessary relation between the location of food and lithic resources… [and] access to raw materials is compromised when other activities must be pursued away from the source" (Milne 2003: 70).

This means that subsistence-related activities must be organized with respect to the procurement of lithic raw materials. This is the fundamental principle behind the theoretical framework of *technological organization* (Binford 1973, 1977, Kelly 1988, Shott 1986), which refers to

> ...the manner in which human toolmakers and users organize their lives and activities with regard to lithic technology…. In this context, the manner in which lithic tools and debitage are designed, produced, recycled and discarded is intimately linked to forager land-use practices, which in turn are often associated with environmental and resource exploitation strategies (Andrefsky 2009: 66).

As Morrow and Jefferies (1989: 29-30) point out, where procurement costs are high, group behaviour with regard to toolkits tends to be aimed at conserving raw material or extending the use-life of tools and cores. For example, bipolar percussion -- a technique used when the core or nodule is too small to be effectively flaked in a controlled manner when held in the hand -- may be used to extend the life of, and extract useful flakes from, cores or broken tools that would otherwise be discarded as being ‘exhausted’ (Milne 2003: 73). When toolstone is plentiful, or acquired under an *embedded* strategy in which the costs of procurement are “subsumed within the normal functioning activities of the society” (Milne 2003: 71), raw material stress is less acute and this is reflected in the toolkit, which may be composed largely of *expedient* tools.

Expedient, or informal tools require little or no effort to make, and can be as simple as an unmodified flake or blade removed from a core. They can be used for a variety of purposes and tasks, and are usually discarded soon after use. Alternatively, some tasks can be performed using tools of different shapes, and because of this, expedient tools "immediately introduce a great amount of variability into the lithic tool assemblage because their morphology is not constrained by design requirements" (Andrefsky 2005: 31).

Formal tools, on the other hand, require more effort in terms of raw material procurement, design and reduction sequence, and are more likely to be transported to a different location for use and/or modification (Andrefsky 2005: 31). This latter type of tool is often referred to as being *curated,* a concept introduced by Binford (1973) in the context of a "spirited debate about the interpretation of Old World Middle and Upper Paleolithic assemblages" (Shott 1996a: 260), championed on the one hand by François Bordes, who believed that variation between Mousterian assemblages was the result of cultural differences between the toolmaking groups, and Binford, on the other, who insisted that the variation was the product of behavioural differences -- in both kind and intensity -- between sites (*ibid.*). In response to Bordes' criticism that cultural identity overrode functional differences and that Upper Palaeolithic assemblages were not characterized by similar variation, Binford argued that Upper Palaeolithic peoples *curated* their tools by using a uniform reduction strategy that could be halted at any point in the process when the tool's form matched the requirements for a given task. This, he suggested, obscured the functional differences seen in Mousterian assemblages, which he believed were non-curated.

Curated tools

> ...are generally made from high quality raw materials because they are isotropic, brittle, and have a high degree of plasticity, making them amenable to resharpening and rejuvenation, thus prolonging use-life… [and are]… conserved more intensively, especially if raw materials are in short supply (Milne 2003: 72).

Expedient tools, by contrast, tend to be comparatively wasteful of raw material and are used when there is little or no raw material stress or time constraint (Milne 2003: 73).

The concept of curation has been the subject of criticism, owing primarily to the variable and sometimes haphazard manner in which it is applied. Because Binford failed to clearly define the term, it has been applied inconsistently by subsequent scholars including Binford himself. Because of this, Nash (1996a, 1996b) believes the term is no longer of use to lithic analysts and argues for its deletion from the archaeological lexicon (Nash 1996b: 96). Indeed, most of the conference participants at the Second Tulsa Conference on Lithic Analysis, held in Tulsa, Oklahoma in the summer of 1993, felt that it would be best to suspend using the term, "employing instead a description of the type of behavior that appears most relevant to the specific case being described (e.g. transport, recycling)" (Odell, et al. 1996: 382). Taking a more moderate view, Shott (1996a) considers the term and the concept still useful -- but only if a standard definition is adopted by the archaeological community. Accordingly, he offers a tentative definition: "Curation," he asserts, "is a relationship between things," and more specifically, is the degree of use or 'utility' extracted from a tool during its life, expressed as a relationship between how much utility a tool starts with, and how much of that utility is realized before discard (Shott 1996a: 267, 1995, 1989: 24).

It has been noted that because raw material acquisition by any means other than opportunistim is costly for most mobile groups, such peoples tend to employ a curated technological strategy dominated by formal tools; sedentary groups tend to be located near raw material sources and toolstone is plentiful; expedient strategies and informal tools tend to dominate their assemblages (Milne 2003: 75).

It should also be noted, however, that curation and expedient tool manufacture can be employed together, further complicating patterns in the archaeological record (Nelson 1991: 64-65); it is therefore "… crucial that curation and expediency not be perceived as mutually exclusive *systems,* but as planning options that suit different conditions within a set of adaptive strategies" (Nelson 1991: 65; emphasis in the original).

Studies in Technological Organization

Nelson's caution is echoed by Andrefsky (1994), who disputes the dichotomization of curation and expediency to the association of mobile and sedentary groups, respectively. He uses ethnographic data from the western United States to consider raw material abundance *together* with raw material quality with reference to curated versus expedient reduction strategies. He finds that poor quality materials universally tend to be manufactured into expedient (informal) tool designs; high-quality toolstone, when scarce, is usually used for curated (formal) tools; but when abundant, it is used for both curated *and* expedient tools in more or less equal proportion (Andrefsky 1994: 31). Factors such as mobility (residential *vs.* logistical) or sedentism are, he finds, less important determinants of curated or expedient tool strategies (see Figure 8).

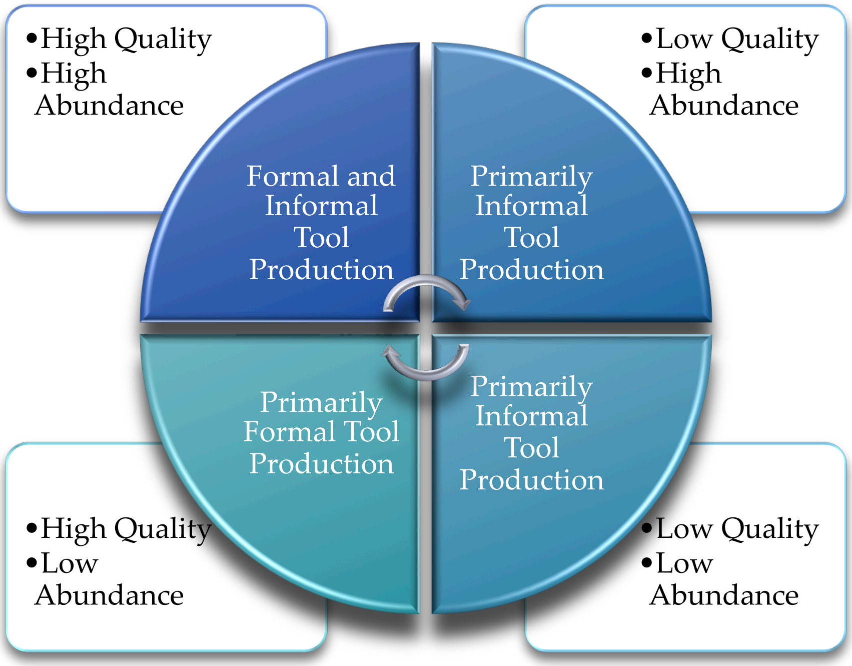


Figure 8: The relationship between the quality and abundance of lithic raw material and the kinds of tools produced (adapted from Andrefsky 1994: 30).

Binford's (1972, 1973, 1976, 1979) ideas about residential *vs.* logistical mobility, and about curated (formal) *vs.* expedient (informal) tools, formed the basis of Morrow and Jeffries' model (see below), which is demonstrated in their study (1989) of the Middle Archaic Black Earth site in Saline County, Illinois. According to Binford, residentially mobile groups forage on a daily basis, returning to their base-camp at the end of each day; as resources within a day's foraging radius are depleted, the base-camp is moved to a new location amidst more plentiful resources. Logistical mobility, on the other hand, is employed when a resource procurement site is too far from the base-camp for the foragers to return the same day, and a special-purpose expedition must be made (Beck, *et al.* 2002: 485).

Based on his observations of the Nunamiut people of northern and northwestern Alaska (Binford 1978, 1979, 1980), Binford argues that there are few, if any toolstone procurement costs to hunting and gathering (foraging) peoples. This is because toolstone procurement is what he calls *embedded* in foragers' round of seasonal resource exploitation activities, such that when they are exploiting other resources in an area near a known source of toolstone, foragers take the opportunity to 'gear up':

> [T]here are few or no direct costs accountable for the procurement of raw materials used in the manufacture of implements…. Raw materials used in [this] manufacture *are normally obtained incidentally to the execution of basic subsistence tasks*. Very rarely, and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw material for tools (Binford 1979: 269; emphasis mine).

This, according to Binford, is the universal pattern for most, if not all, hunter-gatherer toolstone procurement. But the assumption that lithic procurement, being always incidental or ancillary to other subsistence activities, is essentially cost-free carries with it the implication that access to quarries is not likely to be an important factor in determining the movement of stone tool using peoples across the landscape and, by extension, that procurement costs will not be significant determinants of technological patterns (Bamforth 2006: 520).

Ethnoarchaeological data from Gould, however, suggests otherwise. Contrary to Binford's assertion, Gould (1978: 230) finds that among the Australian aborigines, lithic raw material procurement was in fact a very high-cost activity because of transportation limitations. Because trips to quarries were made on foot, he writes,

> … the amounts of material…. collected and carried back were limited… I have observed previously uncontacted desert Aborigines carrying one or two large cores of stone by hand and numerous stone flakes tucked up inside their hair (Gould 1978: 230).

Quarrying and transporting raw toolstone took up the greatest amount of time and effort in the toolmaking process, and that visits to quarries were often planned ahead because they rarely occurred near hunting and gathering encampments. Gould notes further that when there was something special about a particular type of stone (either aesthetically or perhaps in a religious or symbolic context) aborigines made special efforts to visit particular quarries. Bamforth (2006: 521) points out that these limitations on transportation likely existed in other times and places as well, and can therefore be applied to other foraging peoples.

Differing ideas on embeddedness and mobility – particularly Gould's introduction to the problem of a consideration (i.e. symbolic or religious) that was not strictly economic in nature (see also Taçon 1991, MacDonald 1999) – led to the (in)famous 'Righteous Rocks' debate (Binford 1985, Binford and Stone 1985, Gould 1985, Gould and Saggers 1985) between Gould and his supporters, on the one hand, and Binford, who had a knack for becoming involved in high-profile contentious polemic, on the other.

Clearly, then, there is a link between stone tools and the social and economic behaviour of the peoples who made and used them. These people were required by circumstance to organize their technology around and with respect to their other resource exploitation strategies. This circumstantial requirement is a constant: although particular strategies vary from culture to culture and group to group (e.g. Binford 1985, Binford and Stone 1985, vs. Gould 1985, Gould and Saggers 1985), there is no escaping the fact that "[m]obility associated with subsistence and raw material acquisition, and their associated costs in terms of time and energy, directly influence a group's choice of technological strategies and subsequent treatment of toolkits" (Milne 2003: 71). In this sense, both Binford and Gould are correct (Bamforth 2006: 521). In many, if not all areas, peoples' movements "were probably conditioned, in part, by the need to obtain stone as much as by the subsistence and social factors that the archaeological literature tends to emphasize" (Bamforth 2006: 525). This concept is the fundamental basis for the theoretical framework of lithic technological organization.

Quarry Studies

According to Andrefsky (2005: 260, 261), a quarry is simply a location where lithic raw material is mined or collected. It can be either a *primary lithic source* – that is, the location of genesis where the raw material originates – or a *secondary lithic source,* where rock is deposited as the result of erosion from the primary source. Pedrick (1985: 8) offers what is perhaps a more comprehensive definition:

> Large quarry sites are the result of long-term and/or high intensity exploitation of lithic raw material…. Human activity at these quarry sites is centered on the acquisition of material, core or flake preparation, and the initial reduction of pieces for transport away from the site.

Unfortunately, there has been a distinct lack of archaeological treatment of quarry sites until fairly recently. It was nearly a century after the early descriptive works (e.g. Holmes 1890, 1891a, 1894a, 1897, 1919, Phillips 1899, 1900) that Cambridge University's 'New Directions in Archaeology' series published edited volume on quarry studies (Ericson and Purdy 1984). Until that time, publications of quarry sites were largely descriptive in nature (Pedrick 1985: 5-6, Bamforth 2006: 511-512) and the only inclusive and comprehensive look at quarries in North America had been Holmes' (1919) *Handbook of Aboriginal American Antiquities Part I: the Lithic Industries* (Purdy 1984: 119).

Since 1984,

> The evolution of quarry site analysis has carried investigation beyond the mere description of the artifacts present on a site, although this is still important in the total process of analysis. Emphasis has turned to the discussion of lithic processes conducted at a quarry and how these affect the physical form of the artifacts and the structure of the archaeological record (Pedrick 1985: 6).

Quarry studies also figured prominently in the three most recent annual conferences of the Canadian Archaeological Association: the 2009 conference in Thunder Bay, Ontario, devoted a session to Manitoba and Ontario Boreal Forest and Quarry Research (e.g. ten Bruggencate and Fayek 2009, Hanna 2009, Korejbo 2009, Robertson and Saxberg 2009); the 2010 conference in Calgary, Alberta, featured a paper on the mass analysis of lithic debitage applied in a quarry context (De Mille 2010); and the 2011 conference in Halifax, Nova Scotia, also featured a session on quarry research (e.g. Brownlee 2011, Beardsell and Milne 2011a).

Technological Organization Theory in Relation to Quarry Sites

As the source of the raw material necessary to lithic production systems,

> The quarry is the most important site and component of these systems. A complete analysis of the quarry will allow the researcher to reconstruct the processes of extraction, selection, knapping, and on-site activity of the average knapper, as well as documenting the reduction sequences, changes in technology and rates of production over time. The quarry remains the logical site to begin the study of a stone-tool-using culture (Ericson 1984: 2).

Research into quarry sites has tended to focus on narrow range of topics – e.g. strategies and stages of reduction carried out at quarry; material transported away from source; rates of quarry usage over time; techniques used to extract raw stone (Bamforth 2006: 512). But these aspects of quarry studies hold broader implications for cultural behaviour such as, for example, regional land-use patterns (*ibid.*), and recent studies are beginning to provide a glimpse at this larger picture (e.g. Andrefsky 2008).

Key to understanding the relationship between quarries and hunter-gatherer mobility and subsistence is the fact that unlike game animals, quarries do not move through the landscape in accordance with seasonal migration as do game animals; neither can one simply ‘pack up’ a quarry and take it along when following other resources, such as game, during the seasonal round. As Milne has observed, there is no necessary *ipso facto* correlation between the location of toolstone quarries and food resources (Milne 2003: 70).

It therefore follows that behaviour with respect to raw material conservation may vary with distance from locations of this precious resource. This has been found to be the case by Andrefsky, who reports a greater degree of retouch on obsidian projectile points the farther away from their quarries they are recovered (Andrefsky 2008: 203-205, see also Ricklis and Cox 1993).

Similarly, Marks and his colleagues, working in the Avdat-Agev area of the Central Negev, Israel, found that mean debitage length and thickness, and mean core weight, are all lower at sites distant from quarries than at sites near quarries (Marks, et al. 1991: 132). In another example, Newman (1994) uses the Pot Creek Pueblo and nearby Cerrita Pithouse assemblages as a case study in order to provide the first clear test of the hypothesis -- inferred by other scholars such as Feder (1980) and Jefferies (1982) -- of an inverse relationship between flake size and distance from the quarry at which the raw material was obtained.

There are three basic ways in which toolstone can be procured (Morrow and Jefferies 1989: 28, Milne 2003: 70), each with its own associated procurement costs. These are:

1. Direct procurement;

2. Embedded procurement; or
3. Trade.

Morrow and Jefferies (1989) conducted a study to determine whether non-local chert -- which accounts for only a small portion of the total chert assemblage -- "can be attributed to emerging exchange networks at this early date, the direct procurement by special-purpose parties, or mobility on the part of the prehistoric inhabitants" (Morrow and Jefferies 1989: 28). They reason that if non-local cherts were used differentially at a site that was occupied year-round with low-residential mobility, non-local cherts would be more expensive than local cherts, in terms of the value of items exchanged for it or of energy and resources expended in its procurement. It would be expected, then, that items made of the more expensive non-local chert would be reserved only "for particular tasks or activities or, alternately, to have played some other specialized role in the economy" (Morrow and Jefferies 1989: 30), such as, for example, prestige or ceremonial items, as in the much later Hopewell cultures of Ohio (see Milner 2005: 82-85). Such artifacts would likely have been curated (after Binford 1977, 1979), with extra time and labour to maintain, rejuvenate and recycle them (Morrow and Jefferies 1989: 30). A third possibility is that "the presence of the non-local cherts merely reflects the mobility patterns of the site's inhabitants.... with no extra effort expended in their procurement" (Morrow and

Jefferies 1989: 29). Morrow and Jefferies (1989) find, based on the nearly identical usage-patterns of local *vs.* non-local chert, that the inhabitants of the Black Earth site in southern Illinois, though sedentary, were nonetheless mobile enough to acquire distant chert resources at no additional cost to that acquired locally.

Beck and Jones (1990) examine patterns of raw material selection and use in the Western Pluvial Lakes Tradition (WPLT - the late Pleistocene and early Holocene in the Great Basin), and consider both mechanical factors and the availability of raw materials. They argue that tool classes made of local materials will tend to be manufactured from a range of raw materials such as chert, basalt or obsidian, depending on when and where sources of these materials are encountered in the yearly cycle of movement of the population; and second, "at any one location the artifacts represented in exotic stone will be, for the most part, curated tools and debitage related to the maintenance of those tools" (Beck and Jones 1990: 285), with other debitage and expedient (*i.e.* informal) tools made of local materials.

If, on the other hand,

> …a particular material type is singled out for a specific set of tool classes, these tool classes would more often be represented in this material regardless of local availability.

> Also, we might expect a higher degree of curation for these tools, as well as the use of expended tools as cores for new tools (*ibid.*).

They find (*ibid.*, p. 292) that

1) Basalt and obsidian were used interchangeably in making stemmed projectile points, and, in particular, basalt points were manufactured as replacements for expended obsidian ones;
2) Chert and basalt were used interchangeably for the manufacture of unifacial tools such as end-scrapers, which is possibly an indication that toughness was a criterion for raw material selection in the manufacture of this type of tool.
3) Chert and obsidian were rarely used interchangeably, an observation they attribute to mechanical considerations specific to the tool being manufactured.

In other words, Beck and Jones' results show that in the WPLT, chert appears to have been preferred for tools requiring a tougher, harder-wearing material (*e.g.* scrapers, borers, drills, etc.); it may have been rare, however -- perhaps because it was obtainable only from a considerable distance -- and so in some cases basalt had to be substituted. Other tools with less stringent material requirements, such as knives and other bifaces, and especially projectile points, were made of a wider range of materials such as obsidian and basalt, as well as chert (Beck and Jones 1990: 294).

Beck and Jones' (1990) findings support the work of Hayden *et al.* (1996) who find at Keatley Creek in the interior plateau of British Columbia that the most durable materials were often reserved for tools such as bifaces. Although multi-functional, these tools would often have to be modified or converted into scrapers and butchering tools requiring toughness and durability, along with a high re-sharpening potential. They suggest that for these reasons, bifaces were likely most often produced at or near quarry sites, since a large proportion of flakes carried away from quarries would not be suitable for making them (Hayden, et al. 1996: 26-27).

Beck, et al. (2002) use Central Place Theory (after Christaller 1933, 1972) to explain biface reduction patterning in lithic assemblages at two Palaeoarchaic quarry sites -- Cowboy Rest Creek and Little Smoky Quarry and their respective associated residential sites.

Walther Christaller developed his theory of central places in 1933, building Johann Heinrich von Thünen’s model of land-use and agricultural production (see Smith 1976: 9), with which he was familiar. Like von Thünen, he assumed an isotropic landscape with uniform soil fertility, in which travel was equally possible in all directions and that travel and transportation costs were a function only of distance. But where von Thünen assumed a pre-existing centre and investigated how the production would develop around it, Christaller assumed production in the landscape and investigated how the centres would develop within it (Smith 1976: 12).

Central to Christaller's work was the idea that the chief end of a town was to be the centre of a region, and that these centres and their surrounding hinterlands were functionally interdependent (King 1984: 29) in that centres existed to provide a market for goods and services to the surrounding hinterland. He defined the *range* of a good or service as the maximum distance a consumer would be willing to travel in order to purchase it, while the *threshold* was the distance within which the minimum number of consumers existed in order to make the provision of the good or service cost-effective. Thus, in order for a business to 'break even', the range of a good or service would have to exceed its threshold (King 1984: 30-31, Smith 1976: 12-13, Vogeler 2005).

Based on these assumptions and conditions, Christaller posited that centres would space themselves in a triangular lattice pattern, with each centre surrounded by a hexagonal hinterland serviced by it. For a centre in isolation, the hinterland would be circular, as in von Thünen's land use model; however, the hexagon is a more efficient shape for close-packing centres without overlapping areas of duplicated services or leaving some areas unserviced at all (see also King 1984: 33). A helpful analogy might be to think of the way soap bubbles cluster.

Under the central place foraging model, then, Christaller's 'centres' would be analogous to resource patches, and in the specific case of toolstone procurement, to quarries. A quarry's range would be the maximum distance people would be willing to travel in order to exploit it, and its threshold would be the distance within which a sufficient number of people lived in order to make it 'popular' enough to be mined intensively enough that it might be termed a 'quarry.'

Using this model -- previously used anthropologically only in relation to the procurement of food resources – Beck *et al.* predicted that

> …a greater degree of field processing would be expected at Little Smoky Quarry before traveling the 60 km to Limestone Peak-L1 [associated residential site] than at Cowboy Rest Creek quarry, which is only 9 km from Knudtsen [associated residential site].... that is, Little Smoky Quarry should exhibit a greater number of bifaces at later stages of reduction than Cowboy Rest Creek Quarry (Beck, et al. 2002: 495).

This prediction is exactly what they found to be the case. Furthermore, the central place foraging model predicts that the residential sites should yield more bifaces at later stages of reduction than their associated quarries do -- a prediction also borne out by the archaeological record (Beck, et al. 2002: 500).

With regard to this last finding, however, Wilson and Andrefsky (2008: 87) caution that bifaces often undergo extensive retouch *before* they are ever used – in other words, during the production phase at the quarry itself – and that the amount of retouch on a biface therefore "has little or no meaning with regard to curation." Indeed, bifaces at varying degrees of reduction are commonly found in quarry contexts (Wright 1970: 29-30, Pedrick 1985: 8, 11-12, Patterson 1990, Hayden, et al. 1996: 26-27, Andrefsky 2005: 31, 192), along with massive volumes of small waste-flakes – a debitage signature correlated with their manufacture (Stahle and Dunn 1982).

Andrefsky (2005: 192-193) suggests that this is perhaps because not only are bifaces flexible (representing the basis of different tool forms suited to different functions) and maintainable (being easily altered or reworked to suit specific needs), but they are also *portable* – making them ideal for people such as hunter-gatherers, who regularly pursue activities away from residential camps (Andrefsky 1993, Bamforth 1991) and who travel throughout the landscape on a seasonal basis and may be away from reliable sources of toolstone for extended periods. "As a result of all these conditions, bifaces can potentially fulfill the tool requirements for unpredictable situations" (Andrefsky 2005: 192).

Analytical Problems in Quarry Studies

The treatment of quarries with the aim of going beyond mere descriptive studies is a relatively new development in archaeology. It is hardly surprising, then, that a few hurdles have been encountered along the way, and the perceived logistical and analytical problems often associated with quarry sites (Ericson 1984: 2) may account for the reluctance until recently for archaeologists to examine them in any great detail. "Essentially, because lithic procurement sites are often used over long periods of time by different groups of people, quarry records are frequently characterized by mixed technologies and artifact types" (Beck, et al. 2002: 481-482), resulting in considerable variability within their assemblages (Gramly 1980a, Holmes 1897, Johnson 1984, Raab, et al. 1979).

There is a tendency for prehistoric peoples "to have conducted substantial knapping episodes near raw material sources, and transported tools and highly reduced blanks to their habitations" (Odell 1996: 57-58). Quarry sites consequently tend to be characterized by extremely large, complex assemblages. This is because the production of a single tool, or the reduction of a single nodule for transport, will produce many times that number of waste flakes, or *debitage.*

Debitage is in fact the predominant class of artifact found in most quarries. As such, it can shed considerable light on lithic resource procurement activities conducted at a site because its depositional and formal patterns are directly characteristic of specific reduction activities (e.g. Baumler and Downum 1989, Morrow and Jefferies 1989, Patterson 1990, see also Newman 1994).

Summary

This chapter has discussed the ways in which lithic quarry sites and the reduction activities associated with them can inform archaeologists' interpretations of prehistoric peoples' technological organization. Initial treatments of toolstone quarry sites were in the past largely descriptive and focused on the more superficial aspects of quarries; however, in the latter half of the 20th century and into the 21st, it has become evident that lithic technology and toolstone procurement are inextricably bound up in a foraging society's mobility patterns, which are in turn largely determined by subsistence requirements. Contrary to Binford's (1979: 269) assertion that lithic resource procurement is essentially cost-free, the procurement of toolstone has very definite costs associated with it, and these costs are on a par with other resource procurement costs as determinants of settlement, mobility and subsistence patterns.

Chapter 3

Theoretical Framework

One of the fundamental assumptions of archaeology is that human behaviour is *patterned,* and that the material residue left by that behaviour is therefore also patterned. Since quarries represent sources of a resource every bit as critical as food to a hunter-gatherer population's survival (Beck, et al. 2002: 482, Milne 2003: 70-71), their associated assemblages should therefore reflect behavioural patterns dictated largely by limitations in access to sources of toolstone with respect to other critical resources. This is the basis of the theory of *lithic technological organization*.

Despite analytical problems presented by the often immense size and sheer complexity of their assemblages, quarries are the source of a resource critical to most if not all ancient hunting and gathering populations and "represent an important aspect of prehistoric land use and adaptation" (Beck, et al. 2002: 482). It is therefore important that the lack of treatment of quarry sites by archaeologists be addressed and redressed. If the in-depth study of quarry sites is not still in its infancy, it is at the least still in its early pre-adolescence, and only through future research can this source of invaluable information into the subsistence, settlement and mobility strategies of stone tool-using peoples be fully tapped. To that end, this dissertation is one of the first in-depth treatments of a quarry assemblage in the Boreal Forest of Northern Manitoba. In the next chapter, I explore the various methods of lithic analysis and how they might enable the analyst to isolate lithic debitage patterns and provide data against which to test hypotheses formulated in Chapter 5.

Chapter 4: Analytical Methods

Quartz Assemblages and Methods of Lithic Analysis

Introduction

Lithic reduction experiments have historically focused on the fracture mechanics of cherts, flints, chalcedonies and other fine-grained crypto-crystalline stones. However, many lithic assemblages are either significantly or entirely comprised of raw materials other than these fine-grained stones. Often, these alternate materials – such as quartz, for example – have different molecular structures, causing them to behave less predictably than their crypto-crystalline counterparts during the manufacture of stone tools.

Unfortunately the comparative rarity of assemblages dominated by raw materials other than cherts and flints has resulted in a "flint syndrome" (after Knutsson 1998) among lithic analysts, whereby materials such as quartz are either ignored altogether as being 'troublesome' or are subjected to the same typological classifications and analytical methods as crypto-crystalline assemblages, despite both the mechanical differences in performance as a raw material and the underlying reasons for selecting these alternate materials in the first place.

In this chapter, I discuss methods of lithic analysis as they pertain to quartz assemblages. I begin by outlining the origins and development of lithic analysis and experimental studies, and describe their applicability to quartz assemblages, with particular attention to caveats posed by the unique qualities of quartz as a toolstone. I then propose means by which quartz assemblages, despite these difficulties, can be effectively studied. The thesis here advanced is twofold: first, that quartz assemblages can indeed be effectively analyzed and classified typologically, although care must be taken to account for quartz's hardness and tendency to shatter on impact. Second, mass analysis is an effective analytical technique particularly well suited to the study of quartz lithic assemblages. This is because it avoids the typological difficulties associated with quartz assemblages (arising from the particular fracture qualities of quartz).

Lithic Analysis: origins and development

Although stone tools are mentioned in the literature as early as the late 18th century with the work in 1797 of John Frere (Feder 1996: 20), the systematic analysis of lithic artifacts begins with Holmes (1894b), whose work emphasized the use of stone tools as chronological markers and led others to do so as well (Andrefsky 2005: 4). Holmes also stressed the evolution of form and function and influenced a number of studies (e.g. Bordes 1961, Burkitt 1925, Clark 1958, Goodyear 1974, Harold 1993, and Sieveking 1958) in which the functions of sites are characterized on the basis of the inferred function of stone tools (Andrefsky 2005: 4).

Microwear Pattern Analysis

Two major approaches to the study of stone tools developed more-or-less simultaneously. The first involved microscopy to examine microwear patterns on tool edges; this work was conducted initially by Semenov in the Soviet Union during the 1930s, 40s and 50s (see Levitt 1979), and was not published in the west until 1964, when it influenced many western scholars such as Ahler (1971), Gould, et al. (1971), Hayden and Kamminga (1973), Keeley (1974), MacDonald and Sanger (1968), Odell (1975), and Tringham, et al. (1974) (Andrefsky 2005: 5) and led to a conference (see Hayden 1979) held in 1977 at Simon Fraser University in Burnaby, Canada. One direct result of this work was the understanding that stone tools change their shape with time as they are sharpened and retouched, broken and converted to another use, or just worn out (Frison 1968). A major implication of this is that morphological typologies are *static,* like a snapshot; and because they are analyzed as being static in time, they are invariably *conceived* of in that way (Andrefsky 2005: 30, 40). Therefore if tool types are to be useful as temporal, spatial or functional indicators, the dynamic nature of stone tools throughout their use-lives must be considered (Frison 1968: 154).

Experimental Replication

The second major development in lithic analysis was *experimental replication,* a field that had its beginnings in the controlled experiments performed during the late 19th and early 20th centuries by researchers such as Cushing (1895), Holmes (1891b), Nelson (1916) and Warren (1914), and that became widely known in the mid-20th Century owing primarily to the work of François Bordes and Donald Crabtree (e.g. Bordes and Crabtree 1969, Crabtree 1966, 1967a, 1967b, 1968, 1970, 1971, 1972, Crabtree and Swanson 1968). Given the scarcity of strong ethnoarchaeological analogies available, archaeologists "must take ad vantage of their creativity in developing a wide range of models for testing with the archaeological record" (Carr and Bradbury 2001: 145). Experimental replication provides archaeologists with an alternate means of linking tools with behaviour (Larson 2004: 4) – albeit one based largely on trial and error.

In considering experimental replication, it is worth noting that lithic *debitage* (waste-flakes that are the by-product of stone tool manufacture) is every bit as important as the finished stone tool (Andrefsky 2005: 8). Most tools (save those broken during manufacture or use, or lost during their use-life) are taken with the maker and continually retouched, sharpened, worn or otherwise reduced – and debitage is an ubiquitous and inevitable by-product of these processes. Accordingly, the archaeologist is far more likely to encounter debitage, in terms of numbers, than actual tools. Its depositional and formal patterns are therefore directly characteristic of specific reduction activities or behaviours (Milne 2009: 44), and not surprisingly, lithic reduction experiments often focus on debitage in an attempt to identify patterns and associate them with distinct human behaviours.

In an early example, Barnes (1939) performed experiments to simulate forces of nature in order to try and replicate the attributes of flakes formed by natural forces and distinguish them from those of human origin. He recognized that while natural forces can create flakes that might easily be confused with human work, on closer inspection of larger numbers of specimens,

> …examples of aberrant flaking will be present. These aberrant flakes either serve no useful purpose in connection with the supposed tool or occur in positions where they would not be

> found in human work, or present angles platform-scar which are obtuse (Barnes 1939: 107).

The *angle platform-scar* is "the angle between the platform or surface on which the blow was struck or the pressure was applied, and the scar left on the tool where the flake was detached" (Barnes 1939: 107). Noting that satisfactory control of flaking by the knapper results in angles platform-scar of between 20º and 88º (*ibid*., p. 109), Barnes examined that attribute across at least 100 specimens for 8 eolith types, 7 categories of natural fracture, and 16 representative human stone tool industries, and found that

> …the differences in the values of the quartile points for natural fractures and eoliths are very small, whereas the differences between human work and natural fractures, and human work and eoliths are pronounced and are both of the same magnitude (Barnes 1939: 111).

He concluded that an assemblage may statistically be considered to be of human origin if not more than 25% of the angles platform-scar (the angle between the plane of the striking platform and the surface of the scar left by the flake's removal) are obtuse, or greater than 90º (Barnes 1939: 111-112).

More recently, Baumler and Downum (1989) found experimentally the manufacture of *scrapers* produced little or no debitage as large as 6.3mm (¼ inch), whereas *core* reduction "produced significant quantities of debitage in all size classes, both large and small" and that "both types of lithic reduction clearly exhibit the long-tailed, positively skewed frequency curve that can generally be found in the size distributions of lithic reduction activities" (Baumler and Downum 1989: 104-105). They noted that their results concur with those of others (e.g. Magne 1985: 104-106, Magne and Pokotylo 1981: 37, and Sullivan and Rozen 1985: 782-783), and applied their results to Palaeolithic assemblages from the Austrian site of Grubgraben, demonstrating that the debitage frequency distribution patterns of radiolarite flakes closely resembled their results for scraper reduction, while the white flint assemblage reflected a broader range of reduction activity, suggesting a different activity focus for each material. Similarly, Carr and Bradbury (2001) use experimental data to determine the relative percentages of debitage from core production versus tool production within a given assemblage.

In yet another example, Hayden and Hutchings (1989) contend, *contra* Mewhinney (1964), that it is possible to distinguish between billet (soft-hammer) and hard-hammer percussion flakes in the archaeological record. In two blind tests whereby a knapper used either hard-hammer or billet percussion at random to create two series of obsidian flakes, keeping a confidential record of which method was used to create each flake. They find that three variables --

lipping, crushing and point impact features -- along with direct, clear linear relationships between platform area and flake weight (with a different slope for each flake type) yielded a near-certain identification (90% correct in the first series and 100% correct in the second) of billet and hard-hammer flakes (Hayden and Hutchings 1989: 255).

Odell (2003: 59), however, cautions that because each percussor type can potentially produce flakes characteristic of the other, there is “so much overlap that definitive statements on individual flakes are notoriously difficult to make” and, moreover, that there is also confusion with regard to percussor materials themselves. Soft stone percussors, such as limestone, for example, can produce results similar to those of either hard stone percussors of soft bone or antler billets, and “[e]xactly how to categorize the products of soft stone percussors remains an issue that has never been adequately resolved” (Odell 2003: 59).

Fracture Mechanics

At a more abstract level, some scholars have experimentally studied the physics of *fracture mechanics* in order to better understand how its principles might be applied to the archaeological study of stone tool manufacture. These are outlined by Speth (1972) with an eye toward limiting the range of flake attributes considered in lithic analysis, and elaborated upon in considerable detail by Cotterell and Kamminga (1979). They consider fracture mechanics from the perspective of both the anthropologist and the fracture mechanist. The former "seeks to understand the mechanics of flaking in order to identify manufacturing techniques and elucidate the nature of use-fracturing," while the latter "sees flaking as a specialized form of fracture, the study of which can contribute to a general understanding of fracture mechanics" (Cotterell and Kamminga 1979: 97). According to Andrefsky (2005: 25), the work of Cotterell and Kamminga (e.g. 1979, 1986, 1987, 1990) is the most comprehensive body of research into the topic, the most important aspect of which is the description and explanation of three types of flake: *conchoidal* (Hertzian) flakes; *bending* flakes; and *bipolar* (compression) flakes.

Conchoidal (Hertzian) Fracture

Hertzian fracture (after Hertz 1895: 155-173), is generally agreed by archaeologists to be characteristic of conchoidal flakes (Cotterell and Kamminga 1979: 101) with their characteristic 'bulb of force' (partial Hertzian cone). In the technical sense, it occurs when a brittle elastic solid (e.g. glass or chert) is subjected to a force-load either statically (constant pressure) or dynamically (sudden impact).

In stone tool knapping what occurs is actually a special case of Hertzian fracture as studied by Huber (1904: 153), in which a flat surface (the striking platform) is impacted by a spherical surface, such as the rounded striking area of a hammerstone (Speth 1972: 37). “At the point of impact or the point of applied force, a series of concentric cracks develops. One of these cracks will dominate and travel through the brittle mass to form an approximately 136º cone” (Andrefsky 2005: 26). For this reason, Hertzian fracture is also referred to as *conchoidal* (“cone-shaped”) fracture, and is the process involved in the formation of conchoidal flakes (Cotterell and Kamminga 1987: 686).

Bending Fracture

Bending fracture is caused by the application of force at a point away from the point of fracture initiation, as when a fishing rod breaks at the middle under stress because of a snagged hook. It is thought to be caused by pressure-flakers, which ‘pry’ the flake from the objective piece through the application of bending pressure on the edge (Cotterell and Kamminga 1979: 142), although it is generally agreed by lithic analysts that the force of load application under a pressure tool, punch or hammerstone is essentially Hertzian in nature and that “there is no clear evidence that flakes produced by pressure flaking are essentially different from those produced by percussion flaking” (Cotterell and

Kamminga 1979: 101). In this respect, it is noteworthy that Crabtree (1968: 457) distinguishes between pressure and percussion flakes only in the prominence of the bulb of force and the absence of eraillure scars on pressure flakes, *contra* Faulkner (1972: 159) who denies Crabtree's statement but nonetheless agrees that "from the similarity of the flake forms, it is reasonable to assume that pressure and percussion flaking involve similar fracture mechanisms" (Cotterell and Kamminga 1979: 101).

Bipolar (Compression) Fracture

Bipolar or 'compression' flakes are made by placing the objective piece on an anvil and striking it with a hard hammer (Andrefsky 2005: 28). Under these conditions, a fracture is initiated from both the anvil *and* the hammer ends, and the flake appears to have two points of applied load (*i.e.* is 'bipolar'). According to Andrefsky (*ibid.*, p. 28), this technology is often used when the objective piece is too small to be reduced by freehand methods, which require a large enough core to hold onto. Flakes produced this way are recognizable in the record by their opposing smashed surfaces, diffuse percussion bulbs, and small or even nonexistent striking platforms; but Odell (2003: 61) stresses that these characteristic features are not necessarily present on every flake in a bipolar assemblage, and thus "while blind testing of analysts has exhibited a high accuracy rate in discriminating freehand from bipolar industries at the assemblage level, accuracy on individual flakes has proven to be considerably lower."

It should be noted that the issue of bipolar flaking is controversial. Patterson, for example, rejects bipolar flaking out of hand, considering it "an overrated subject" and contending that

> [t]rue bipolar fracturing, with force rebound from a hard anvil to initiate a secondary fracture plane, may be useful for pebble and cobble splitting, but this technique is not suitable for controlled flaking. Primitive man would soon so determine and preferably use conventional flaking, that is, the application of force at a single point in order to control fracture planes more effectively (Patterson 1983: 305).

He comments further that the only place he has seen large numbers of unambiguously bipolar flakes is in samples from mechanical gravel crushers (*ibid.*, p. 306), the actions of which more closely resemble natural geological forces than they do systematic, controlled flaking.

Analytical Methods

Experiment and Replication

Our ability to recognize behavioural patterns in the archaeological record is often the result of replication and other experiments. Studies such as those by

Cotterell and Kamminga (1979) have led to an understanding of the physical mechanics of what goes on when a piece of toolstone is struck with the intent of removing a flake, and a number of analytical methods for inferring behaviour have arisen out of this understanding.

For example, Baumler and Downum (1989), discussed on page 71, found that experimentally produced scraper and core reduction flakes clearly display the distinctive frequency distribution curves found elsewhere by other writers; this pattern can now be used to identify lithic reduction activity in the archaeological record. A year later, Patterson showed experimentally that "the characteristics of flake-size distribution can be employed as a useful analytical tool for detecting bifacial-reduction activities at archaeological sites", but added that "flake-size-distribution characteristics alone do not appear to be very useful… as a general analytical method for determining which stages of biface manufacture occurred at specific locations," cautioning that this "requires data on bifaces in various stages of completion as well as on by-product flakes" (Patterson 1990: 557).

Mass Analysis

Of late, there has been an increasing focus on the analysis of lithic debitage (Andrefsky 2005: 9), which is “typically the most abundant and durable artifact type found in archaeological sites worldwide” (Milne 2009: 44).

Problematic in analyzing debitage assemblages is that they tend to be extremely large, as the production of a single tool will produce many times that number of waste flakes. Methods of debitage analysis have therefore tended to minimize the handling of individual flakes in favour of *mass analysis* (after Ahler 1975, 1989), which

> ...is conducted by stratifying the entire assemblage of debitage by some uniform criterion and then comparing the relative frequencies of debitage in each stratum. When different assemblages are stratified using the same criteria, differences and similarities in the populations can be used to make interpretations about each population (Andrefsky 2005: 131-132).

The late Stanley Ahler first developed mass analysis in the 1970s as an alternative to Individual Flake Analysis (IFA). Although IFA may identify discrete knapping incidents applied to a particular core or objective piece, it is often selectively applied only to complete flakes, and can be extremely time-consuming, especially with regard to extremely large, complex assemblages -- such as those found in quarry sites (Ahler 1989: 89). Mass analysis has several advantages over other analytical methods in that it avoids the subjectivity of typological determinations by analyzing the entire assemblage using non-technical criteria; it provides assemblage-level characterization of the technology; and as long as the same criterion is used (e.g. size-grade), it allows comparison between assemblages (Larson 2004: 6). One commonly used criterion is screen-graded flake size (e.g. Stahle and Dunn 1982). The advantages of this method are that each flake need not be extensively handled or measured, reducing both the time needed to process the assemblage and the likelihood of accumulated error arising from a large number of measurements and observations (Andrefsky 2001: 4, Ahler 1989). While size-grade is the most commonly used attribute in mass analysis, other criteria such as linear size and weight increment (Andrefsky 2005: 132-140), as well as flake volume (length×width×thickness) and flake thickness (Newman 1994) can also be used.

Potential problems with Mass Analysis

Mass analysis has recently come under fire by a number of scholars (e.g. Larson 2004, Root 2004), but most notably Andrefsky (2004, 2007, 2009), who argues that a number of sources of error – in particular, replicator variability, raw material influences and mixed assemblages (Bradbury and Carr 2009: 2789) – make it unsuitable for investigating archaeological lithic assemblages.

The sources of error with which Andrefsky (2007: 394-398) is concerned are:

1. replicator variability;
2. variability in raw material size, shape and composition;
3. debitage "mixing" from different production events;
4. the occurrence of similar diagnostic signatures in flake size frequency distribution for very different production activities; and
5. inferring reduction sequences from flake size frequency distribution.

The last two points, 4 and 5, were acknowledged by Ahler (1989: 88-89) when he presented the refined technique some 18 years prior to Andrefsky's critique, and in any case they are largely subsumed within the first three. In both cases, Andrefsky cautions that although mass analysis is successful under replicative, laboratory conditions, this is because such conditions are not subject to the first three sources of error. This is not the case, he argues, with excavated archaeological assemblages (Andrefsky 2007: 397, 398).

However, Bradbury and Carr (2009: 2789) counter that these issues "are not restricted to mass analysis, but pertain to any flake debris analysis method to some degree." They argue that much of the criticism is based on faulty evidence and can be corrected for with careful attention to method. They point out that much of the criticism is based on faulty evidence and can be corrected for with careful attention to method. For example, in trying to replicate Ahler's (1989) experiments, Andrefsky a) failed to control for raw material; b) did not specify the goal (i.e. desired end product) of the different knappers; and perhaps most importantly, c) inconsistently collected mass analysis data *vis-à-vis* the number and type of screens used, the manual handling of individual flakes, and the removal of usable flakes in order to simulate an assemblage in which, presumably, usable flakes would have been collected and taken away by the knappers (Bradbury and Carr 2009: 2790).

Underlying all of Andrefsky's concerns is the problem of *variability:* variability arising from different knappers, from different materials, and from different production events. In their own experiments, however, Bradbury and Carr (2009: 2791) show that so long as different knappers have similar goals in mind, use the same raw material and start with nodules of a similar size, the results of a mass analysis are not adversely affected by the variability with which Andrefsky is concerned. Thus, for example, one can control for raw material variability by segregating debitage made from different raw materials, although in the case of the Grandfather Quarry the point is rendered moot by the fact that 100% of the artifacts analyzed are quartz. Furthermore, much of the critique garnered by mass analysis can be said to be true of other methods as well (Bradbury and Carr 2009: 2789), or derives from questionable or inappropriate application of the technique, or may be mitigated when mass analysis is supported by complimentary results obtained from other techniques employed simultaneously, thus adding robustness to the results using multiple lines of evidence (Anderson and Hodgetts 2007, Bradbury and Carr 2009).

Thus the issues raised by Andrefsky, if they exist at all, may be ameliorated by introducing *multiple lines of evidence* (Anderson and Hodgetts 2007: 231, Bradbury and Carr 1995, Magne 2001: 23, Morrow 1997) or "cabled" arguments (after Wylie 1989, see also Lewis-Williams 2002: 102), in which evidence derived from two or more analytic techniques complement each other.

Aggregate Analysis

The term 'mass analysis' is often used synonymously with 'aggregate analysis' (Larson 2004: 5), but Hall and Larson (2004) present mass analysis as "one extreme of a more broadly defined type of analysis" (i.e. aggregate analysis), which they define as "a method that analyzes an entire assemblage using nontechnical criteria, provides assemblage-level characterization of the technology, and allows comparison between assemblages" (Larson 2004: 6).

Continuous vs. Staged Reduction

Recognizing that reduction is a continuum rather than a staged process, Sullivan and Rozen argue that "it is more useful to design an approach that describes distinctive assemblages of artifacts, than one that describes assemblages of distinctive artifacts" (Sullivan and Rozen 1985: 758). They propose a system of classifying debitage using "interpretation-free, mutually exclusive, and operationally unambiguous categories [e.g. 'complete flake', 'broken flake', 'flake fragment', or 'debris'] defined by a simple key of dichotomous [e.g. present/absent; discernable/not discernable; intact/not intact] technological attributes" (Sullivan and Rozen 1985: 773; see also p. 759). Applying their classification to two case studies and obtaining concurring results, the find that "...shaped stone tool manufacture produces comparatively high and invariable proportions of flake fragments and broken flakes, while core reduction results in relatively high and variable proportions of complete flakes and debris" (Sullivan and Rozen 1985: 773). They are thus able to characterize their assemblages without referring to distinct stages of reduction.

Refitting and Minimum Analytical Nodule Analysis (MANA)

Similarly, *refitting* (e.g. Cooper and Qiu 2006, Hofman 1981, Schurmans and De Bie 2007) can identify the order of flake removal from cores or tools, and although removal 'chains' are rarely long or complete, they occasionally

> … contain sufficient numbers of refits that they can be used to test the continuum view of reduction…. The continuous trend to smaller flake size with removal order cross-cuts 'stages' and suggests that size variation among flakes in these refit chains is more continuous than categorical (Shott 2004).

Minimum Analytical Nodule Analysis, or 'MANA' (Larson 1990, 2004: 15-16, Larson and Kornfeld 1997), also avoids treating reduction as a staged process by considering attributes "below" the raw material level: colour, texture, inclusions, etc. (Larson and Finley 2004: 96) and is based on the idea that tools and debitage associated with one another will come from the same piece of rock that will have the same 'below raw material level' attributes. The assemblage is sorted into virtual 'nodules' by raw material type, colour, cortex, inclusions, etc.; it is then resorted multiple times "to find the most internally cohesive nodules" (*ibid.*, p. 97); refitting is then performed where possible, to verify the nodule's cohesiveness; and finally, provenience, morphological and technological characteristics and metric analyses are added in order to "further refine the sort." This method attempts to virtually 'reconstruct' nodules in much the same way as refitting, but "[w]ithout the certainty of the 'click' when two pieces fit or cojoin" (*ibid.*, p. 97).

The disadvantages of these methods recognizing the continuous nature of lithic reduction are that they are time-consuming and negate the advantage of mass analyses using 'staged' categories (e.g. mesh size-graded categorization) in that most or all of the individual pieces must be handled. That said, whether an analytical method considers reduction as being 'staged' or 'continuous', an evolution is recognized in the shape of the tool from raw material acquisition to finished tool (Andrefsky 2005: 187).

Typological and Attribute Analyses

Two other types of analysis are commonly utilized in studying lithic debitage. The first, *typological* analysis, deals with individual specimens, classifying them "into types that have some kind of technological or functional meaning" (Andrefsky 2001: 6, see also Andrefsky 2005: 114-131). One advantage of this type of analysis is

> …the immediate behavioral inference gained from recognition of a single piece of debitage…. The realization that an individual flake contains significant behavioral information is a powerful argument for using debitage typological analysis (Andrefsky 2001: 6).

The technique has been used to distinguish, for example, between hard-hammer and billet percussion (e.g. Bradley 1978, Crabtree 1967a) although as discussed above, Odell (2003: 59) has pointed out the difficulties in using individual typological analysis to make definitive statements about the percussion method used to create individual flakes.

Nonetheless, typological analysis has the additional advantage of being able to correctly identify different kinds of tools or cores -- which are often linked to particular kinds of debitage -- from the assemblage, an advantage not shared by aggregate analysis (Andrefsky 2001: 6).

Finally, *attribute* analysis, in contrast to typological analysis, "examines the distribution of an attribute(s) over an entire population or assemblage" and is often similar to (mass) aggregate analysis; however, the latter is almost always used with regard to size categories, whereas attribute analysis is not so confined (Andrefsky 2001: 9). An example of attribute analysis is Barnes' (1939) work, discussed above, in which he examines a single attribute – the platform-scar – over a several assemblages and determines that human knapping behaviour almost always results in acute (<90º) angles platform-scar (Barnes 1939: 111).

Lithic Analysis: applicability to quartz

One major caveat that must be noted when performing lithic analyses, particularly with regard to debitage patterns is that raw materials must be considered and accounted for in interpreting results. That they do not necessarily account for differences in raw materials is one of the major problems Andrefsky (2007, 2009) finds with aggregate techniques such as mass analysis.

This is of particular concern when dealing with raw materials of markedly different physical and structural properties, as is the case with quartz.

One way to mitigate this concern is to partition the assemblage into its constituent raw materials prior to performing the analysis, to avoid ‘comparing apples and oranges’ in the same sample:

> It is becoming increasingly clear that debitage assemblages should be stratified into as many behaviorally meaningful groups as possible before MA [*sic*] is performed. For instance, it makes little sense to use MA [*sic*] on aggregate assemblages comprised of different types of raw materials or variations of the same raw material type. These different raw material packages most likely represent different reduction or production episodes, even if the materials were used to make the same kinds of tools. The debitage from each of those episodes should be handled as separate analytical populations for MA [*sic*] to be an effective form of aggregate analysis. (Andrefsky 2007: 399, see also Andrefsky 2004).

In situations where the assemblage is entirely of one particular raw material, partitioning the assemblage into separate raw materials is obviously unnecessary; but in any case, an understanding of the fracture properties of any raw materials present is essential if for no other reason than to differentiate debitage, shatter and tools, which may appear different when manufactured of different raw materials.

Structure and Properties of Quartz

Typical toolstones such as chert, flint, and especially obsidian are extremely fine-grained, homogeneous and isotropic: that is, they can be cracked reliably and predictably because they "are brittle and do not have direction-dependent properties such as bedding planes, fissures, cracks or inclusions" (Andrefsky 2005: 24). Quartz in its purest form, by comparison, is composed at the molecular level of a repeating structure of silicon and oxygen atoms - silicon dioxide (SiO_2) - arranged hexagonally (see Figure 9). This structure results in SiO_2 forming natural crystals of hexagonal cross-section (see Figure 10) and causes quartz to fracture differently from chert or flint. Specifically, quartz has a strong tendency to shatter during flake detachment, and this tendency is much more common in quartz than in other materials likely because of its relatively low tensile and compressive strength and high frequency of internal flaws (Tallavaara, et al. 2010: 2442-2443). Moreover, it is not as isotropic as flints, cherts or obsidian because its crystals of hexagonal cross-section impart a degree of direction-dependency to its fracture properties.

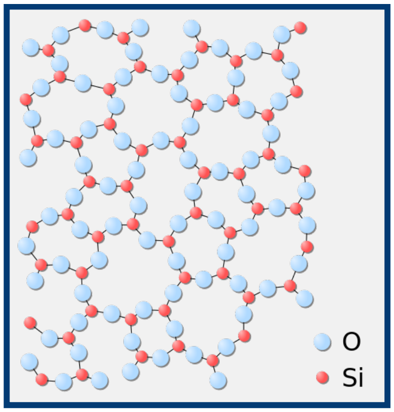


Figure 9: Diagram showing the hexagonal molecular structure of SiO_2, or silicon dioxide (quartz). Image: Public Domain (http://upload.wikimedia.org/wikipedia/commons/thumb/4/4b/Silica.svg/500px-Silica.svg.png).

Figure 10: quartz crystals of hexagonal cross-section, formed by a latticework of hexagonal silicon dioxide molecules. Image: Public Domain (http://www.wpclipart.com/rocks_minerals/Quartz/Quartz_Crystal.png.html).

Quartz as Toolstone

Although hard, quartz is much more brittle than chert or flint, and has a tendency to shatter during knapping (Tallavaara, *et al.* 2010: 2442-2443). As well, quartz flakes are almost always thicker, more angular and more irregular than their flint, chert or chalcedony counterparts (Ballin 2008: 73, Wenzel 1972: 3, see also: Driscoll 2011, and Tallavaara, et al. 2010); fracture surfaces are noticeably more rugged (Tallavaara, et al. 2010: 2443); and features such as force-bulbs and, when visible, eraillure scars, are often ‘chunky’ and ‘angular’ (Christy de Mille, personal communication, 2010). Reher and Frison (1991: 379) note that quartz crystal flakes "… can take on a very rough, relatively unpredictable shape," and Seong (2004: 74) laments that this tendency has led to an a priori assumption that ‘crude looking’ artifacts are inevitable when ‘coarse’ materials such as quartz are used. Archaeologists therefore often believe that quartz, when it was used, was used reluctantly and only in the absence of finer-grained, more easily-worked raw materials such as flint or chert. This certainly appears to be the case in most of sub-Saharan Africa (Bisson 1990). Cornelissen (2003), however, argues that quartz was the *preferred* raw material at the Terminal Pleistocene site of Shum Laka, Northwest Cameroon, where obsidian, chert and basalt were just as plentiful as was quartz. Whether used reluctantly or by choice, quartz was nonetheless an important lithic resource to many prehistoric hunting and gathering peoples -- as early as the Clovis complex in North America (Reher and Frison 1991: 375), and even earlier in the Old World.

Although according to Seong (2004: 74), quartz was unsuitable for some tool types such as blades and microblades, the evidence would suggest otherwise. Contrary to Seong's claim, the crystalline structure of quartz causes it to form ready-made cores, with little or no need for shaping (Powell 1965, see also Ballin 2008: 8). This in fact makes it *particularly* well suited for blade and microblade technology: the knapper need simply strike off portions with a natural edge, or arris. "Striking in one direction on a single platform generates parallel ridges on the core face that guide subsequent flake removals" (Bisson 1990: 137). Ballin (2008: 47 and Illustration 39) documents a microblade of quartz, and I have directly observed and recorded microblade technology in quartz from Grandfather Quarry near Granville Lake, Manitoba (Beardsell and Milne 2011a, 2011b).

But in the hands of a skilled knapper, quartz is also suitable for most tool types. I have personally observed and photographed a number of intricately and finely retouched quartz points at the Manitoba Museum (see Figure 11). Thus it is clear that, despite any difficulty encountered in working quartz, a skilled knapper can produce tools as refined and sophisticated as those made flint or chert (e.g. Boudreau 1981).

Figure 11: Projectile points from northern Manitoba, manufactured in quartz. Photograph by R. Beardsell and artifacts courtesy the Manitoba Museum.

Quartz in Archaeological Context

Although known to have been used as a toolstone by prehistoric peoples, quartz has received little treatment in the literature until fairly recently, and only began to receive special consideration for study in the late 1970s and 1980s (Ballin 2008: 40). Even today, most quartz studies are confined to Africa, where it is ubiquitous and often the only practical choice south of the Sahara Desert (e.g. Bisson 1990, Cornelissen 2003); to Ireland, Scotland and the Hebrides (e.g. Ballin 2004, 2008, Driscoll 2010, 2011). In Sweden, quartz outcrops are common in both the interior and the coastal regions (Broadbent 1973, 1979, Broadbent and Knutsson 1975, Callahan 1987, Callahan, et al. 1992, Knutsson 1988b, 1998, Knutsson and Lindgren 2009), where quartz is noted to have been incorporated into prehistoric rock-art (Tilley 2004: Chapter 4).

The lack of treatment accorded to quartz may be because of the differences, well-known among archaeologists studying lithic tools, in the fracture properties between crystal minerals like quartz as compared to those of fine-grained cryptocrystalline materials such as flint, chert or chalcedony (Callahan, et al. 1992, Crabtree 1967a, Knutsson 1988a, 1998, Knutsson and Lindgren 2009). Where it has been studied, the analysis of quartz debitage and artifacts has typically fallen victim to what Knutsson calls *flint syndrome.* This term refers to the "automatic use of an ill-fitting flint artefact typology" in which quartz assemblages are approached in the same way as chert and flint ones while failing to take raw material differences into account (Knutsson 1998: 79).

Earlier research into the fracture mechanics of quartz sought to find a new approach to quartz assemblages. Callahan, et al. (1992) argued that although quartz fractured differently than finer-grained materials, the way it fractured was nonetheless predictable, and through extensive experimentation they developed *Fracture Analysis* as a means of quartz flakes and debris with knapping behaviour and stage of reduction. Much more recently, however, Tallavaara, et al. (2010) have shown that quartz fracture is not, in fact, as predictable as Callahan, et al. (1992) claim; and in the same vein Driscoll (2011: 742) has found through experimentation that unless the analyst is present at the knapping event and collects debitage at each and every strike, he/she will invariably -- and mistakenly -- classify some debitage as debris, to the degree that up to 50% of the “debris” class may actually be debitage mistaken for shatter.

Discussion

Knutsson and Lindgren (2009: 6) contend that the unique fracture mechanics of quartz and the thick, irregular flakes it produces, make flint-based typological classifications incompatible with quartz assemblages, and that a new system of classification is needed. Ballin, on the other hand, argues that no such new system is needed in order to accommodate quartz assemblages. "It is quite practicable,” he writes (2008: 91), “to apply the same typology to all raw materials.” He suggests that the most central problem to quartz classification is that it is difficult to identify retouch on quartz tools because of high reflectivity, translucence and transparency. Similarly, "high reflectivity has made successful identification of polishes on quartz more difficult" (Bisson 1990: 133). This problem, Ballin maintains, will not be ameliorated merely by coming up with a new classification system, approach or method (2008: 91).

My own observations of the Grandfather Quarry assemblage, and of the collections at the Museum of Manitoba, lead me to concur with Ballin: Figure 11 should make it self-evident that as at least with respect to tools, quartz artifacts can indeed be classified under the same typological and functional criteria as those of other, more fine-grained raw materials. Furthermore, the presence of microblade technology at Grandfather Quarry supports the contention of others (e.g. Ballin 2008: 8, Bisson 1990: 137, Powell 1965) that quartz is particularly conducive to the manufacture of recognizable blades and microblades.

It is when we look at debitage that differences with flakes of more fine-grained raw materials become much more apparent. As noted above, Driscoll (2011) has determined experimentally that unless the analyst is present at the actual knapping event and can immediately separate debitage from shatter at each blow, as much as 50% of what is actually debitage may be mistakenly classified as debris or shatter when dealing with an assembly of quartz debitage, and that this may be exacerbated by taphonomic processes (Nielsen 1991). Notwithstanding this, the remaining, correctly-identified debitage flakes are still amenable to analysis and interpretation and can yield statistically valid results so long as pieces of questionable identification are omitted from the analysis (Driscoll 2011: 742). This is undeniably preferable to the reverse situation, with debris and shatter mistakenly identified as debitage flakes and thus included in the analysis!

Preliminary observations of the Grandfather Quarry debitage bear out the findings of others (e.g. Ballin 2008: 73, Wenzel 1972: 3, Reher and Frison 1991: 379, Tallavaara, et al. 2010: 2443) *vis-à-vis* the relative thickness, shape, texture and features. Indeed, what are technically flakes may often be more aptly described as 'nuggets' given their thick, chunky, angular appearance (see Figure 12). As an added benefit of this property of quartz, such 'nugget-flakes' may even be utilized as cores themselves if they derive from an early enough stage of reduction and are therefore large enough to begin with (Driscoll 2011).

Nonetheless, the attributes of debitage, such as striking platforms, the single-interior surface, dorsal scars, and even force-bulbs and eraillure scars (when present), are all identifiable (see Figure 12b). What is less clear is whether the actual *behaviour* associated with manufacture was any different because of the different properties of quartz:

> The relative thickness of the flake has an effect on fragmentation. Increasing the relative thickness increases the odds of the flake staying intact and evidently decreases the odds of radial and, especially bending fractures (Tallavaara, et al. 2010: 2446).

Thus, the thicker debitage flakes commonly found in quartz assemblages as compared to those of finer-grained materials such as chert may in fact be the result of an intentional knapping strategy meant to reduce shatter.

On a final note, it is certainly worth mentioning that the question of whether or not quartz debitage and tools may be analyzed using the same classifications and typologies as those of finer-grained materials such as chert in fact becomes a moot point when the distinction is made using interpretation-free, non-technical criteria such as the presence or absence of a particular attribute. "Functional interpretations of artifact forms are notoriously risky and if possible should be avoided unless scientific means can be found to determine the uses of particular tools" (Bisson 1990: 133). Given the difficulty involved in detecting retouch, use-wear patterning and polish on quartz artifacts (Ballin 2008: 91, Bisson 1990: 133), it seems preferable to make use of analytical methods such as mass and attribute analyses, that avoid such subjective determinations.

Summary

In this chapter, I have outlined the origins and objectives of experimental methods in lithic analysis and the analytical methods developed to identify and understand human behaviours vis-à-vis the manufacture of stone tools. I have discussed these methods in relation to quartz as a raw material, noting that historically, archaeologists have tended to uncritically and 'automatically' approach quartz assemblages using the same methods and typological classification system as with more common, fine-grained toolstones that behave differently when knapped (Knutsson 1998: 79).

Based on my preliminary observations (Beardsell and Milne 2011a, 2011b) of this exclusively quartz assemblage, and the work of others (Ballin 2004, 2008, Bisson 1990, Cornelissen 2003, Driscoll 2010, 2011, Powell 1965, Tallavaara, et al. 2010), I have argued (contra Knutsson and Lindgren 2009: 6), that the experimental and analytical methods developed so far, and the typologies and classifications arising from them, are as applicable to quartz artifacts as to other materials. It is clear that in the hands of a skilled knapper with an intimate knowledge of the material, quartz can be used to make finely chipped and intricate pieces of the same typologies and classifications as artifacts of chert, flint or obsidian.

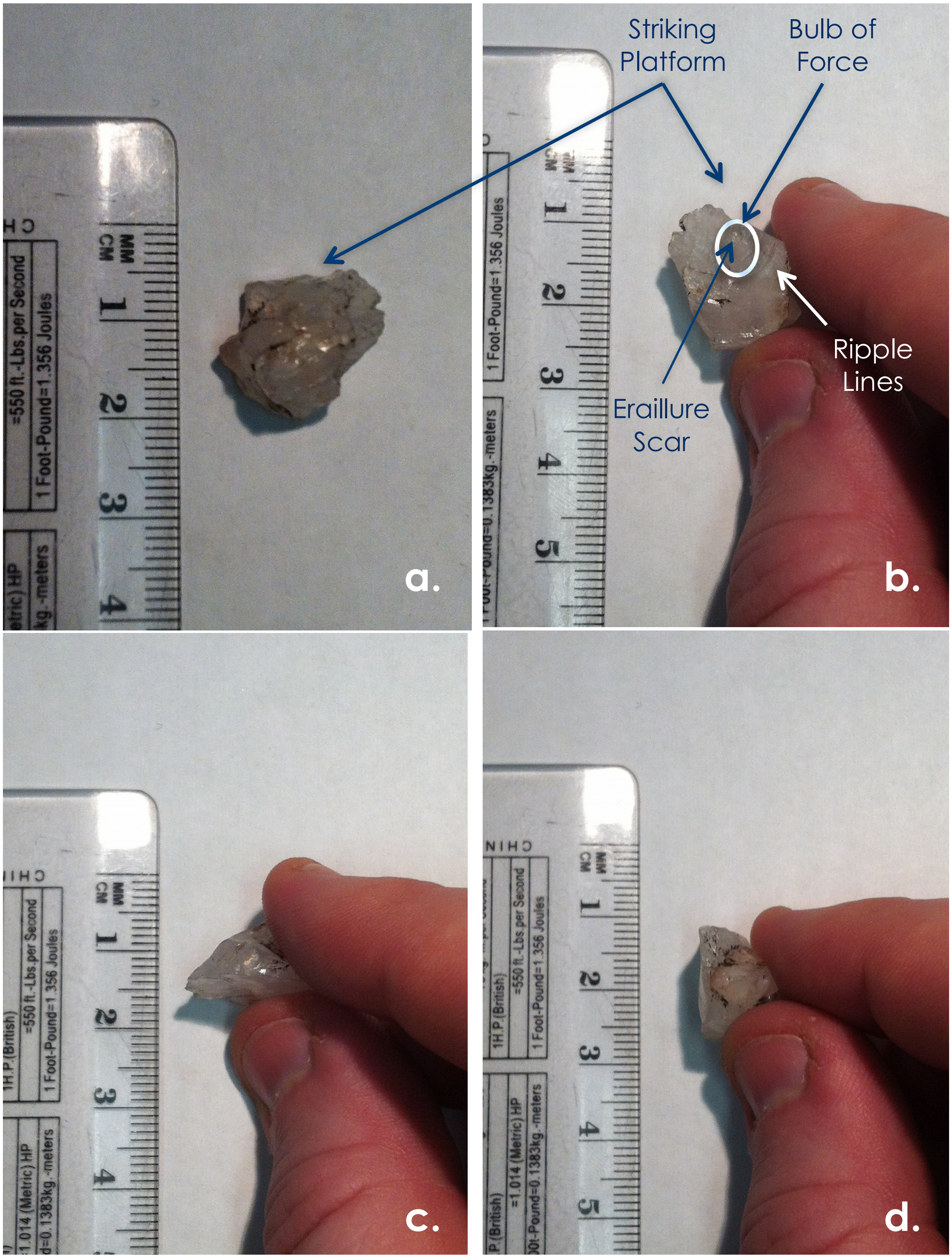


Figure 12: four views of a thick, rough-surfaced, "chunky" quartz debitage flake from the Grandfather Quarry: a) dorsal; b) ventral (note the bulb of force, eraillure-scar and ripple-lines); c) lateral; and d) proximal (looking down on the striking platform).

It is certainly true that quartz is more brittle and has a greater tendency to shatter than finer-grained toolstones, and that the debitage flakes produced are often thick, irregular, angular or “chunky;” but they are nonetheless identifiable when the focus is placed on the presence or absence of diagnostic attributes rather than an overall ‘resemblance’ to tools and debitage of other materials (as is the tendency among the 'Swedish' school -- Ballin 2008: 91). It is, however, important to bear in mind that the actual knapping *behavior* (i.e. techniques used), and indeed the procurement, mobility and subsistence strategies of a people, may be influenced or informed by the unique fracture properties of quartz (Tallavaara, et al. 2010: 2446).

Generally speaking, however, the ability to recognize and analyze quartz tools and debitage is more a matter of experience and/or familiarity with the properties of quartz (Gramly 1981), than it is a matter of semantics and typology. Just as all anthropologists must be constantly aware of the ‘lens’ of their own cultural milieu, through which they cannot help but view their research (after Benedict 1934), archaeologists working with quartz lithic artifacts must also be constantly aware that they are working with a different material than the ones usually examined in a predominant academic ‘culture’ of flint analysts: one that behaves differently during the knapping process, and, where differences are encountered with artifacts in other materials, they must consider whether or not these differences could be attributable to the different raw material. Indeed, the very question of whether to use existing or new classifications and typologies in relation to quartz is rendered moot if we employ methods such as mass and attribute analyses, that make use of interpretation-free, non-technical criteria (e.g. Sullivan and Rozen 1985) such as the presence or absence of diagnostic attributes. For this reason, mass analysis supported by an attribute analysis will be used to produce data against which the research hypotheses outlined in the next chapter will be tested.

Chapter 5:
Hypotheses and Procedure

This chapter outlines the procedure followed in the analysis and recording of data. I first present three research hypotheses (plus a null hypothesis) to be tested against the data collected. I then discuss the procedure followed, referring to the analytical methods discussed in Chapter 4 in order to describe the rationale behind the procedure. Variables recorded and equations for quantifying variability are defined, sampling procedures are described, and the equation for calculating sample size is defined.

Research Hypotheses

The Grandfather Quarry and the Shield Archaic

Continent-wide, the Archaic period (approx. 6,500 – 2900 BP) was characterized by an increasingly sedentary way of life (Milner 2005: 34-53, Petch, et al. 1998). In the Churchill River Basin, however, the residentially mobile way of life continued until the first permanent settlements were established in the early-to-mid 1900s (Kroker 1990: 152-163, Park and Stenton 1998a: 9-21, 1998b: 55). According to Lithic Technological Organization theory, residentially mobile groups have different tool requirements than do residentially sedentary ones (see Chapter 3) because the incongruity between food resource locations and lithic resource locations requires them to anticipate their technological requirements in advance of their occurrence. The necessity of economizing raw material because of scarcity and also to minimize the amount of raw material carried with them leads to the manufacturing of flexible forms such as bifaces and curated toolkits that may be adapted to a particular task or need on an *ad hoc* basis. Sedentary groups, on the other hand, may be located such that resources, including toolstone, are relatively plentiful or easy to access through either direct procurement or trade, and tool manufacture tends to be more wasteful of raw material and less formal in manufacture. If Andrefsky's (2005: 192-193) suggestion that bifaces are the perfect multi-purpose tool and therefore ideal for residentially mobile hunter-gatherers holds true, then the Boreal Forest-wide trend noted by Wright (1970: 42-43) of decreasing frequencies of biface blades over time reflects the broader, continental trend toward increasing sedentism during this period.

These different kinds of tools leave distinctive debitage patterns in the archaeological record: a curated tool or biface leaves many more times the amount of debitage flakes, and of differing sizes and dorsal scar count, than does an expedient tool that may require as little as one hammer-blow to extract and little-to-no retouch (e.g. see Deller and Ellis 1992). Moreover, groups with a long distance yet to travel are likely to perform much of their raw material reduction at the point of extraction: the quarry (e.g. Beck, et al. 2002). It follows, therefore, that the quantity of debitage found at the quarry site should be indicative of the type of residential and subsistence strategy followed by the people who used the quarry.

According to the most recent research in the Churchill River Basin, the Grandfather Quarry area is a culturally diverse one, having been occupied by numerous small-scale hunting and gathering peoples from about 8,000 BP up to the turn of the 20th century (ten Bruggencate, et al. 2013: 2703). The absence of large-scale residential dwelling remains at or near the Grandfather quarry suggests that the site was a specialized toolstone extraction site utilized by these residentially mobile peoples. Furthermore, more commonly used crypto-crystalline toolstones such as chert or flint do not occur in the Churchill River Basin: quartz appears to be the only usable toolstone in this area. What is not clear at present, however, is whether the Grandfather Quarry was the only available source of toolstone, or simply one of many such locations; the degree to which it was utilized; and by whom. The following four hypotheses aim to address these questions so as to better understand the importance of the Grandfather Quarry and the role it played in the lives of the people who used it.

Hypothesis 1 (H_1)

This hypothesis states that the Grandfather Quarry was the only location in the region where useable toolstone could be reliably procured. All stone-tool using populations known to have inhabited the region could therefore have used it for raw material acquisition to renew their lithic toolkits in the absence of other suitable lithic materials. Alternatively, the Grandfather Quarry was the *preferred* location where toolstone of a better quality than from other locations could be procured.

H_1 Expectations

If the Grandfather Quarry was the only reliable source of toolstone, we would expect the following findings:

1) The assemblage should be mixed in terms of informal tools for immediate use, on the one hand, and formal types such as blanks, cores and preforms on the other hand, in preparation for a long journey elsewhere where stone might not be as available. According to Andrefsky (1994: 30), formal tools should dominate the tool portion of the assemblage (see Figure 8, lower-left quadrant, on page 47). Toolstone of better quality would have been reserved for bifaces and cores, while the inferior stone would have been used for other implements such as scrapers and flake tools.

2) There should be discarded tools with evidence of intense curation and/or use wear, along with broken and/or failed bifaces, blanks and preforms (attempted resupply for a long journey).

3) Debitage should reflect early and middle-stage reduction with some later-stage reduction resulting from tool or preform shaping.

4) There should be little or no evidence of bipolar reduction since at a procurement site such as this one, there would be little need for tool liquidation. Any liquidated tool fragments should be of superior quality to that generally available at the Grandfather Quarry.

5) There may be evidence of different quarrying activities at different loci within the site as particularly suitable nodules were removed to another area of the site so that they could be reduced with greater care and precision, perhaps with the use of other tools.

If this was the preferred location, where better quality quartz was available, the following patterns are expected:

6) There should be evidence of considerable effort expended to extract material resulting in substantial discard for the sake of proportionately fewer pieces of better quality raw material, with the latter being used to make standardized formal types (i.e. bifaces, microblades).

7) There should be higher frequencies of late stage and/or small debitage of higher quality, while higher frequencies of the more inferior quality raw material at earlier stages of reduction.

Hypothesis 2 (H_2)

Under this hypothesis, useable quartz toolstone was readily available throughout the entire study area and that mobile hunter-gatherer populations did not use one source preferentially over any other source. Given the ubiquity of these sources, access to them would be unrestricted and they could be used as required. This, according to Andrefsky (1994: 30), should result in the presence of informal tools (see also Figure 8, both upper quadrants, on page 47).

H_2 *Expectations*

If hypothesis two is true, then, quartz would be plentiful throughout the region, and a reduction strategy should be evident that is more expedient, but more wasteful of raw material, since there would be no requirement that populations carry useable toolstone wherever they went.

1) Debitage reflecting early stages of reduction should dominate.
2) We would not expect to find evidence of the discard of formal tool types since these would be retained and used more intensively.
3) Expedient, informal tools should dominate the tool assemblage.

Hypothesis 3 (H_3)

One of the stated objectives of the Granville Lake Project is to understand how traditional lands that have existed over thousands of years were utilized by the ancestors of the Cree communities situated in the central Churchill River Basin in Saskatchewan and Manitoba (Brownlee, et al. 2007-2010). To accomplish this, the upstream region of the Churchill River Basin, including the Granville Lake and Pukatawagan areas, were investigated. The underlying assumption of this objective is that the users of the Grandfather Quarry were, in fact, ancestral to the Cree of the Granville Lake area, that is, Okawamithikani (Pickerel Narrows) First Nation.

Hypothesis 3 therefore aims to infer something of the cultural identity of the users of the Grandfather Quarry. Hypothesis 3 states that, given the location of the quarry in the Boreal Forest of Manitoba, and particularly in the Churchill River Basin where lithic and ceramic assemblages indicate the presence of Shield Archaic and later Woodland peoples over some 6,000 years, the earliest users of the quarry were one of the Shield Archaic peoples, whom Wright (1970: 44) identifies as culturally ancestral to the later Laurel (Woodland) cultures of the Boreal Forest. If, like other sites in the Churchill River Basin (ten Bruggencate, et al. 2013: 2703) the site was in more-or-less continuous use up to the 19th century AD, subsequent users of the quarry would have been the Woodland and later Algonkian-speaking peoples.

H_3 *Expectations*

If this hypothesis is correct, then as noted by Beck, *et al.* (2002: 481-482), the assemblage should exhibit a palimpsest of marked intra-assemblage variability as the archaeological record was written and over-written by multiple occupations and usage events through time (see also Gramly 1980a, Holmes 1897, Johnson 1984, Raab, et al. 1979). The tool (i.e. non-debitage) assemblage from the Grandfather Quarry should show multiple components associated with the quarry's users at each cultural phase present in the Manitoba Boreal Forest, and should include artifacts diagnostic of the Shield Archaic, Woodland and later Cree occupations, such as lanceolate points, Baker's Narrows corner-notched points, ovoid bifaces, as well as the ceramics associated with Woodland and later cultural occupations (Nash 1970).

The Null Hypothesis ($H_{\emptyset}$)

According to the Null Hypothesis, there was a wide variety of toolstones, including quartz, available in the study area that were acquired by the toolmakers using direct and/or indirect means. From the geological evidence (ten Bruggencate, et al. 2013: 2703) we know that other toolstones do not occur naturally; however, they may have been brought from elsewhere or acquired through trade (Beck and Jones 1990).

$H_{\emptyset}$ Expectations

If this hypothesis were true, the expectation would be to find all these toolstones represented in proportion to their respective degrees of quality and abundance. Toolstones not available locally but acquired indirectly through exchange (Beck and Jones 1990: 294) would be comparatively rare and therefore highly curated.

The Analysis

Step 1: Establishing Baseline Data

Mass Analysis

Rationale

Mass analysis was selected as the primary analytic method because of its noted suitability for objectively and quickly processing extremely large debitage assemblages and because of the ease of assemblage comparison it affords given the standardized data it yields. These data will facilitate future analyses with other lithic assemblages at the regional and super-regional levels.

Size grade as Mass Analysis criterion

For the mass analysis, ten size-grades were defined based on the mesh-sizes of ten standard geological sieves, ranging from the smallest at 1/16” to the largest at 3” (see Table 1). While it would have been preferable from an analytical standpoint to use metric sizes, the state of industry is such that standardized geological sieves are still in British Imperial mesh sizes.

In a real-time setting, it is presumed that any usable flakes in a quarry assemblage would have been collected and taken away by the miners. To reflect this, researchers conducting mass analyses in an experimental, laboratory context (Beardsell and Milne 2011b) have usually removed any un-retouched flakes deemed “usable” from the sample. This practice is questionable, however: in theory, at least, *all* debitage flakes are “usable” as unmodified, informal tools, and use-wear or retouch is the only determinant as to whether or not they actually *were* so used.

Table 1: Geological sieve sizes and their corresponding size-grade numbers.

Mesh Size	Size Grade
1/16″	**1**
1/8″	**2**
1/4″	**3**
½″	**4**
¾″	**5**
1″	**6**
1.5″	**7**
2.0″	**8**
2.5″	**9**
3″	**10**

The point is moot, however: the Grandfather Quarry material reflects a “real” or archaeological assemblage and not a laboratory simulation, and it was therefore unnecessary to remove any material to ‘simulate’ the removal of “usable” flakes. Such flakes *without* retouch found in significant numbers (i.e. not attributable to incidental loss) constitute behavioural information regarding the knappers’ lithic reduction decisions; usable flakes *with* discernable retouch were removed as encountered, and not counted in the debitage analysis since they constitute "utilized flakes" and are therefore informal tools to be categorized with other tools.

Size grade data were collected for virtually 100% of the material from Unit 11, using standard geological sieves of differing mesh-sizes (see Figure 13). Although it is more time-consuming than simply pouring the material through a stack of nested sieves, pieces were individually "hand-fitted" to the appropriate size-grade in order to ensure that the largest dimension of each piece would be the defining size grade attribute.

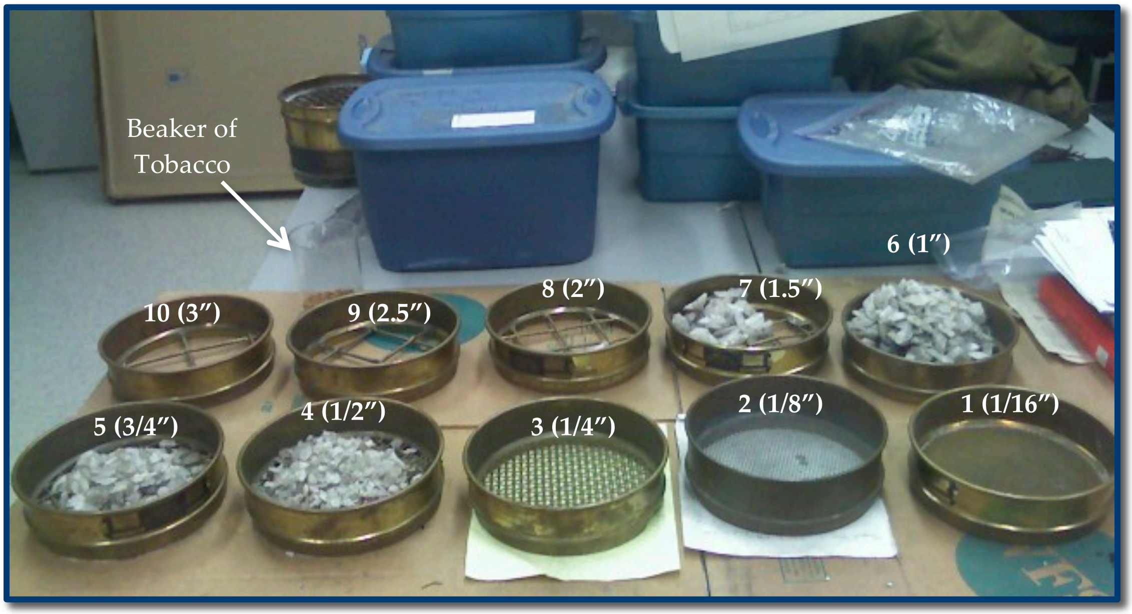


Figure 13: Geological sieves of varying mesh-sizes, into which artifacts were fitted in order to determine their size-grades.

Smallest size grade omitted

Unit 11 yielded a total of 29,046 items stratified into size grades. Size Grade 1, defined before it was known that all material from Unit 11 had previously been sifted through a 1/8″ hardware cloth, was rendered superfluous. This is because any archaeological material smaller than 1/8″ would have been lost in the field, and anything of that size found in the sample must be breakage or accretion. As such, 1,143 items were omitted from the sample because they fell into Size Grade 1 (1/16″ < n < 1/8″). For the sake of simplicity, Size Grade 1 data were simply omitted for Unit 11 and were not recorded for Unit 3. The smallest size grade for our purposes here is therefore Size Grade 2 (1/8″ < n < ¼″). Unit 11 therefore yielded a valid N of 27,903 items graded by size.

Attribute Analysis

Rationale

Because each piece must be individually handled anyway – admittedly defeating one of Ahler's (1989) stated purposes of mass analysis, namely that large volumes of flakes may quickly and expediently be analyzed without extensive handling – it entails little more time and effort to weigh each piece and record a number of attributes as variables, and to use these data to perform an attribute analysis that will either complement or refute the mass analysis data

(Anderson and Hodgetts 2007, Bradbury and Carr 2009). This will enhance rigour to the research by providing multiple lines of evidence (Anderson and Hodgetts 2007: 231, Andrefsky 2005: 135, Bradbury and Carr 1995, Magne 2001: 23, Morrow 1997).

Attribute variables

In addition to basic provenience data, nineteen variables were recorded for each item, where present, focusing on discrete technological, functional, and post-depositional attributes (see

Table 2). Tools were identified and recorded separately for statistical purposes, but do not form part of the mass or attribute analyses of the lithic debitage.

Step 2: Obtaining Data from Other Loci

A major stated goal of this research is to obtain data from different loci of the quarry, and to compare these data in an effort to isolate different lithic reduction activities in discrete activity areas. Specifically, the goal of doing this is to determine if toolmakers were extracting stone from inside the main quarry proper and then selectively removing the better quality pieces for more intensive reduction nearby. The sheer quantity of material from each unit, however, made this a formidable task. It was time-consuming enough to analyze nearly 100% of the material from Unit 11, and it was neither practicable nor indeed possible to analyze as many artifacts again as had already been examined.

But as Milne (2009), following Anderson and Hodgetts (2007: 231), Bradbury and Carr (1995), Magne (2001: 23), and Morrow (1997) has argued, it is neither desirable nor necessary to undertake such a monumental task, provided the criteria of analysis and the archaeological context are the same. Why, she asks, would one examine *another* 30,000 tiny pieces of debitage when only a fraction of that volume will suffice?

Sampling procedure

The solution, Milne (2003, 2009) argues, is to draw a sample from the second population of lithic material that has the same degree of variability as the initial population. This is done by quantifying the variability present in the first population and using it to calculate the minimum sample size required from subsequent populations that will yield results as statistically valid as those from the first population.

To quantify the variability within a population, a *coefficient of variation* is calculated, based upon a continuous variable within the population. In order to obtain more robust results, the variability of Unit 11 was calculated conservatively: a coefficient of variation was calculated for <u>two</u> variables in each size grade for the Unit 11 material, and the size of the sample drawn from Unit 3 was based upon the Unit 11 variable showing the greatest degree of variability Milne (2009: 47).

Table 2: Variables recorded for attribute analysis.

Variable	Name	Type	Description/comments
wt	Weight	Ratio	The weight, in grams, of the item.
size_gr	Size-Grade	Ordinal	Codes for the screen-size of the geological sieve in which the item is captured.
rm_col	Raw Material Colour	Nominal	Codes for the raw material colour according to the Munsell Rock Colour Chart (2009).
rm_opacity	Raw Material Opacity	Ordinal	Codes for the degree to which light will pass through the item: 1 = transparent; 2 = translucent; 3 = opaque.
rm_qual	Raw Material Quality	Ordinal	Codes for the raw material quality according to subjective but consistently applied criteria. 1 = unusable; 2 = poor; 3 = fair; 4 = good; 5 = excellent.
sing_int_sfc	Single Interior Surface	Nominal (binary)	Presence or absence of a discernable single-interior surface.
thickness	Thickness	Ordinal	Subjective observation of the item's thickness, relative to its height and width. 3 grades: 1 (thin); 2 (medium); 3 (thick).
platform	Platform	Nominal (binary)	Presence or absence of a discernable striking platform.
plat_bat	Platform Battering	Nominal (binary)	Presence or absence of battering around the striking platform.
crushing_point	Crushing Point	Nominal (binary)	Presence or absence of a crushing point-mark left by percussion impact.
bulb	Bulb	Nominal (binary)	Presence or absence of a discernable bulb-of-force indicating Hertzian fracture.
eraillure	Eraillure	Nominal (binary)	Presence or absence of an eraillure scar on the bulb-of-force.
dsc	Dorsal Scar Count	Interval	Number of flake-removal scars discernable on the dorsal surface of the piece.
sec_dist_crush_flak	Secondary Distal Crushing/Flaking	Nominal (binary)	Presence or absence of secondary crushing or flaking on the distal end of the piece; indicative of bipolar percussion.
long_split	Longitudinal Split	Nominal (binary)	Indicates whether or not the item is complete, or a fragmentary flake split horizontally, determined by whether or not one of the margins is absent.
long_crack	Longitudinal Crack	Nominal (binary)	Presence or absence of a crack running longitudinally along the flake.
horiz_brk	Horizontal Break	Nominal (binary)	Indicates whether the flake is complete, or a fragmentary flake broken horizontally. If horiz_brk = 1 AND platform = 1 AND sec_dist_crush_flak is BLANK, flake is a proximal fragment; if horiz_brk = 1 AND platform = 0, flake is a distal fragment.
horiz_crack	Horizontal Crack	Nominal (binary)	Presence or absence of a crack running horizontally across the flake.
retouch?	Retouch	Nominal (binary)	Presence or absence of secondary retouch on one or more edges of the flake.

Calculating the coefficient of variation

Two continuous variables were selected for the calculation: Weight and Dorsal Scar Count (see

Table 2), and the coefficient of variation (c_{var}) for each was calculated using Equation 1 (Milne 2009: 47), which can be simplified to Equation 2 (after Yamane 1967: 34). The coefficients of variation for both variables were calculated separately for each size grade and can be found in Table 3. In every case, weight proved to be the variable with the greatest degree of variability and was therefore selected for the next step in all size grades.

$$c_{var} = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{\bar{x}^2}}$$

Where:

- x_i is the value of a given data point;
- $\bar{x}$ is the mean, or average

Equation 1: Formula for calculating the coefficient of variation.

$$c_{var} = \frac{\sigma}{\bar{x}}$$

Where:

- $\bar{x}$ is the mean, or average value of a population of data points; and
- σ is the standard deviation of a population.

Equation 2: Simplified formula for calculating the coefficient of variation.

Calculating Unit 3 sample sizes

Using Equation 3 (Yamane 1967: 88), the minimum sample size was calculatfor each of the three levels of confidence in each size grade, following Milne (2009: 48). The three confidence levels generally used are 90%, 95% or 99%; the reliability would be 1, 2 or 3 and the precision level 0.1, 0.05 or 0.01 respectively (Milne 2009: 48, Yamane 1967: 88). The results of this calculation are found in Table 4.

Table 3: Coefficients of Variation for Weight and Dorsal Scar Count, with the larger value in bold type, calculated for each size grade.

Size Grade	Variable	Valid N	Mean ($\bar{x}$)	Std. Deviation (σ)	Coefficient of Variation (C_{var})
1	**Weight**	1143	0.09501	0.0038	N/A
	Dorsal Scar Count	7	2	0	N/A
2	**Weight**	5664	0.089188	0.0973	**1.0909427**
	Dorsal Scar Count	3648	2.512336	0.5825	0.2318555
3	**Weight**	13040	0.207416	0.1978	**0.9536198**
	Dorsal Scar Count	6546	2.401467	0.6767	0.2817786
4	**Weight**	3707	0.90458	0.8174	**0.9036768**
	Dorsal Scar Count	2140	2.323832	0.6921	0.2978266
5	**Weight**	2131	2.34871	4.1563	**0.6806179**
	Dorsal Scar Count	1017	2.276303	0.686377	0.3639581
6	**Weight**	2240	5.756483	4.1563	**0.7220205**
	Dorsal Scar Count	918	2.17865	0.8448	0.3809001
7	**Weight**	783	13.86534	10.56	**0.7616005**
	Dorsal Scar Count	336	2.196429	0.8269	0.3764542
8	**Weight**	191	37.50136	29.908	**0.7975217**
	Dorsal Scar Count	79	2.405063	0.9131	0.3796732
9	**Weight**	60	80.78717	47.236	**0.5846951**
	Dorsal Scar Count	31	2.258065	1.0945	0.4846907
10	**Weight**	40	153.3917	114.92	**0.7491970**
	Dorsal Scar Count	18	2.333333	0.767	0.3286993

$$n = \frac{N(c \times c_{var})^2}{Np^2 + (c \times c_{var})^2}$$

Where:

- c_{var} coefficient of variation;
- N is the number of data points in the first population;
- n is the minimum sample size required from

Equation 3: Formula for calculating the required size of a subsequent sample, using the coefficient of variation of the original population.

Table 4: Unit 3 sample sizes with confidence levels of 99%, 95% and 90%, calculated from the coefficient of variation for weight for each size grade using Equation 3.

Size Grade	Valid N (Unit 11)	c_{var} (raw)	c_{var} (%)	$n_{99\%}$	$n_{95\%}$	$n_{90\%}$
1	1143	N/A	N/A	N/A	N/A	N/A
2	5664	1.0909427	109.09%	5380	1425	117
3	13040	0.9536198	95.36%	11248	1309	90
4	3707	0.9036768	90.37%	3529	966	80
5	2131	0.6806179	68.06%	2027	550	45
6	2240	0.7220205	72.20%	2138	608	51
7	783	0.7616005	76.16%	771	425	54
8	191	0.7975217	79.75%	190	161	48
9	60	0.5846951	58.47%	60	54	22
10	40	0.749197	74.92%	40	38	23

Drawing the Unit 3 sample

A confidence level of 95% was selected as best compromise between confidence and practicality, and a stratified random sample of the material from Unit 3 was collected. The specified sample was drawn from each size grade of Unit 3 (see Table 5), and randomness was assured through the use of a soil splitter. Material was poured through the device, which evenly splits the pour into two portions, and an individual item has a 50% chance of falling into either. The "non-sample" portion is split again, and again, etc., until enough items have accumulated in the "sample" container (see Figure 14).

Figure 14: Material from Unit 3 being poured through a soil splitter to ensure the randomness of the sample -- a particular item has exactly a 50% chance of being included in the sample.

Table 5: Calculated and actual sample sizes for each size grade in Unit 3. In size grades 4 through 10, values for n_{actual} (highlighted) reflect a 100% sample.

Size Grade	$n_{calculated}$	n_{actual}
1	N/A	N/A
2	1425	1425
3	1309	1310
4	966	**471**
5	550	**189**
6	608	**93**
7	425	**31**
8	161	**4**
9	54	**1**
10	38	**2**

As can be seen in Table 5, the actual samples drawn are considerably smaller than their respective calculated sample sizes in size grades 4 through 10. In these cases, there was simply not enough material in these size grades to make up the calculated sample sizes; *all* of the material in these size grades was therefore chosen for analysis and the value n_{actual} reflects a 100% sample.

Recording the Unit 3 data

Once the Unit 3 samples were obtained, each item within them was analyzed using the exact same procedure as was used for the material from Unit 11. Along with provenience data, the attributes defined in Table 2 were recorded for each Unit 3 item sampled.

Other excavation units

Finally, partial data from Test Pits 5, 6, 7, 8 and 9 (see Figure 6 on page 32), were made available by the Manitoba Museum. These data are incompatible for my purpose here, because they were recorded by another researcher during the previous season. As a result, attribute variables and size-grades taken from the materials from Unit 11 and Test Pit 3 were not recorded for these units. For example, the designation of "flake" for debitage may have been made subjectively and not necessarily based on the presence or absence of a single interior surface (Sullivan and Rozen 1985). Furthermore, all debris and soil from these units was discarded in the field, and it is therefore impossible to obtain debitage and tool percentage frequencies from these units. Because these data are incompatible with my own, they are do not form a part of my study.

Summary

In this chapter, I presented three research hypotheses to test against the data generated from my analysis. This will allow me to make interpretations about what people were doing at the Grandfather Quarry. I then described the procedure followed in conducting the analysis, and outlined my sampling strategy and techniques used to draw the sample. The next chapter presents the data acquired using this methodology.

Chapter 6: the Data

In this chapter, I present the results of my debitage analysis of Units 11 and 3 together so as to illustrate trends within the entire study sample. Thereafter, I discuss the patterns isolated within each respective unit so as to highlight differences in activity areas inside the quarry pit compared to the adjacent test units located outside of it.

Other than some fragments of feldspar and mica, a few pecking stones, and one possible sandstone abrader (see Figure 15), the lithic material recovered from Units 11 and 3 is overwhelmingly quartz, and consists near exclusively of debitage. Formal tool types including the pecking stones, bifaces, and scrapers, among others as well as a range of informal tools consisting largely of retouched flakes, were also recovered. A complete breakdown of the study sample (Units 11 and 3) is provided in Table 6 and is illustrated in Figure 16.

Figure 15: dorsal (left) and ventral (right) views of item #32524, a possible sandstone abrader from Unit 3.

Debitage and Debris

Debitage and debris overwhelmingly dominate the material recovered. By far the predominant artifact type found here is debitage, which accounts for more than half (54%) of the assemblage, while debris comprises just 44%. By comparison, tools and cores are extremely scarce, accounting collectively for just 2% of the material recovered (see Figure 16). The ratio of flakes to debris is 1.2:1 and the ratio of flakes to tools is 67.7:1.

Table 6: a complete breakdown of the study sample by size-grade, locus and artifact type.

Size Grade	Unit	Debris	Debitage						Cores	Informal Tools	Formal Tools								
			Complete Flakes	**Split Flakes**	**Broken Flakes**	**Flakes both Split and Broken**	**Burin Spalls**	**Total Debitage**			**Points**	**Scrapers**	**Burins**	**Borers/Awls**	**Blades/Microblades**	**Bifaces**	**Liquidation Fragments**	**Unknown Tools**	**Total Formal Tools**
1	11	1143	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3	N/A																	
2	11	2007	2833	352	401	54	0	3640	2	1	0	1	0	0	10	0	0	1	12
	3	499	638	118	129	23	1	909	10	1	0	0	0	0	4	0	0	1	5
3	11	6426	4376	606	1043	137	0	6522	75	2	0	0	0	0	5	0	4	0	9
	3	318	669	127	148	24	0	968	7	1	0	0	0	1	1	6	0	3	11
4	11	1452	1428	230	402	68	6	2134	69	7	1	1	0	2	17	18	10	4	53
	3	117	236	36	51	8	0	331	5	2	1	4	0	0	2	5	0	2	14
5	11	1045	760	82	151	15	26	1034	42	9	2	0	0	0	15	12	0	9	38
	3	51	82	19	18	5	1	125	0	0	2	1	2	0	1	1	0	5	12
6	11	1228	725	51	122	13	3	914	2	8	1	4	8	3	4	21	0	3	44
	3	20	49	5	9	0	0	63	2	1	0	3	0	1	2	0	0	0	6
7	11	433	303	5	24	2	0	334	6	1	0	0	0	0	1	5	0	3	9
	3	11	18	2	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0
8	11	106	73	3	6	0	0	82	0	1	0	0	1	0	0	1	0	0	2
	3	1	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1
9	11	29	23	3	1	4	0	31	1	0	0	0	0	0	0	0	0	0	0
	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	11	19	17	0	0	0	0	17	1	1	0	0	0	0	0	1	0	1	1
	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1
Totals	11	12745	10898	1332	2150	293	35	14708	222	30	4	6	9	5	52	58	14	20	168
	3	1018	1695	307	355	60	2	2419	24	5	3	8	2	2	10	13	0	12	50
	Both	**13763**	**12593**	**1639**	**2505**	**353**	**37**	**17127**	**246**	**35**	**7**	**14**	**11**	**7**	**62**	**71**	**14**	**32**	**218**

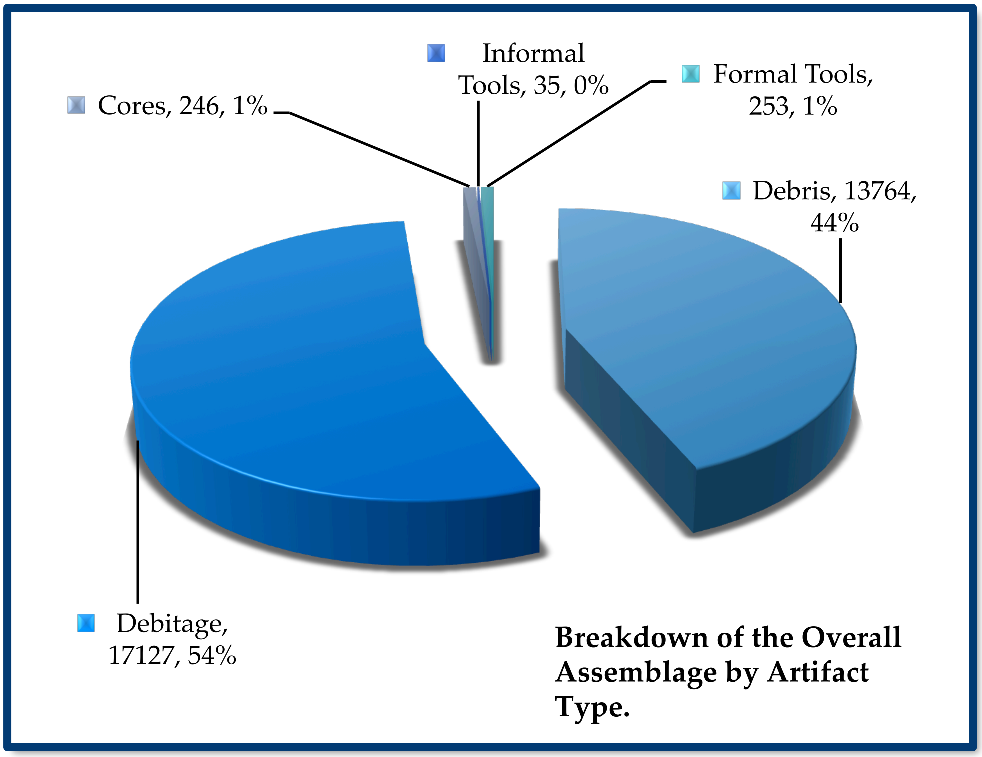


Figure 16: a breakdown of the study sample (N=31,425) by artifact type. Percentages are rounded to the nearest whole percent.

Debris reflects residue and breakage left over from flake failure during detachment when excessively heavy force-loads are used, from raw material extraction from the walls and floor of the quarry, or even from natural processes geological processes. Debitage flakes, on the other hand, are the result of the deliberate and systematic reduction and shaping of raw material nodules into blanks, preforms and, ultimately, tools. The attribute used here to distinguish between debitage and debris was the presence or absence of a single interior surface (following Sullivan and Rozen 1985). This is the surface exposed on the ventral side of the flake when it is struck from the objective piece, leaving a removal scar on the latter. This newly-exposed ventral surface is ‘fresh’, not having had subsequent flakes struck from it (which might ultimately occur if, as is often the case with quartz flakes, the flake is robust enough and of a high enough raw material quality to be set aside as a child core (after Driscoll 2011: 736)); the dorsal surface, on the other hand, may have multiple scars from previous flake removals (see Figure 17).

Figure 17: a fine example of a debitage flake (item #15681), showing in profile the single interior surface (left) and the dorsal surface (right).

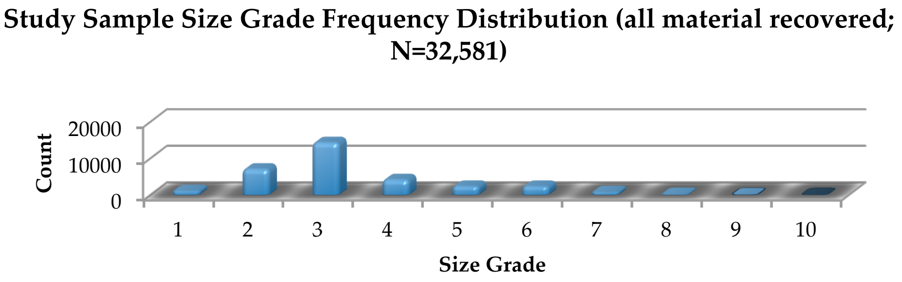
The Study Sample Overall

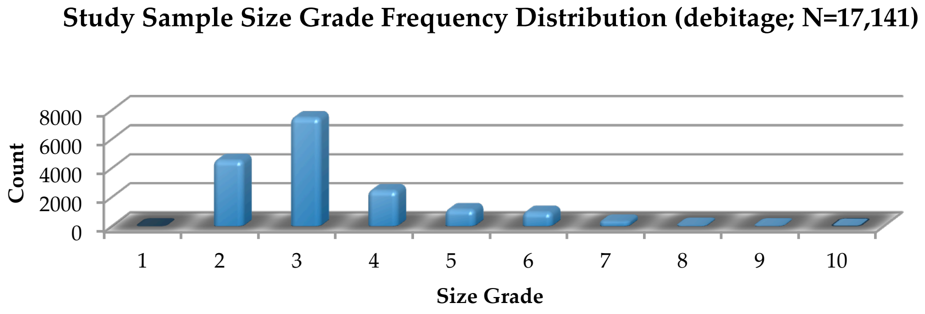
Weight Frequency Distribution

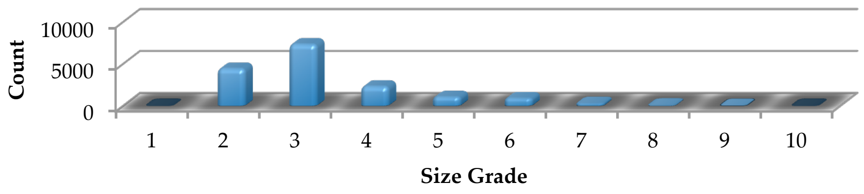
Weight frequency distribution shows a long-tailed curve that is highly skewed toward the low end of the range, with the mode being the very lowest weight category (0.0 – 0.2g). This pattern does not change appreciably when the population is narrowed to debitage; to debitage with discernable striking platform; nor even when restricted to debitage that has a discernable striking platform and is of "good" (rm_qual = 4) or "excellent" (rm_qual = 5) quality (see Figure 18).

Size Grade Frequency Distribution

Overall size grade frequencies are clustered at the low end of the range, with most specimens falling between Size Grade 2 (1/16″ < n < 1/8″) and Size Grade 6 (3/4″ < n < 1″). The mode is Size Grade 3 (1/8″ < n < 1/4″). As with weight frequencies, this pattern remains essentially unchanged when the population is filtered for debitage; for debitage with a discernable striking platform; and for high-quality (rm_qual = 4 or 5) debitage with a discernable striking platform (see


Study Sample Size Grade Frequency Distribution (all material recovered; N=32,581)


Study Sample Size Grade Frequency Distribution (debitage; N=17,141)


Study Sample Size Grade Frequency Distribution (debitage with platform; N=16,637)

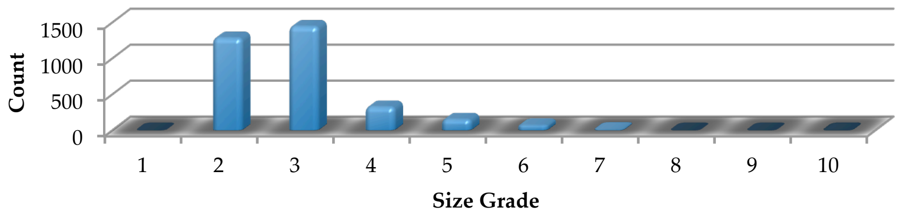
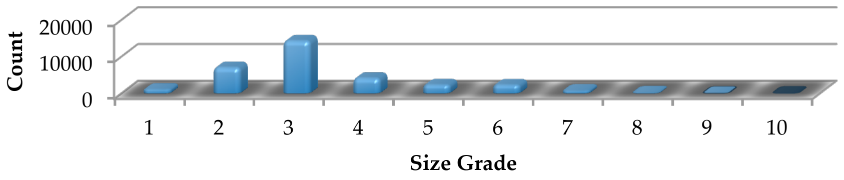
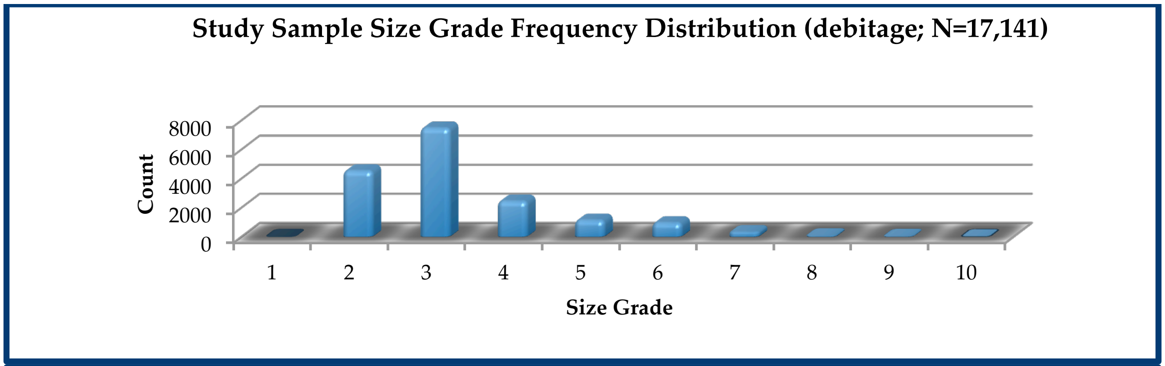
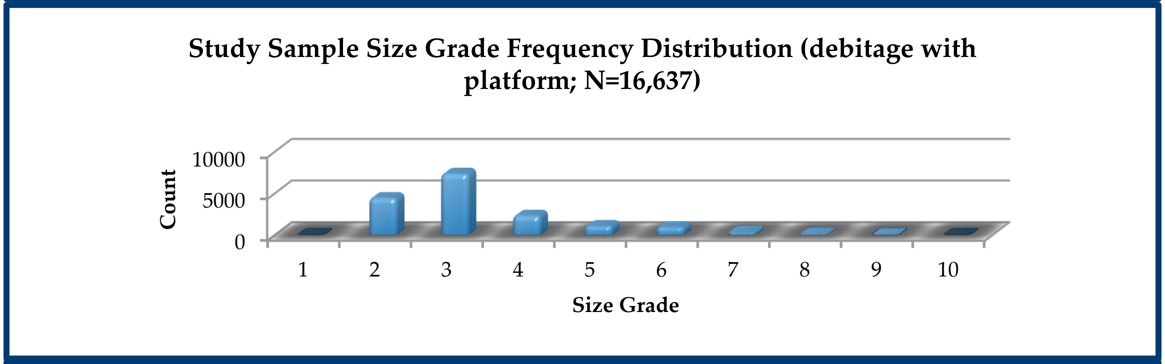

Study Sample Size Grade Frequency Distribution (high-quality debitage with platform; N=3,300)

Figure 19). However, this last population does show a noticeably higher proportion of debitage from the smallest effective size-grade (size grade 2 – ¼″ mesh – remembering that size-grade 1 was omitted; see page 114). See


Study Sample Size Grade Frequency Distribution (all material recovered; N=32,581)


Study Sample Size Grade Frequency Distribution (debitage; N=17,141)


Study Sample Size Grade Frequency Distribution (debitage with platform; N=16,637)

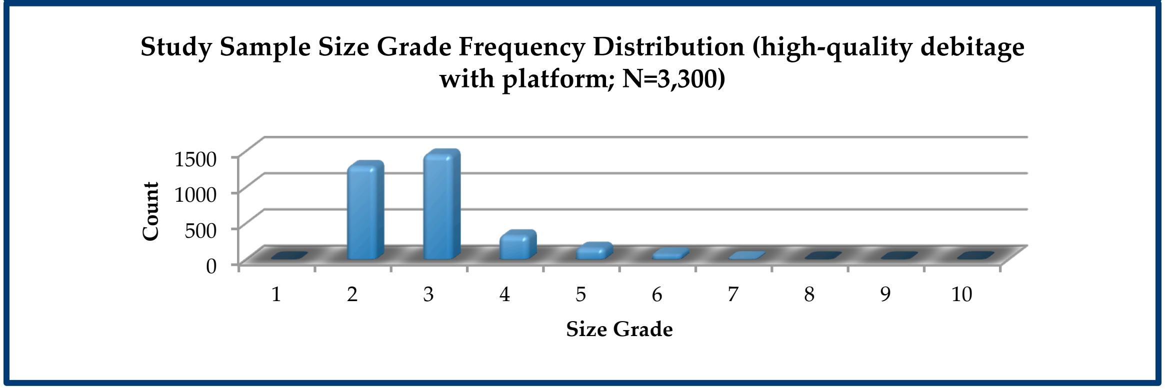

Study Sample Size Grade Frequency Distribution (high-quality debitage with platform; N=3,300)

Figure 19, bottom chart.

Dorsal Scar Count Frequency Distribution

There is an overall predominance of flakes with two and three dorsal scars, with the mode being two (2), regardless of the presence or absence of a striking platform. However, when the population is confined to high-quality debitage flakes (rm_qual = 4 or 5) with platforms, the mode becomes three (3). See Figure 20.

Raw Material Quality

The quality of raw material from the Grandfather Quarry is generally poor: the frequency distribution of raw material quality levels is skewed toward the poorer end of the spectrum, and the mode is a Quality of 2 (Poor – see Figure 21). High-quality raw material (4/Good and 5/Excellent, taken together) comprises just 13% of the material recovered (see Figure 22).

When the population is constrained to debitage (with or without a discernable striking platform), the frequency distribution takes on a more 'normal'-shaped bell-curve, with the mode being a Quality of 3 (Fair -- see Figure 23).

But when the population is further narrowed to debitage with a discernable striking platform and four (4) or more dorsal scars, the curve becomes skewed toward the higher end of the raw material quality spectrum (see Figure 24). This would seem to indicate that higher-quality raw material was often further reduced than was lower-quality quartz.

Unit 11 – the Main Quarry

The artifact category breakdown of Unit 11 is very close to that of the assemblage as a whole: of the material recovered from this unit (N = 27,903), 53% (*n* = 14,708) is debitage and 45% (*n* = 12,745) is debris. Cores and tools each account for approximately 1% of this material (see Figure 25).

Of the debitage from this locus (N = 14,708), 74% (*n* = 10,898) are complete flakes; 9% (*n* = 1,332) are split longitudinally; 15% (*n* = 2,150) are broken horizontally (that is, with either the proximal or distal portion missing); and 2% (*n* = 293) are both longitudinally split and horizontally broken (see Figure 26).

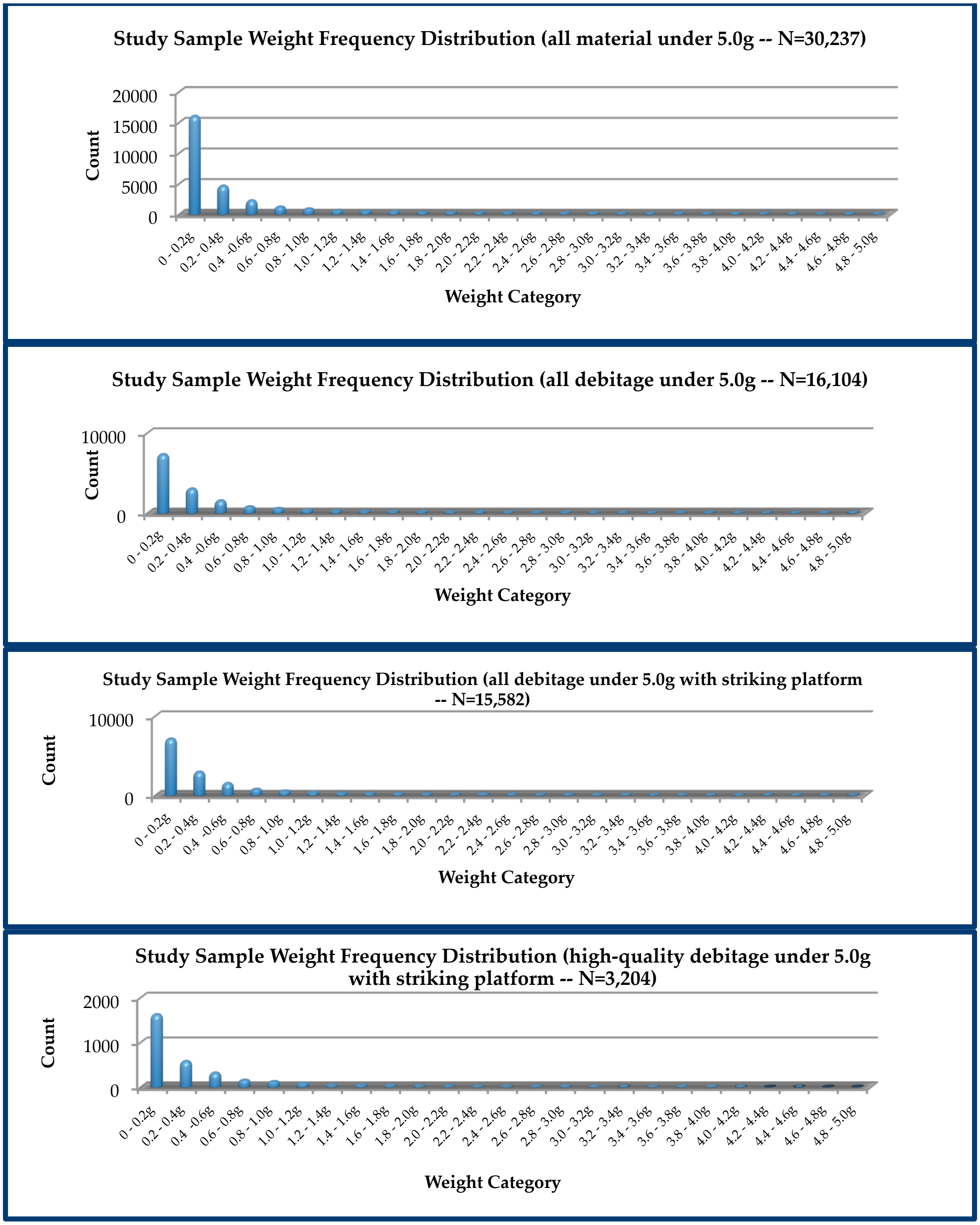


Figure 18: study sample weight frequency distribution for all material recovered (top); for all debitage (i.e. debris omitted; upper-middle); for all debitage with discernable striking-platform (lower-middle); and for all high-quality debitage with discernable striking platform. Population restricted to items weighing 5.0g or less for purposes of clarity.

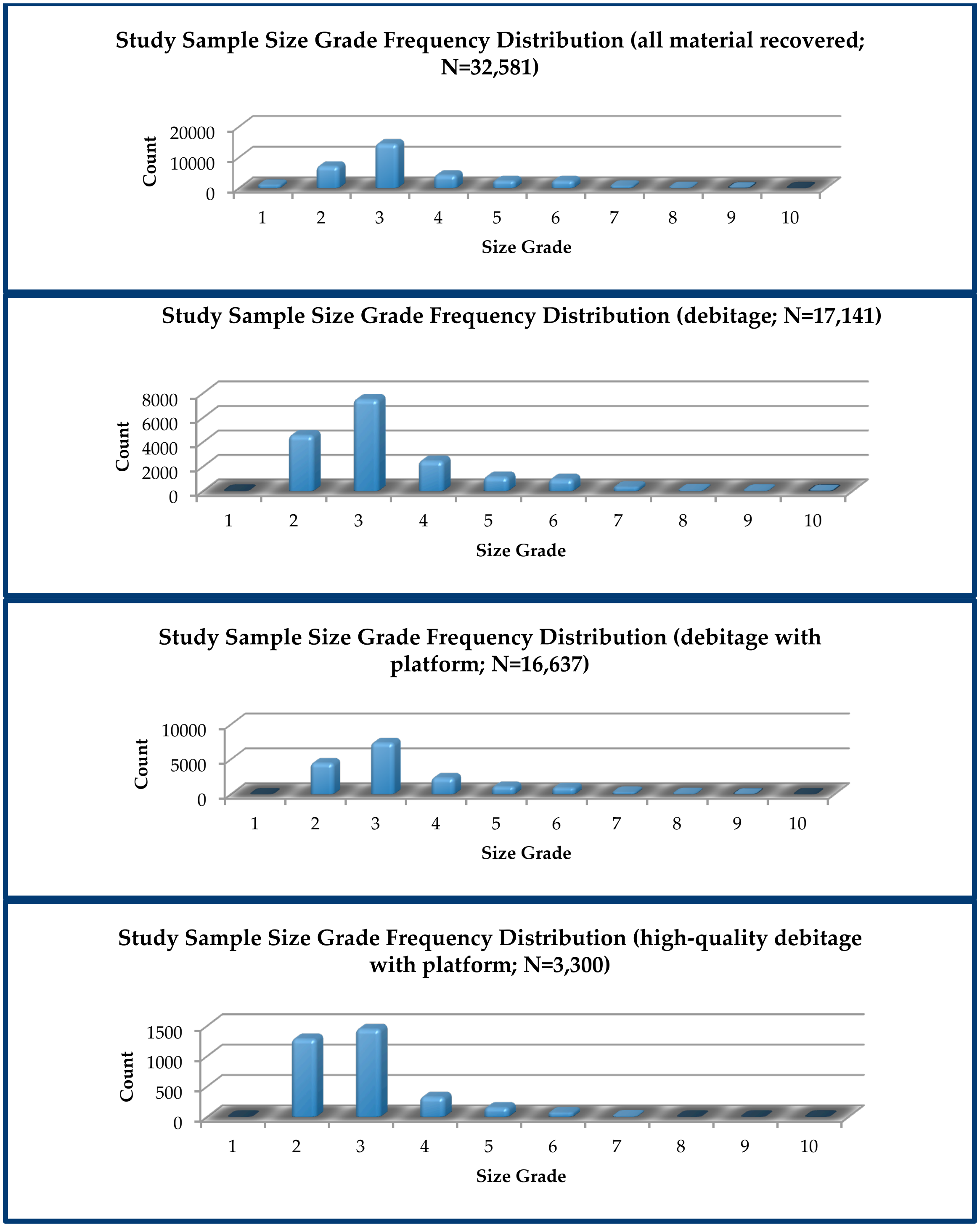
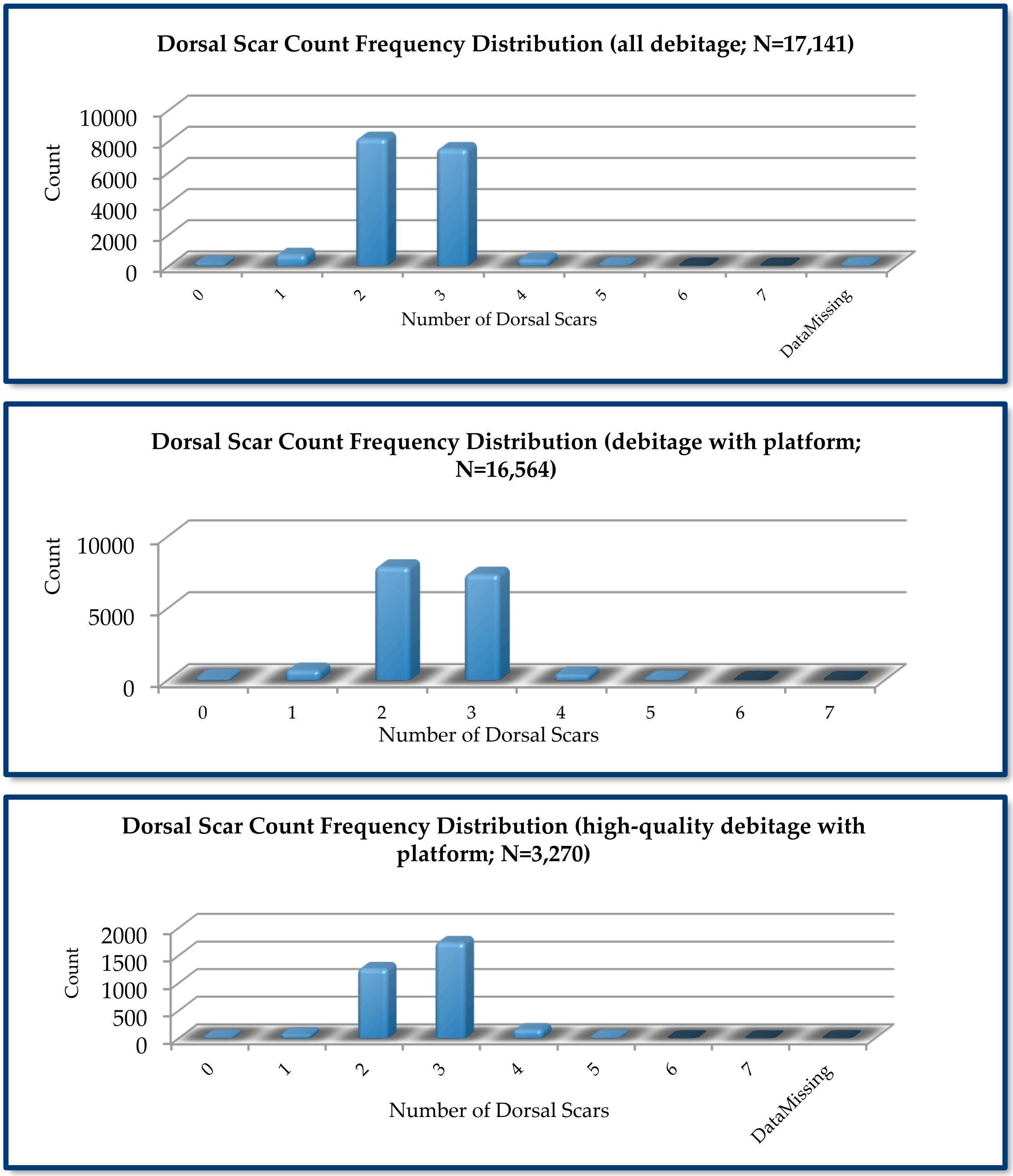


Figure 19: study sample size grade frequencies for all material recovered (top); debitage (i.e. debris omitted - upper-middle); debitage with discernable striking platform (lower-middle); and high-quality debitage with discernable striking platform (bottom).



Dorsal Scar Count Frequency Distribution (all debitage; N=17,141)

Dorsal Scar Count Frequency Distribution (debitage with platform; N=16,564)

Dorsal Scar Count Frequency Distribution (high-quality debitage with platform; N=3,270)

Figure 20: dorsal scar count frequency distributions for all debitage (top); debitage with platform (middle); and high-quality debitage with platform (bottom).

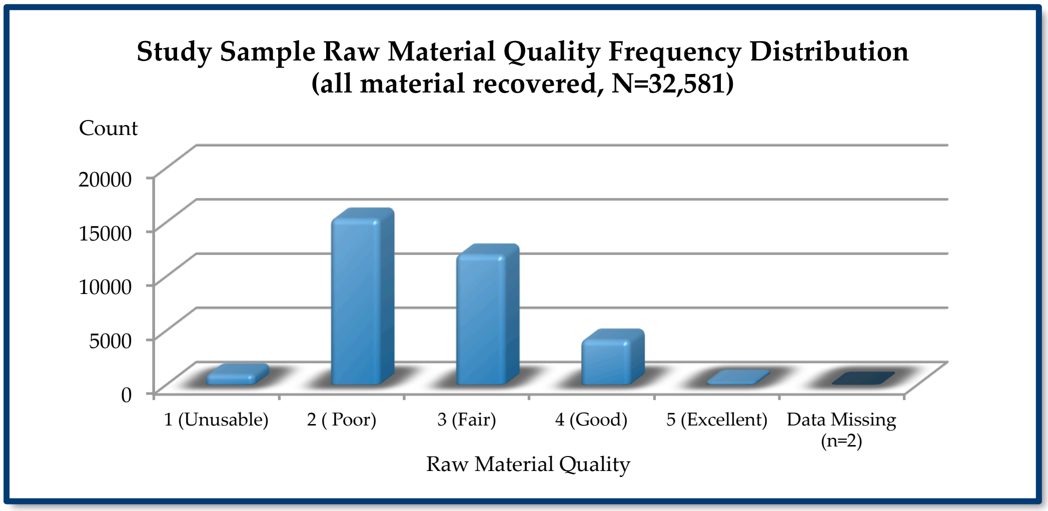


Figure 21: a raw material frequency distribution chart for all material recovered.

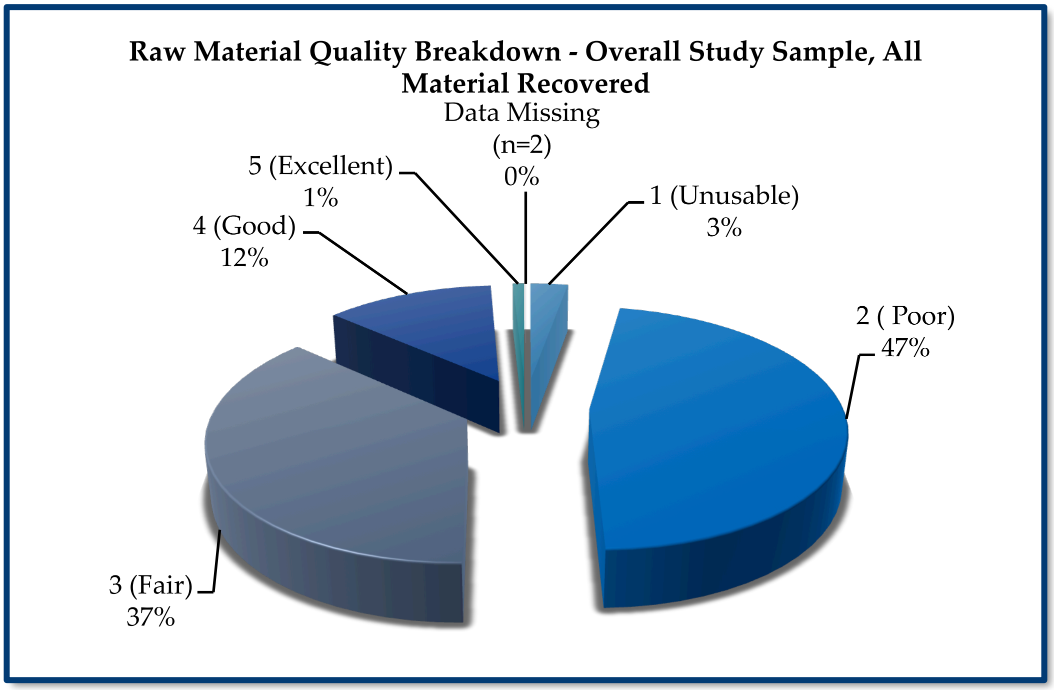
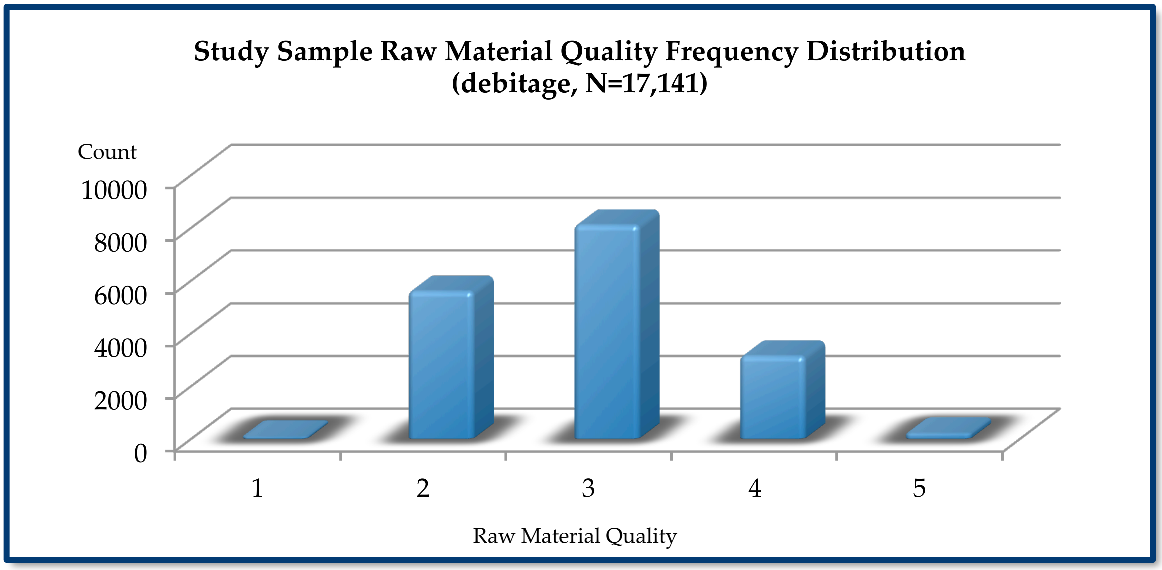


Figure 22: a breakdown of the overall study sample by raw material quality. Percentages are rounded to the nearest whole percent.


Study Sample Raw Material Quality Frequency Distribution (debitage, N=17,141)

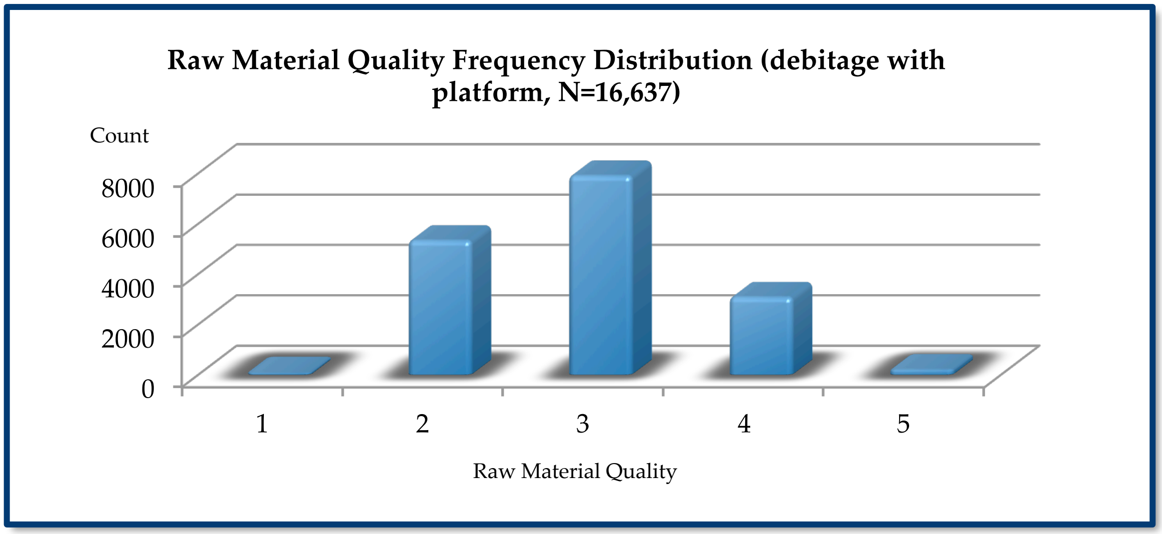

Raw Material Quality Frequency Distribution (debitage with platform, N=16,637)

Figure 23: frequency distribution charts of raw material quality for the study sample debitage (above) and debitage with discernable striking platform (below).

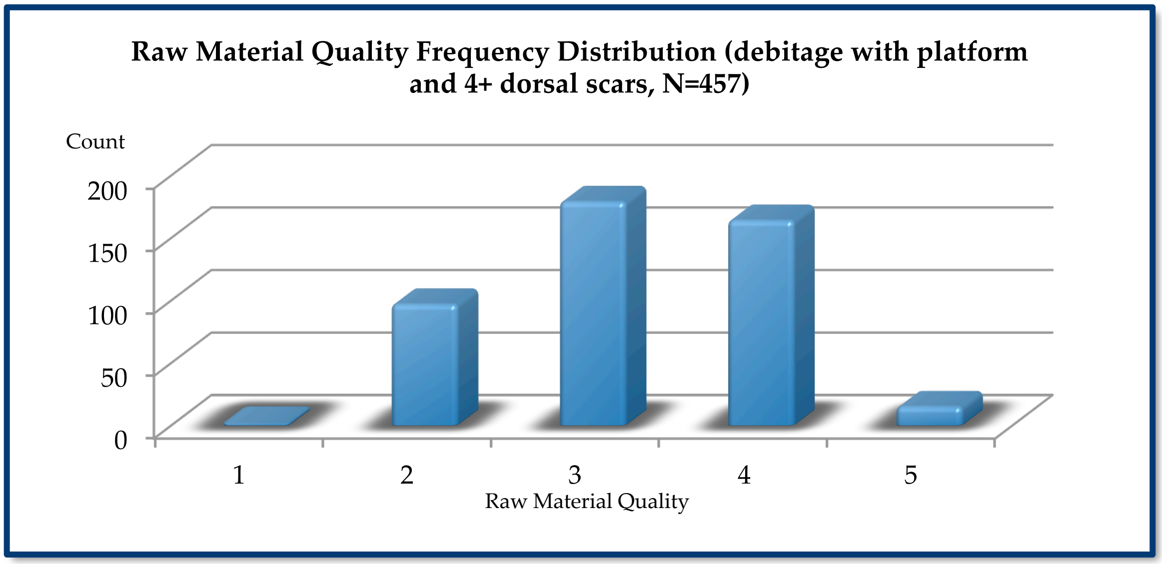


Figure 24: a frequency distribution chart for study sample debitage with discernable striking platform and four (4) or more dorsal scars.

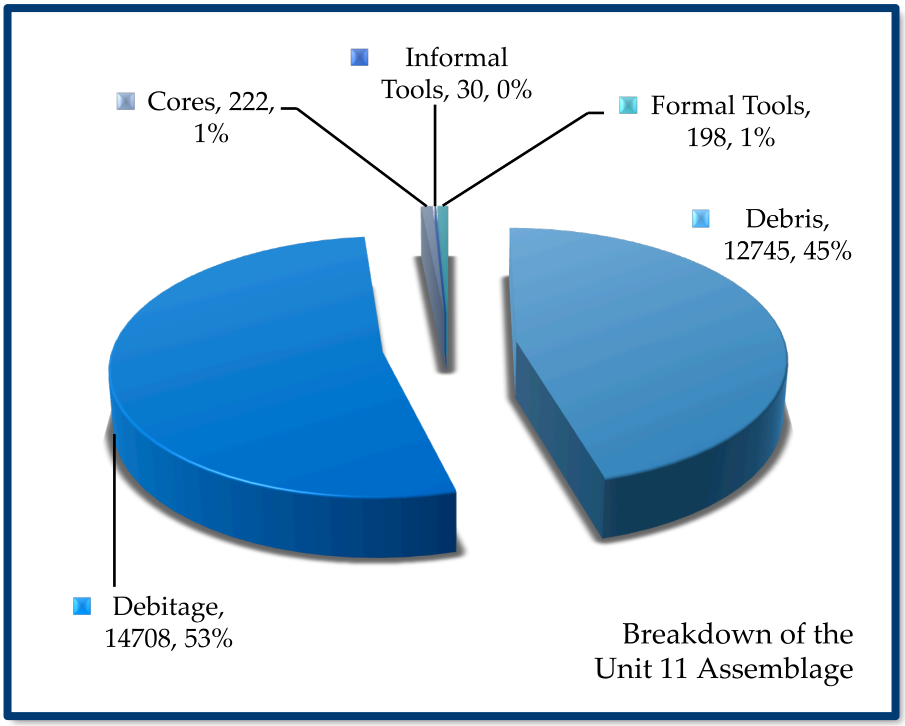


Figure 25: a breakdown of the assemblage from Unit 11 (N=27,903). Percentages are rounded to the nearest whole percent.

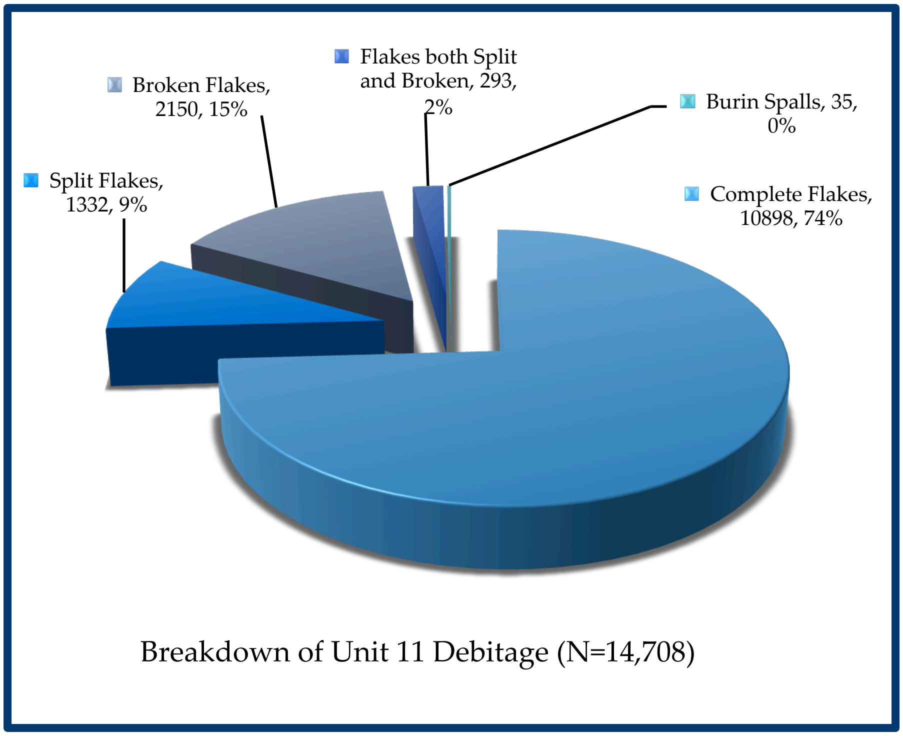
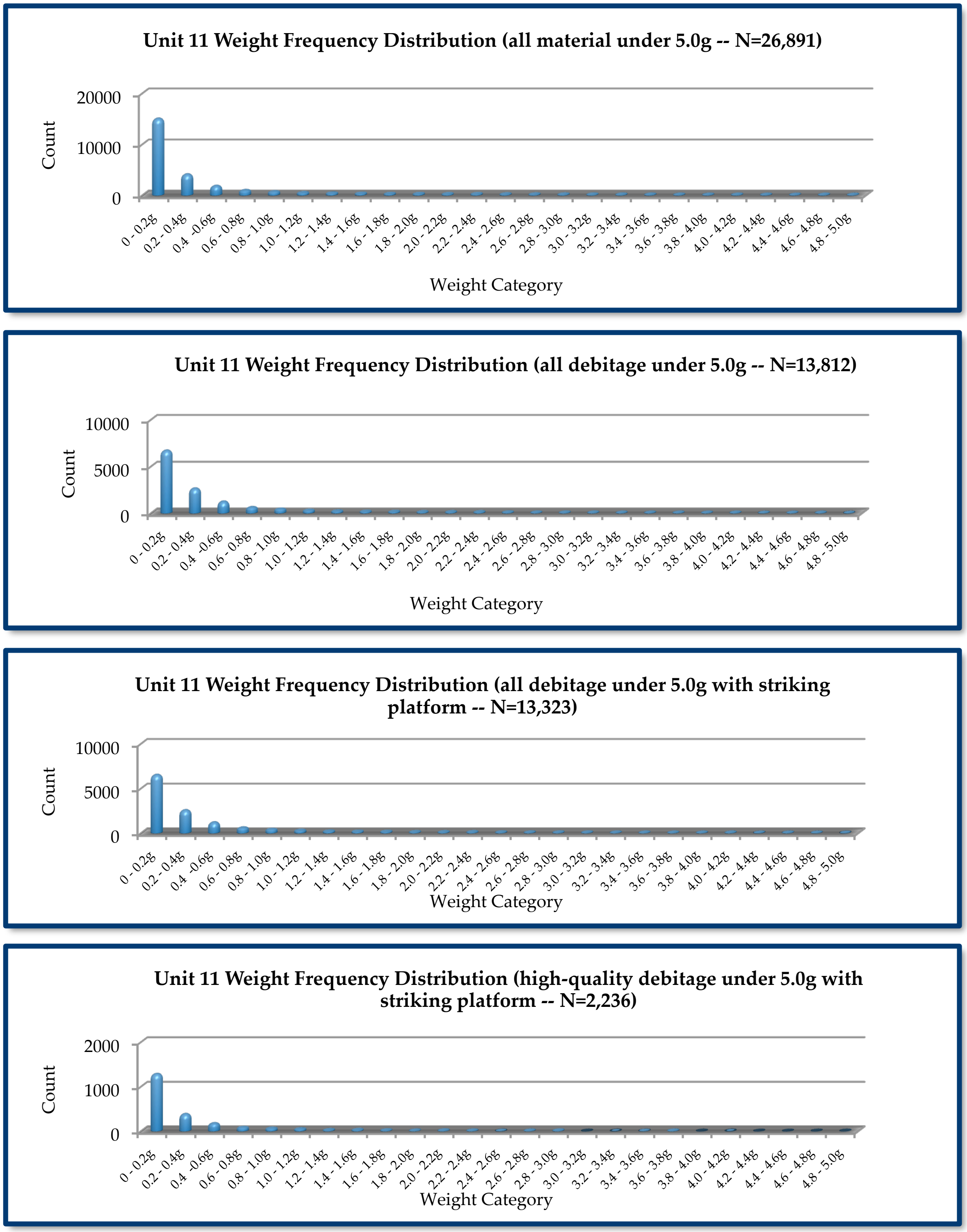


Figure 26: a breakdown of the debitage from Unit 11. Percentages are rounded to the nearest whole percent.

Weight Frequency Distribution

The weight frequency distribution for Unit 11 mirrors that of the overall study sample: it shows a long-tailed curve that is highly skewed toward the low end of the range, with the mode being the very lowest weight category (0.0 – 0.2g). Again, this pattern does not change appreciably when the population is narrowed to debitage; to debitage with discernable striking platform; nor even when restricted to debitage that has a discernable striking platform and is of “good” or “excellent” quality (see Figure 27).



Unit 11 Weight Frequency Distribution (all material under 5.0g -- N=26,891)

Unit 11 Weight Frequency Distribution (all debitage under 5.0g -- N=13,812)

Unit 11 Weight Frequency Distribution (all debitage under 5.0g with striking platform -- N=13,323)

Unit 11 Weight Frequency Distribution (high-quality debitage under 5.0g with striking platform -- N=2,236)

Figure 27: Unit 11 weight frequency distribution for all material recovered (top); for all debitage (i.e. debris omitted; upper-middle); for all debitage with discernable striking-platform (lower-middle); and for all high-quality debitage with discernable striking platform. Population restricted to items weighing 5.0g or less for purposes of clarity.

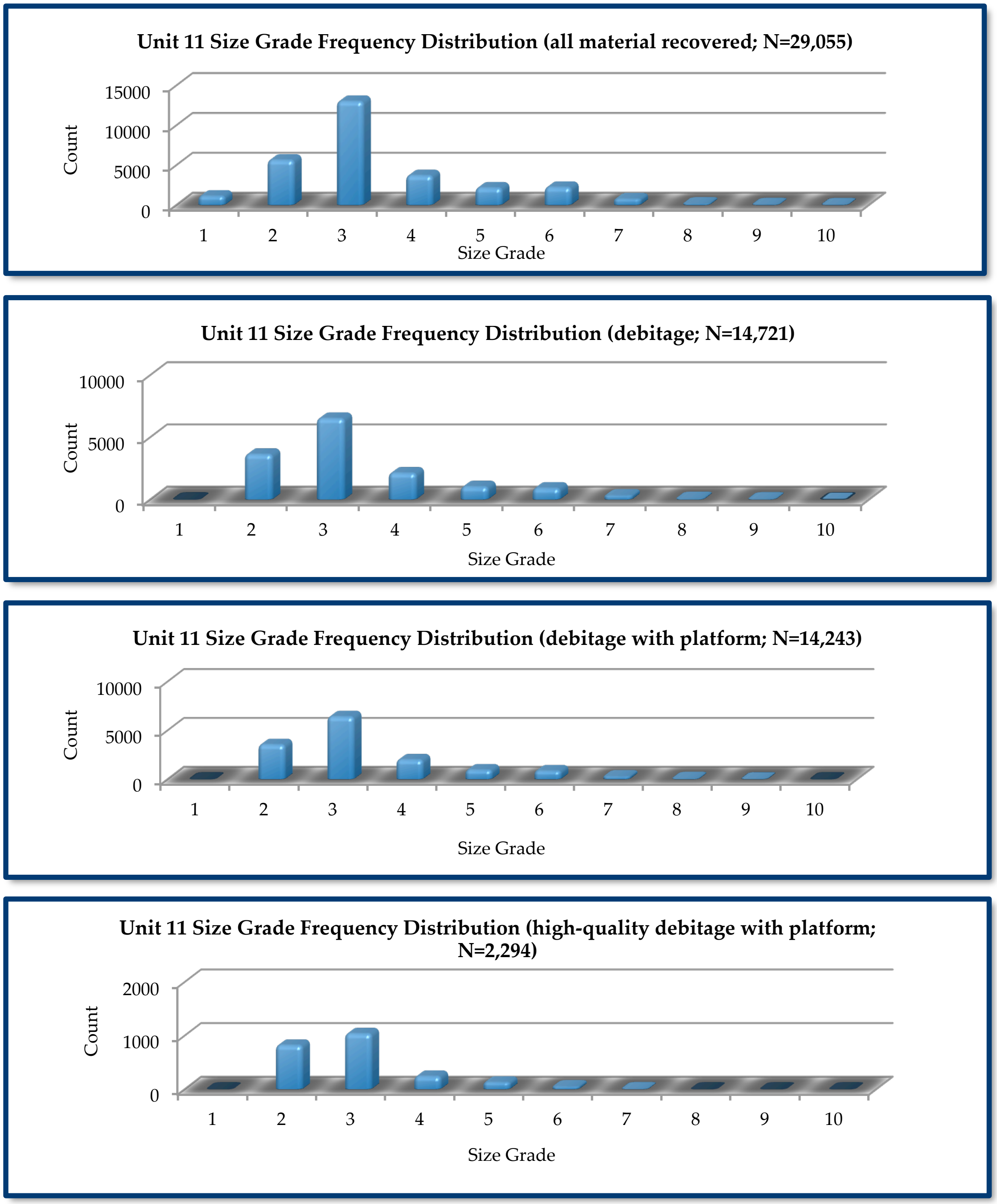
Size Grade Frequency Distribution

As with the overall size grade distribution, Unit 11 size grade frequencies are clustered at the low end of the range, with a mode of Size Grade 3 (1/4″) and most cases falling between Size Grade 2 (1/8″) and Size Grade 6 (1″).

Also as with the overall size grade distribution, this pattern does not change when the population is filtered for debitage; for debitage with a discernable striking platform; and for high-quality (rm_qual = 4 or 5) debitage with a discernable striking platform (see Figure 28).

Dorsal Scar Count Frequency Distribution

Unit 11 shows the same overall predominance of flakes with two and three dorsal scars, with a mode of two (2), whether or not there is a striking platform. However, when the population is confined to high-quality debitage flakes (rm_qual = 4 or 5) with platforms, the mode becomes three (3). See Figure 29.



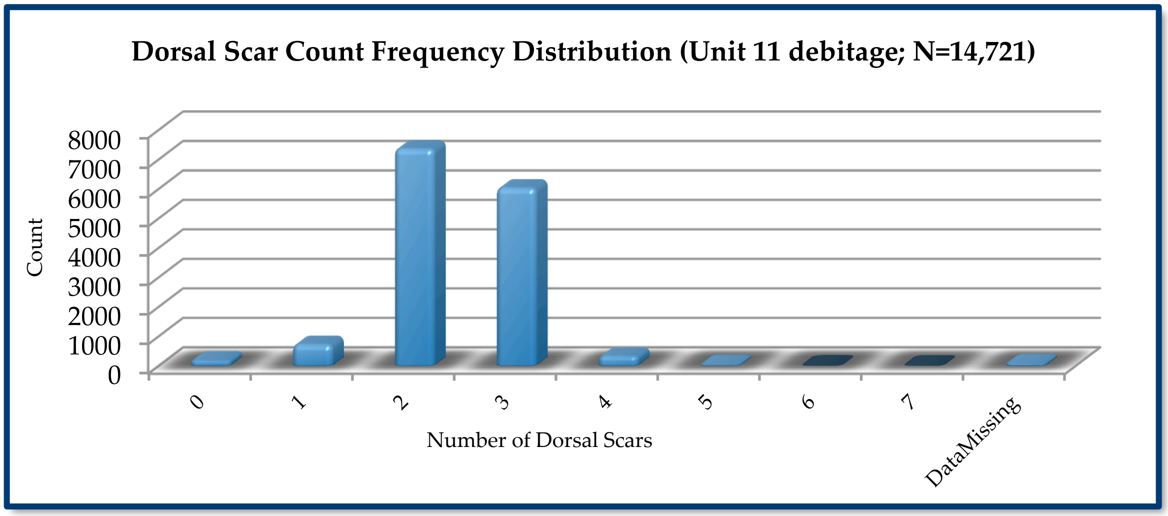
Unit 11 Size Grade Frequency Distribution (all material recovered; N=29,055)

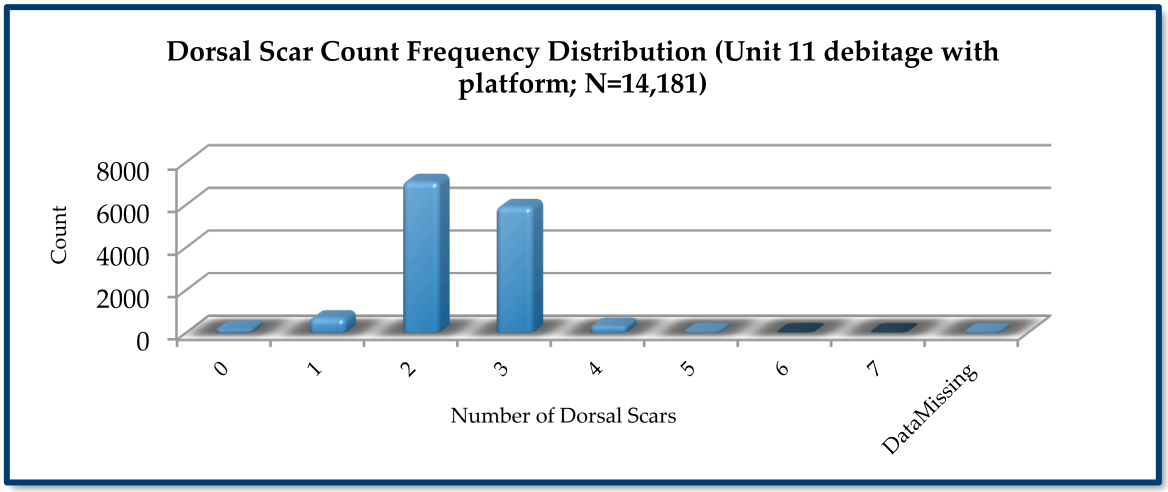
Unit 11 Size Grade Frequency Distribution (debitage; N=14,721)

Unit 11 Size Grade Frequency Distribution (debitage with platform; N=14,243)

Unit 11 Size Grade Frequency Distribution (high-quality debitage with platform; N=2,294)

Figure 28: Unit 11 size grade frequencies for all material recovered (top); debitage (i.e. debris, tools and cores omitted - upper-middle); debitage with discernable striking platform (lower-middle); and high-quality debitage with discernable striking platform (bottom).





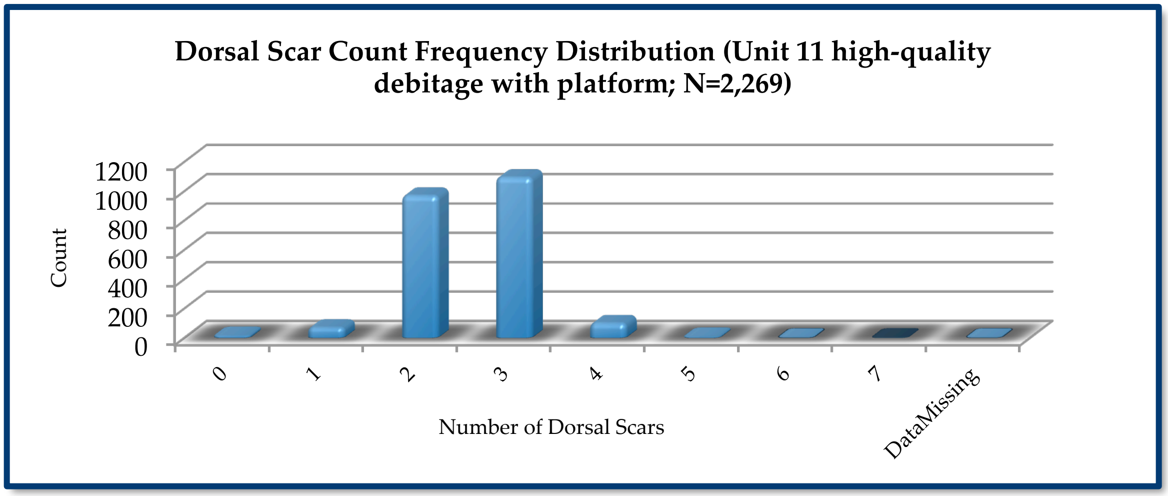


Figure 29: dorsal scar count frequency distributions for all Unit 11 debitage (top); Unit 11 debitage with platform (middle); and high-quality Unit 11 debitage with platform (bottom).

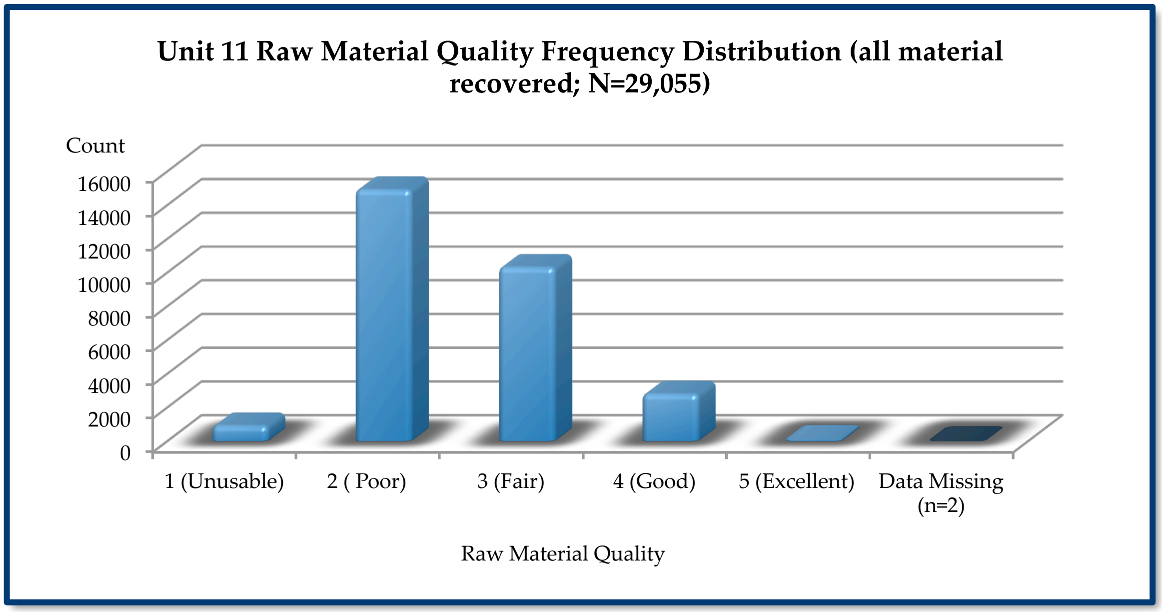


Figure 30: a frequency distribution of raw material quality for all material recovered from Unit 11.

Raw Material Quality

The material from Unit 11 reflects the overall pattern of the study sample: the frequency distribution of raw material quality levels is skewed toward the poorer end of the spectrum, and the quality mode is 2 (Poor – see Figure 30).

As with the overall study sample, the Unit 11 frequency distribution for raw material quality takes on a more 'normal'-shaped bell-curve (albeit slightly skewed to the lower end of the range), with a mode of 3 (Fair), when the population is constrained to debitage, with or without a discernable striking platform; and, also like that of the overall study sample, it becomes more skewed toward the higher end of the range when further constrained to debitage with a platform and four or more dorsal scars (see Figure 31).

High-quality (rm_qual=4 or 5) raw material accounts for 16% of the debitage from Unit 11, and this figure doubles to 32% when the population is constrained to debitage with striking platform and four (4) or more dorsal scars (see Figure 32).

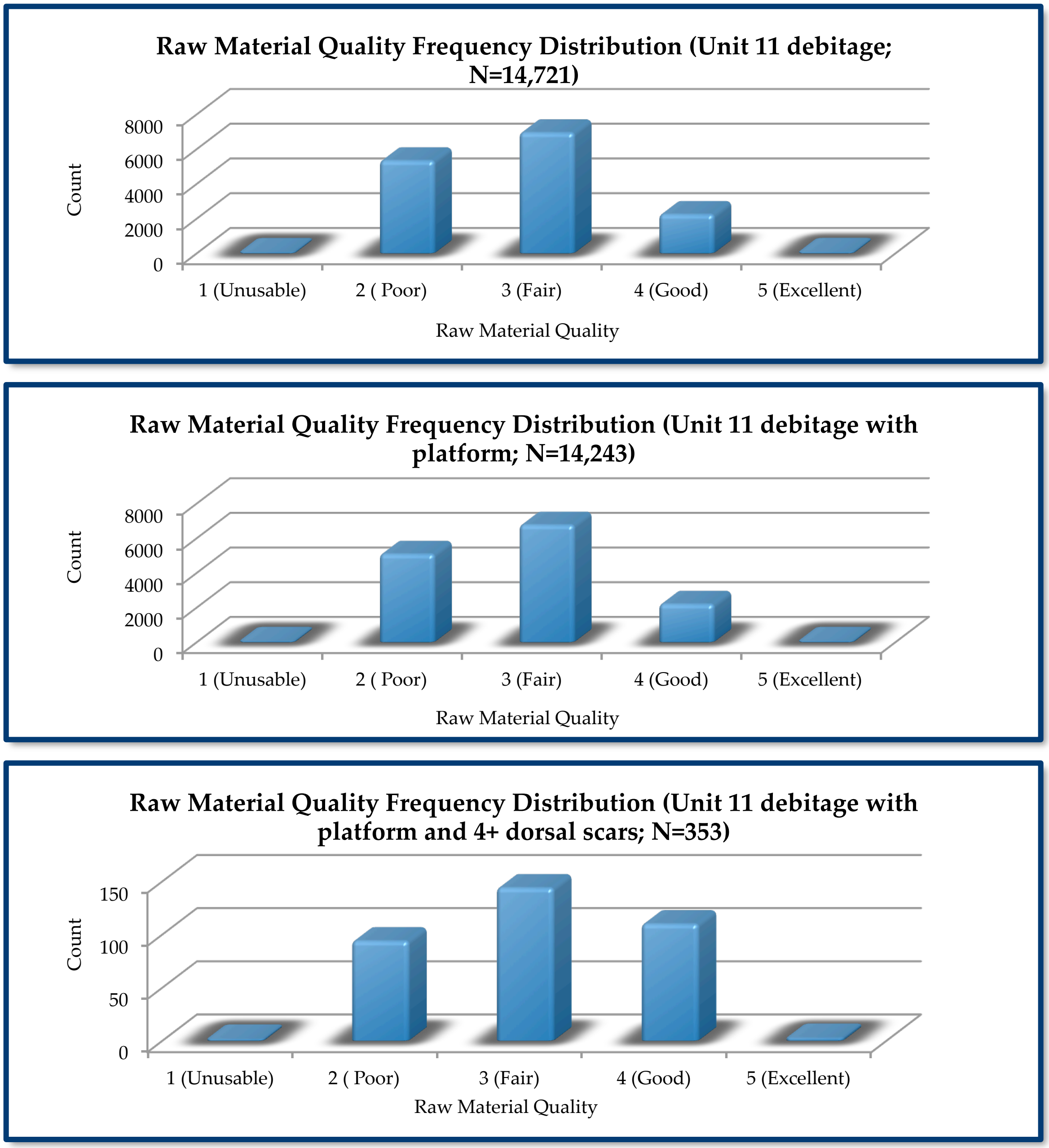
Unit 3 – a Test-Pit at the Edge of the Main Quarry

The artifact category breakdown of Unit 3 is similar to that of Unit 11 with respect to cores and tools, with each comprising less than 1% (*N* = 24 and *N* = 55, respectively) of the unit total (N = 3,522 – see Figure 33).

Unit 3's ratio of debitage to debris, however, is markedly different from that of Unit 11, with debitage accounting for fully 69% (*N* = 2,419) and debris for just 29% (*n* = 1019). Of the debitage itself, 70% (*N* = 1,695) are complete flakes; 13% (*N* = 307) are split flakes; 15% (*n* = 355) are broken flakes; and 2% (*N* = 60) are both split and broken (see Figure 34).

Weight Frequency Distribution

Once again, the weight frequency distribution for Unit 3 shows the familiar long-tailed curve that is highly skewed toward the low end of the range, with the mode being the very lowest weight category (0.0 – 0.2g). As with Unit 11 and the overall study sample (Units 11 and 3 together), this pattern does not change appreciably when the population is narrowed to debitage; to debitage with discernable striking platform; nor even when restricted to debitage that has a discernable striking platform and is of “good” or “excellent” quality (see Figure 35).

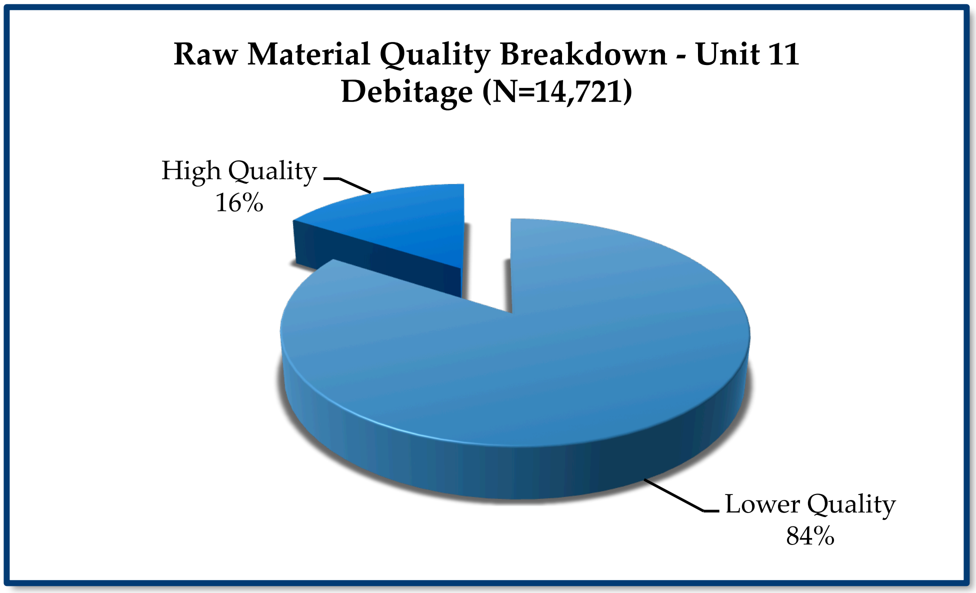


Raw Material Quality Frequency Distribution (Unit 11 debitage; N=14,721)

Raw Material Quality Frequency Distribution (Unit 11 debitage with platform; N=14,243)

Raw Material Quality Frequency Distribution (Unit 11 debitage with platform and 4+ dorsal scars; N=353)

Figure 31: raw material quality frequency distributions for Unit 11 debitage (top); for Unit 11 debitage with discernable striking platform (middle); and for Unit 11 debitage with striking platform and 4 or more dorsal scars (bottom).



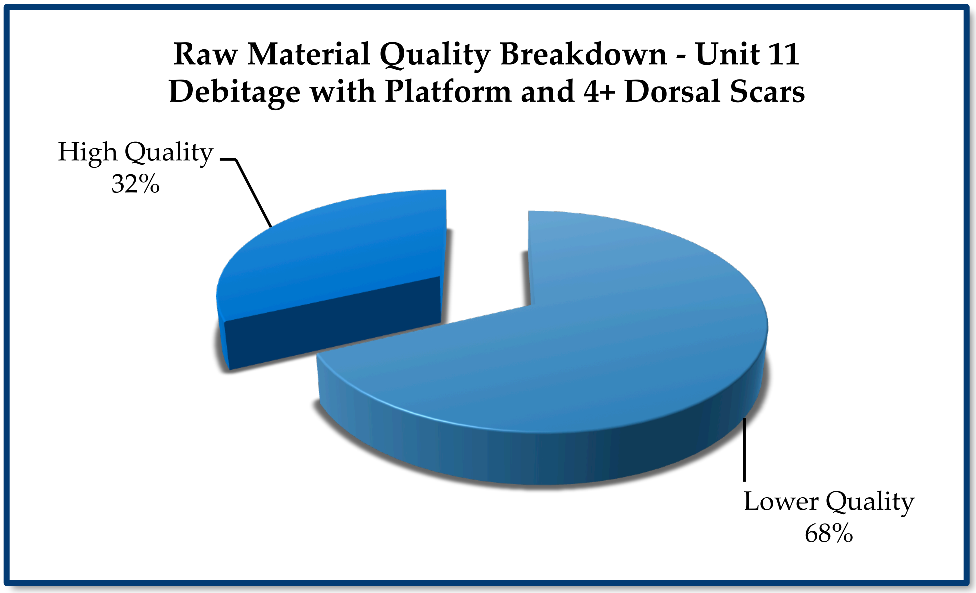


Figure 32: the proportion of high-to-lower quality raw material in all debitage from Unit 11 (above) and debitage from Unit 11 with a discernable striking platform and 4 or more dorsal scars (below).

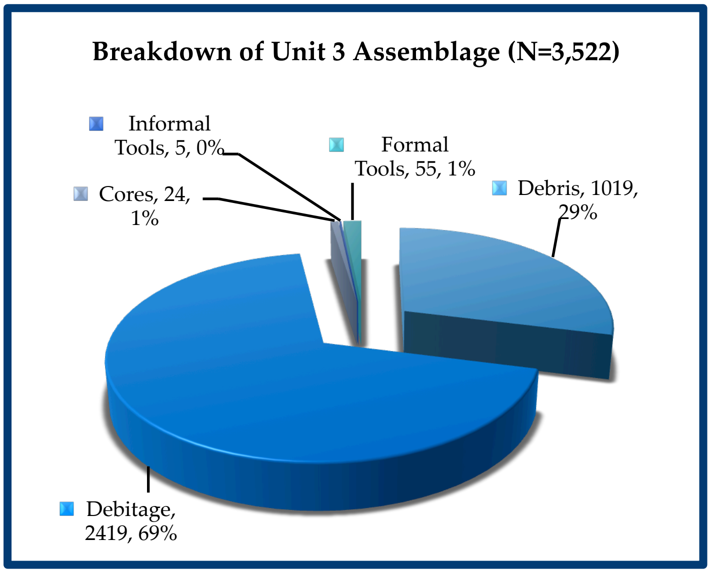


Figure 33: a breakdown of the Unit 3 assemblage (N=3,522) by artifact category. Percentages are rounded to the nearest whole percent.

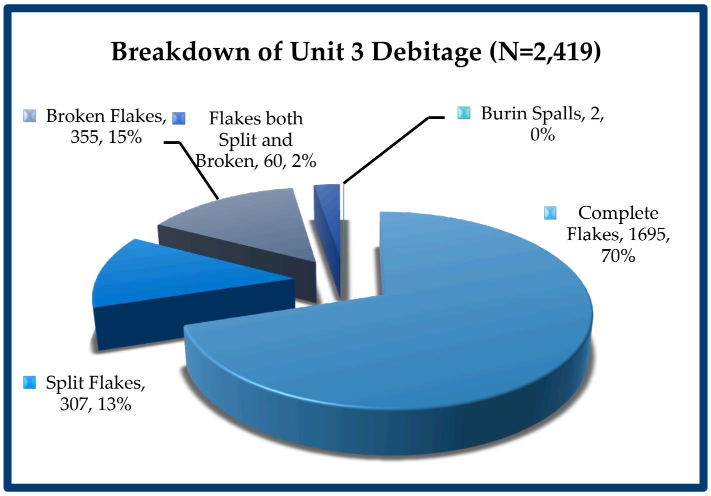


Figure 34: a breakdown of the debitage (N=2,419) from Unit 3. Percentages are rounded to the nearest whole percent.

Size Grade Frequency Distribution

As with the overall size grade distribution, Unit 3 size grade frequencies are clustered at the low end of the range, this time with most cases falling between Size Grade 2 (1/8″) and Size Grade 5 (3/4″) and having a mode of Size Grade 2 (1/8″ – see Figure 36, top chart).

Also as with the overall size grade distribution, this pattern does not change when the population is filtered for debitage and for debitage with a discernable striking platform, although the mode for these is 3 (1/4″ mesh – see Figure 36, upper-middle and lower-middle charts). The pattern holds for high-quality (rm_qual = 4 or 5) debitage with a discernable striking platform, but the mode once again becomes 2 (see Figure 36, bottom chart).

Dorsal Scar Count Frequency Distribution

Unit 3 shows the same overall predominance of flakes with two and three dorsal scars, with a mode of three (3), regardless of whether the population is confined to debitage, debitage with discernable striking platform, or high-quality debitage (rm_qual = 4 or 5) with platform (see Figure 37).

Raw Material Quality

In contrast to Unit 11 and to the overall study sample, the frequency distribution of raw material quality levels in Unit 3 is skewed toward the higher end of the spectrum, and the quality mode is 3 (Fair – see Figure 38, upper 3 charts).

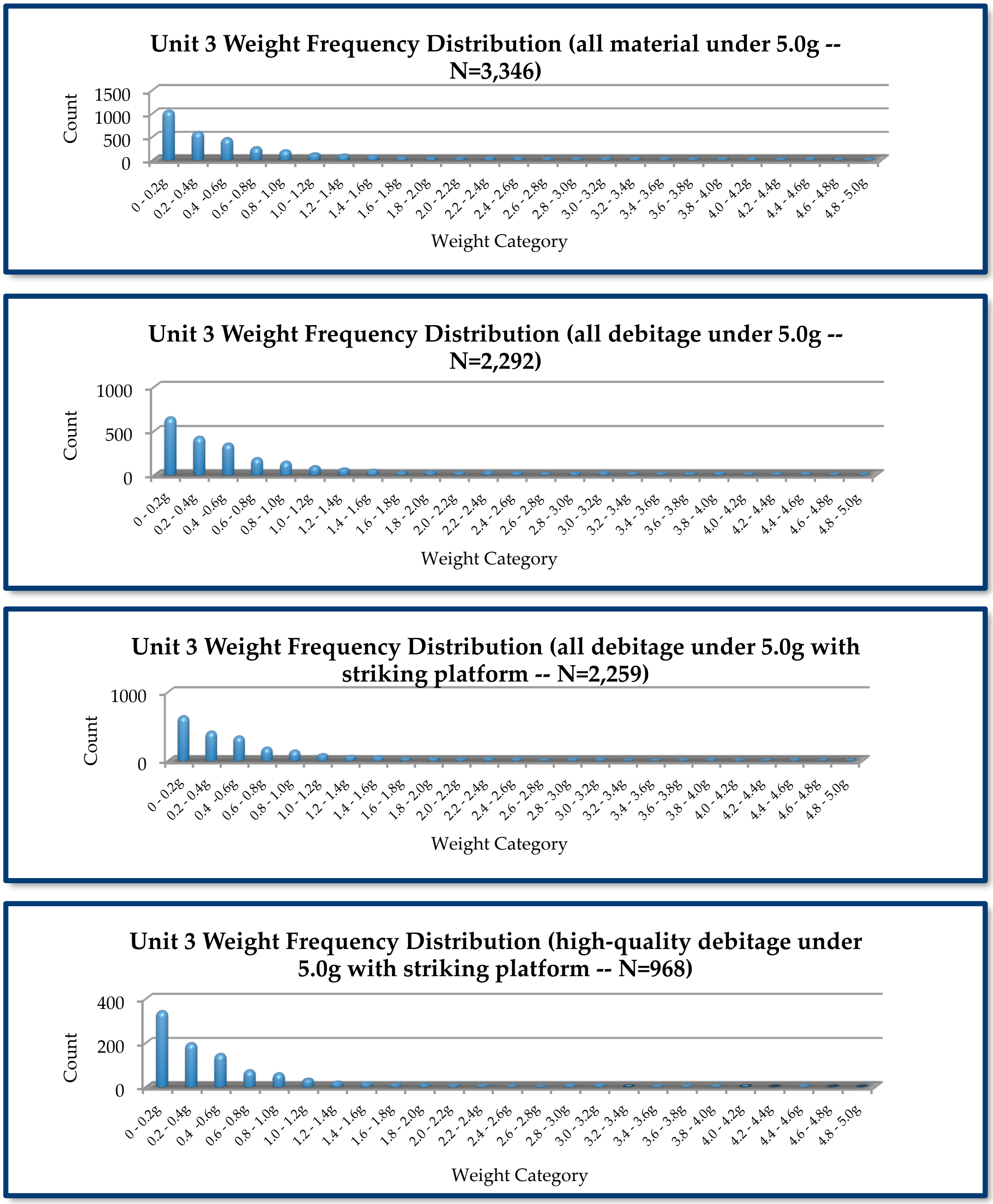
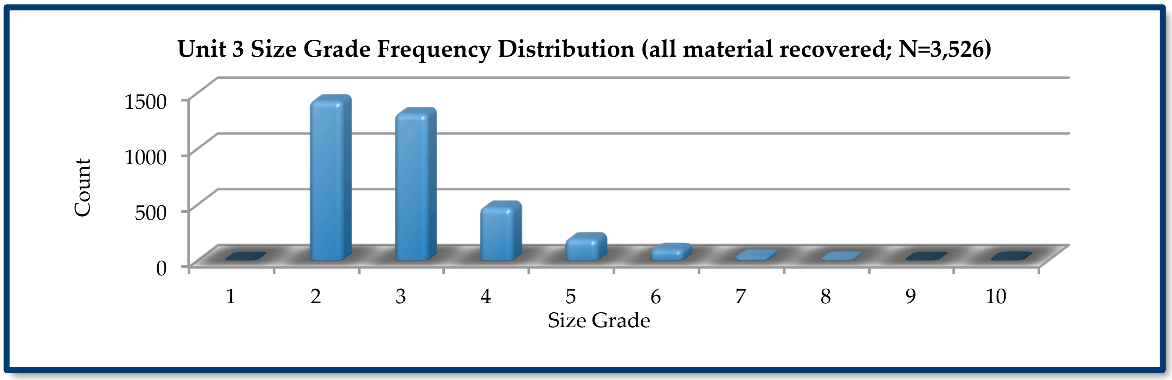
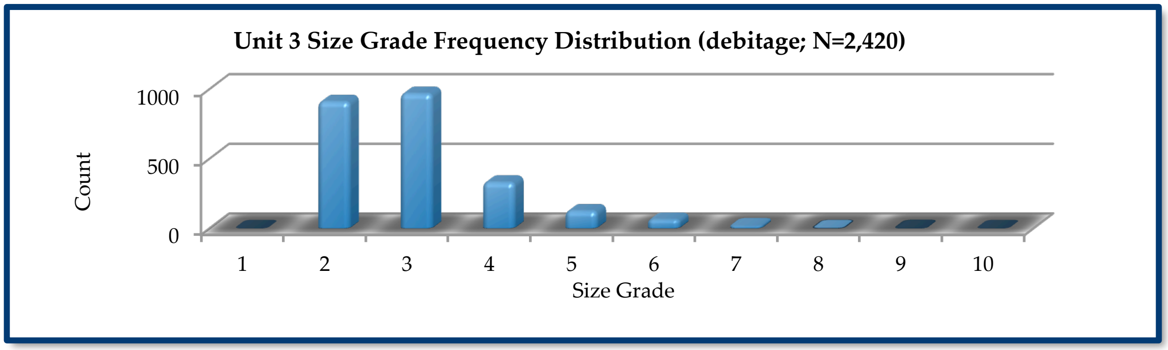
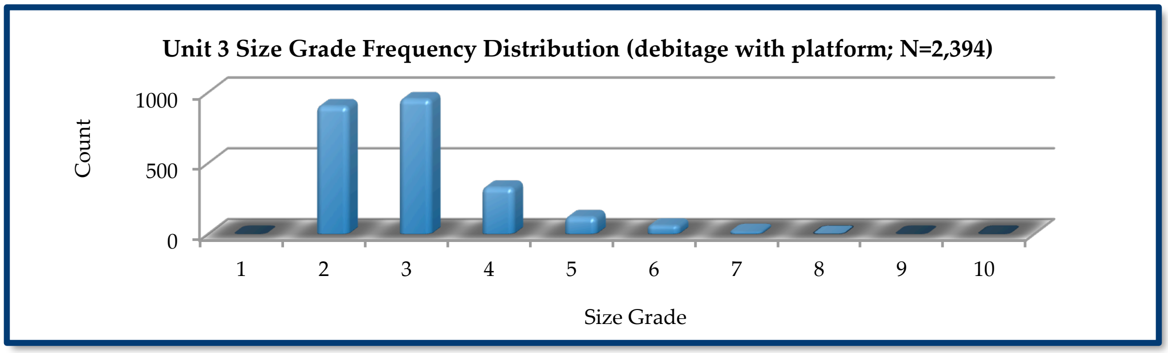


Figure 35: Unit 3 weight frequency distribution for all material recovered (top); for all debitage (i.e. debris omitted; upper-middle); for all debitage with discernable striking-platform (lower-middle); and for all high-quality debitage with discernable striking platform. Population restricted to items weighing 5.0g or less for purposes of clarity.


Unit 3 Size Grade Frequency Distribution (all material recovered; N=3,526)


Unit 3 Size Grade Frequency Distribution (debitage; N=2,420)


Unit 3 Size Grade Frequency Distribution (debitage with platform; N=2,394)

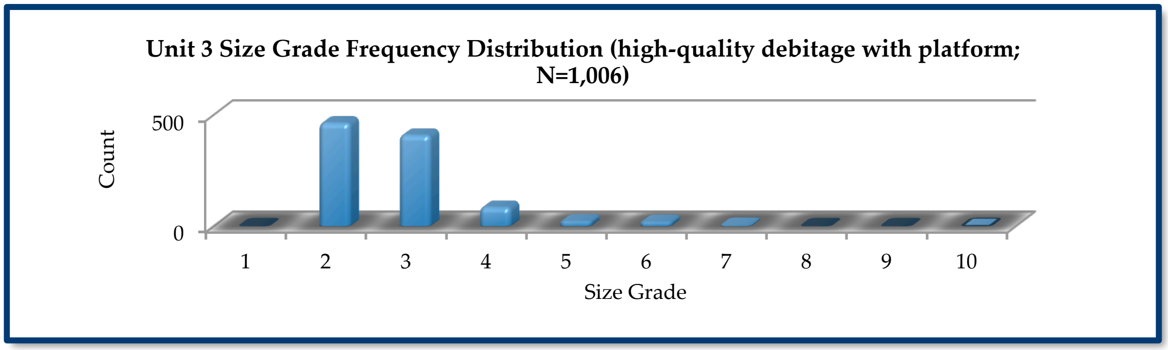

Unit 3 Size Grade Frequency Distribution (high-quality debitage with platform; N=1,006)

Figure 36: Unit 3 size grade frequencies for all material recovered (top); debitage (i.e. debris omitted - upper-middle); debitage with discernable striking platform (lower-middle); and high-quality debitage with discernable striking platform (bottom).

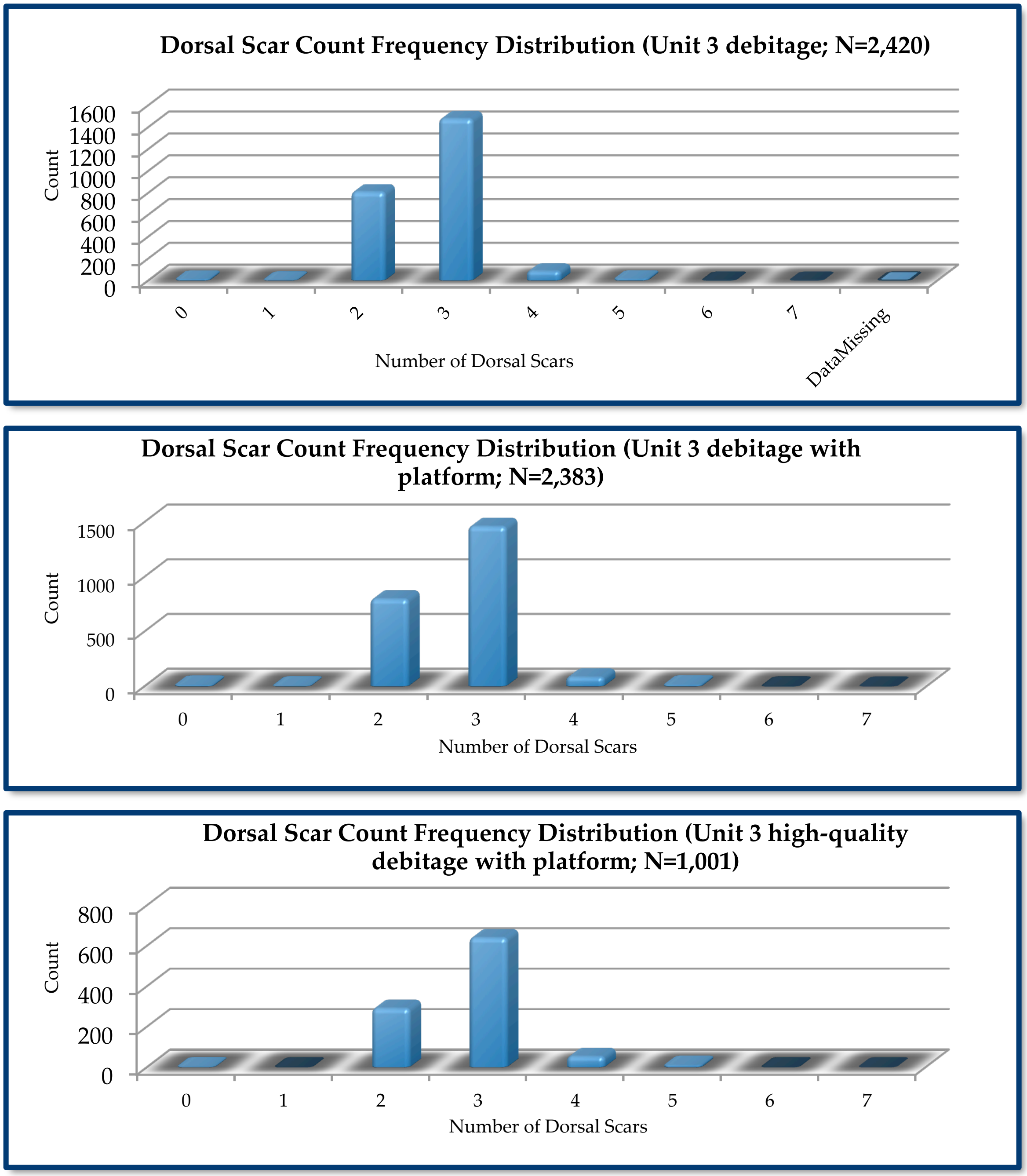


Figure 37: dorsal scar count frequency distributions for all Unit 3 debitage (top); Unit 3 debitage with platform (middle); and high-quality Unit 3 debitage with platform (bottom).

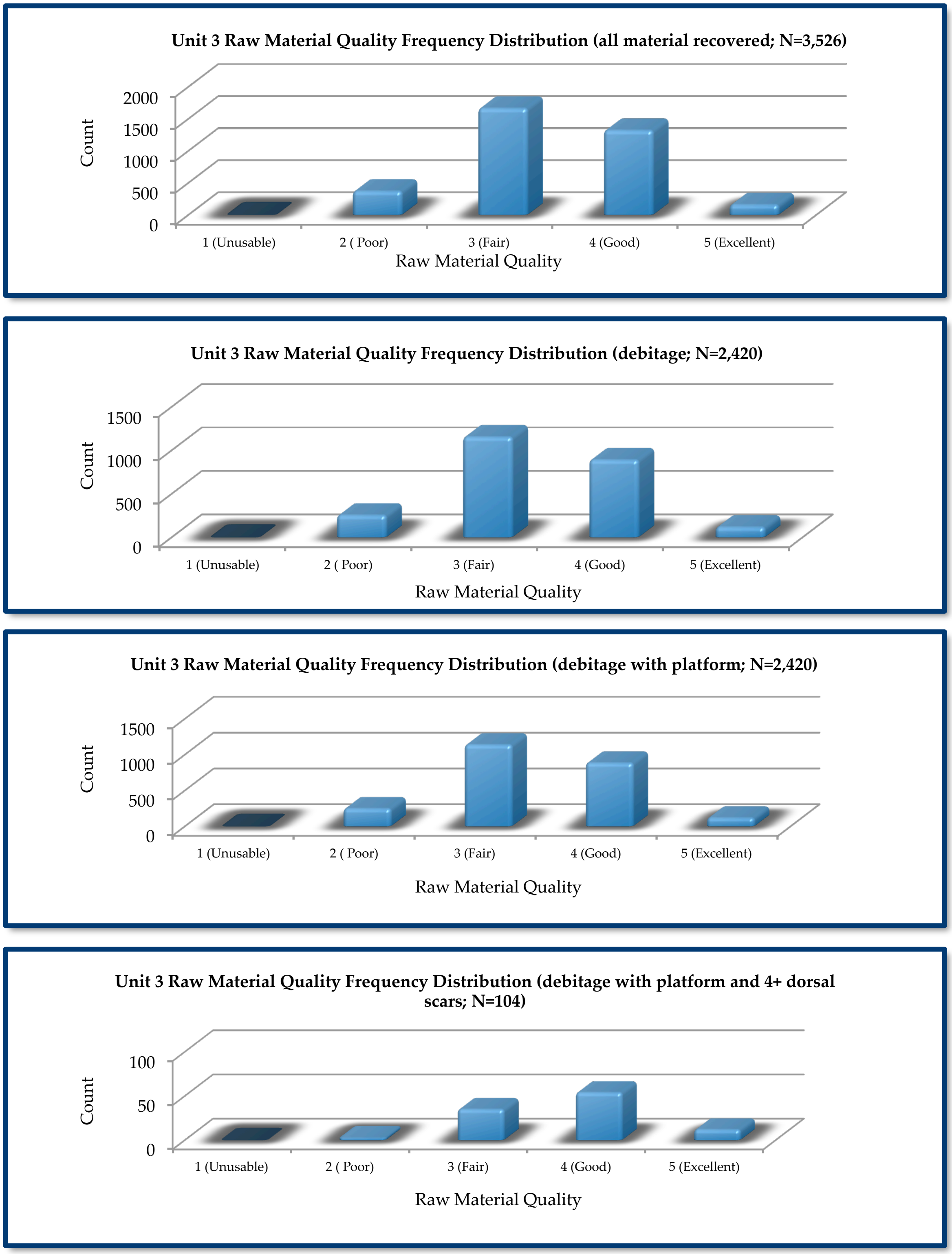


Figure 38: Unit 3 raw material quality frequency distributions for all material recovered (top); for debitage (upper-middle); for debitage with discernable striking platform (lower-middle); and for debitage with striking platform and 4 or more dorsal scars (bottom).

When the population is constrained to debitage with discernable striking platform and 4 or more dorsal scars, the mode becomes 4 dorsal scars (see Figure 38, bottom chart). In Unit 3, high-quality (rm_qual=4 or 5) raw material accounts for a much larger proportion of the debitage (42%), and when the population is constrained to debitage with striking platform and four (4) or more dorsal scars, the percentage of high-quality material increases to 63% (see Figure 39).

The Non-Debitage Artifacts

As noted previously (see page 80), one of the stated advantages of mass and attribute analyses is that they avoid the of typological determinations (see, for example, Andrefsky 2001: 6-9) by analyzing the entire assemblage using non-technical criteria (Larson 2004: 6).

That said, a description of the assemblage, detailing the numbers and types of tools recovered, provides one of multiple lines of evidence and is helpful in interpreting the patterns found in the mass and attribute data (after Anderson and Hodgetts 2007: 231, Bradbury and Carr 1995, Magne 2001: 23, Morrow 1997). It is also essential for assessing site function, reduction strategies, and the like (Andrefsky 2005: 214-221).

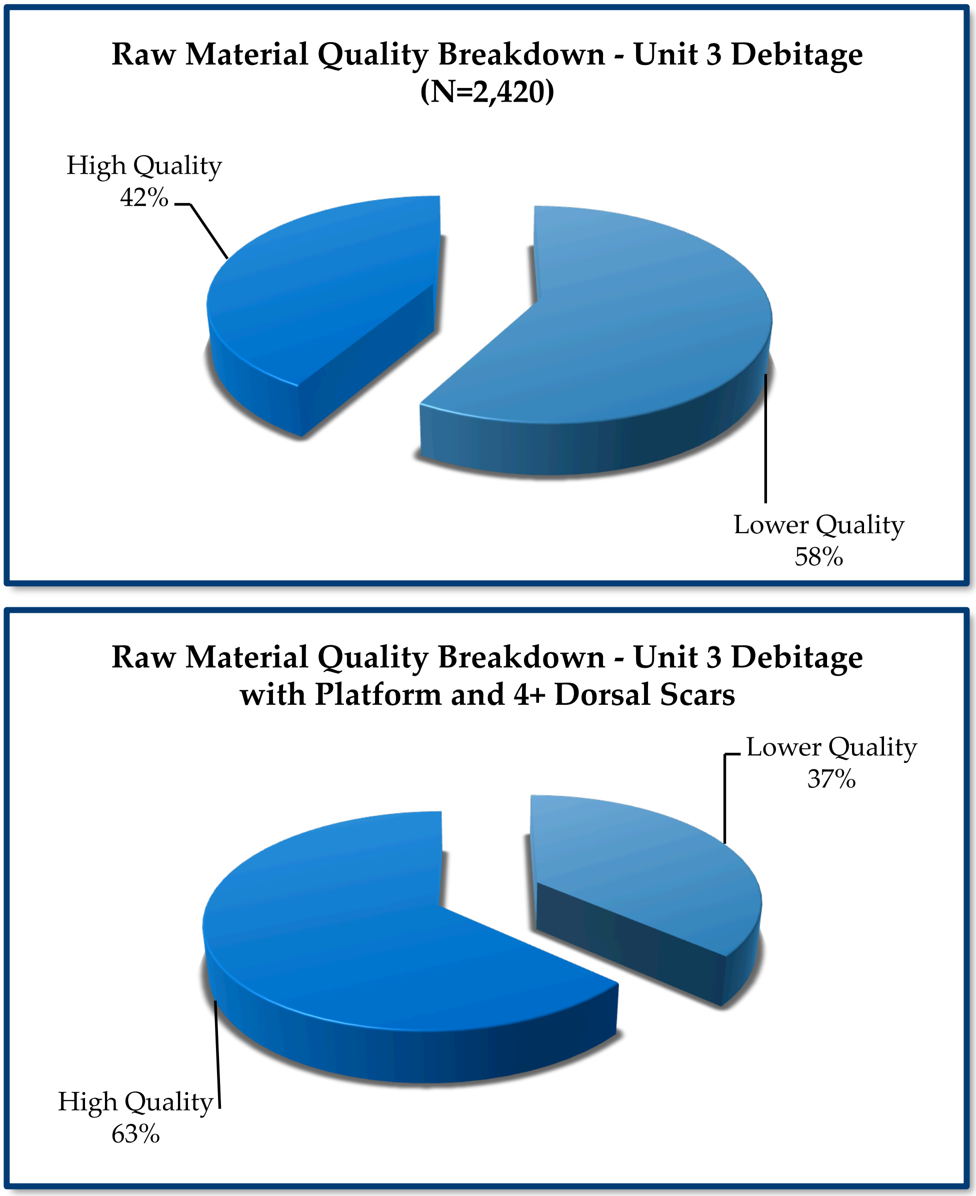


Figure 39: the proportion of high-to-lower quality raw material in all debitage from Unit 3 (above) and debitage from Unit 3 with a discernable striking platform and 4 or more dorsal scars (below).

This secton of the chapter provides a descriptive overview of the Grandfather Quarry non-debitage artifacts found in Units 11 and 3. Where appropriate, stylistic similarities with artifacts with known tool traditions are also noted, as these too have a bearing on the interpretation of the data.

Cores

A core is simply a nodule of toolstone from which flakes are deliberately and repeatedly removed (Whitehouse 1983: 123). It "serves primarily as a source for detached pieces" (Andrefsky 2005: 254) such as flakes or blades. Cores vary in size, shape and desired end-product. Many are prepared in advance, or deliberately shaped such that they produce a specific kind of flake every time. One such type is the unidirectional core, which has been shaped so that it has a flat surface called a striking platform at one end. Percussion is applied at points around the edge of this platform in order to strike off uniformly blade-like flakes. Such cores from the Canadian Arctic are known as *conical* or *microblade* cores; in Japan, they are called *Shirataki* and *Yubetsu* cores, and those from Mesoamerica are known as *polyhedral* cores (Andrefsky 2005: 14-16). *Bi-polar* cores are similar to unidirectional cores except that they have a striking platform at both ends – one at each 'pole' – from which long, blade-like flakes may be struck.

Flakes, if they are thick and substantial enough, may also be utilized as cores. This is especially true of quartz, which may produce reduction flakes thick enough that the term 'nugget' may be a more apt descriptor than 'flake'. These 'child cores' (after Driscoll 2011: 736) are often unidirectional like microblade cores, since they tend to have a ready-made striking platform at the proximal end. Their facets, however, may be more suitable for producing flakes other than microblades or blades unless further preparation and shaping is done. A total of 246 cores – mostly fragmentary or remnant – were recovered from the Grandfather Quarry (see Figure 40).

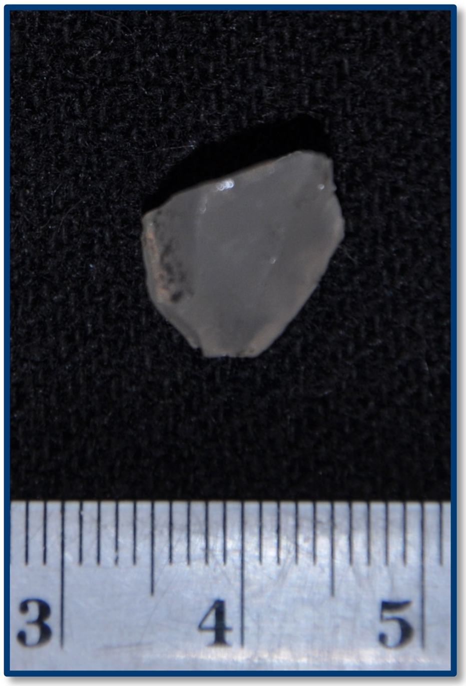


Figure 40: item #7144, a conical (microblade) core remnant from Unit 11.

Unit 11

Unit 11 yielded 222 cores or core fragments, of which at least 27 appear to be of the microblade or conical or variety. Nearly all of the remainder are unidirectional cores, and may be 'child cores' of the type mentioned above. Thirteen possible bi-polar cores (or fragments thereof) were also recovered.

Unit 3

Unit 3 yielded 24 cores or core fragments, 4 of which are identifiable as being 'conical' or 'microblade' cores. One (1) appeared to be a bi-polar core, with the remainder being generic but unidirectional. Again, most if not all of this last kind may be particularly chunky flakes used as 'child' cores.

Informal Tools

As noted earlier (see page 42), informal, or expedient tools require little or no effort to make. They are usually produced on an *ad hoc* basis for an immediate task, and are usually discarded immediately after use. They can be as simple as an unmodified flake or blade removed from a core.

For the purpose of this study, however, only flakes exhibiting retouch or use wear – in addition to being unidentifiable as specific type of formal tool – can reliably be classified as informal tools: blades are classified as blades, and unmodified flakes are categorized as debitage unless there is clear evidence of use wear on them.

Of the material recovered from Unit 11, 30 specimens are identified as informal tools (for example see Figure 41), a number amounting to nearly 15% of the all tools from this unit (N = 198 – see Figure 42, upper chart), but far less than 1% of all Unit 11 material recovered (N = 12,745). Unit 3 yielded 5 informal tools representing about 9% of the total tool count (N = 55 – see Figure 42, lower chart).

Figure 41: item #15690, an informal tool consisting of a retouched flake from Unit 11.

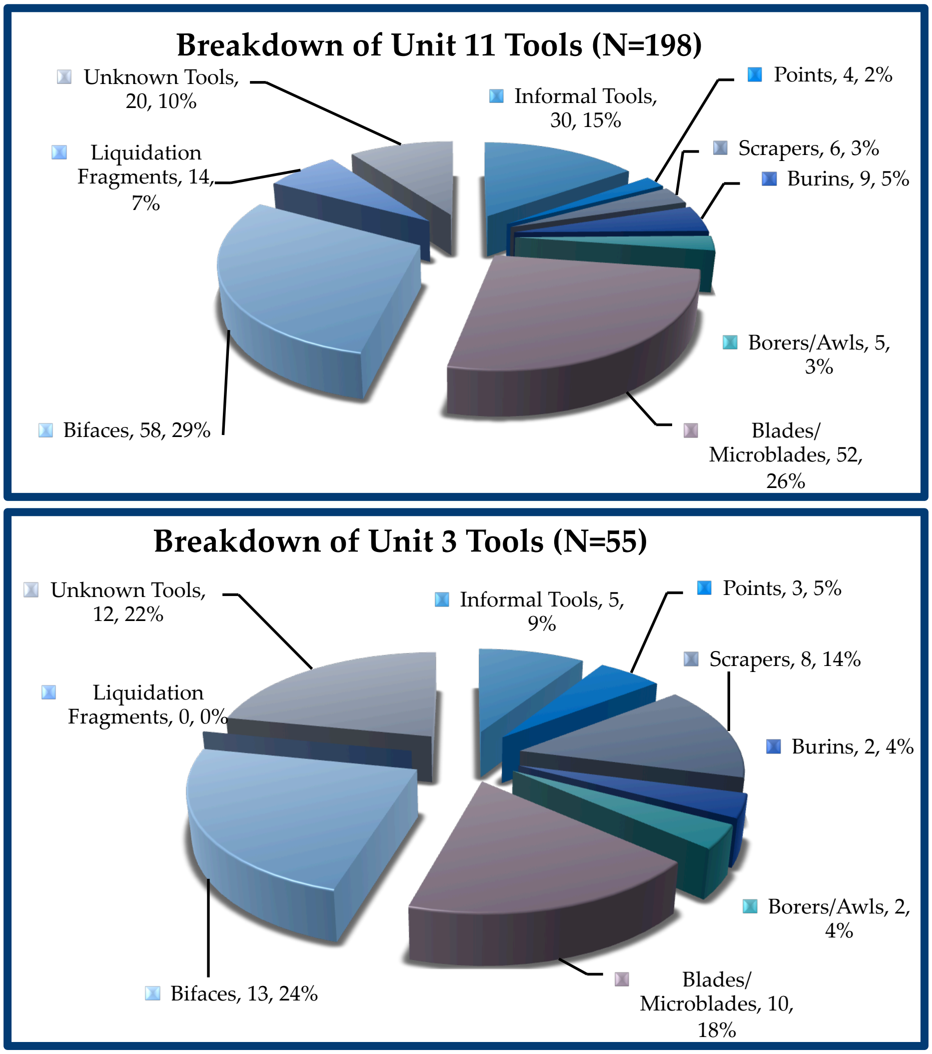


Figure 42: breakdowns of the tool assemblages for Unit 11 (above) and Unit 3 (below). Percentages are rounded to the nearest whole percent.

Formal Tools

Formal tools, as previously noted, require more effort to produce than informal tools in terms of raw material procurement, design and reduction sequence. They are more likely to be transported away from the site of manufacture because their use-lives continue as they wear or break and are re-shaped into new tools before eventual discard (Andrefsky 2005: 31).

Bifaces

A 'biface' is a…

> … tool that has two surfaces (faces) that meet to form a single edge that circumscribes the tool. Both faces usually contain flake scars that travel at least half-way across the face (Andrefsky 2005: 253).

A surprisingly high frequency of bifaces and biface fragments was found within the Grandfather Quarry assemblage. Unit 11 yielded 58 bifaces and fragments thereof (see Figure 42, upper chart); while another 13 were found in Unit 3 (see Figure 42, lower chart). Most are fairly small, and fall within size-grades 4 (0.5" < n ≤ 0.75") through 6 (1" < n ≤ 1.5").

Blades/Microblades

After bifaces, the single most numerous type of formal tool found at Grandfather Quarry is the blade and/or microblade (see Figure 43). A 'blade' is simply "a detached piece [or flake] with parallel or subparallel lateral margins. It is usually at least twice as long as it is wide" (Andrefsky 2005: 253, see also Whitehouse 1983: 65). A 'microblade' is, as one would expect, a very small blade, which are frequently associated with stone tool using populations along the northwest coast (e.g. Saskatchewan Heritage Online 2005: 93, Carlson 1996: 217), Alaska (e.g. Ricklis and Cox 1993, Giddings 1964, Cook 1968) and in the eastern Arctic and Greenland (e.g. Maxwell 1985, McGhee 1996, Milne and Park In Press).

Figure 43: item #8082, a microblade from Unit 11. Scale in millimetres and centimetres.

Unit 11 yielded 52 blades or microblades, with a further 10 coming from Unit 3. These blades and microblades, along with the presence documented above of blade/microblade cores, clearly indicate the presence, albeit unexpected, of a blade technology at Grandfather Quarry.

Borers/Awls

A number of tools recovered from Grandfather Quarry appear to be borers and/or awls (see Figure 44). These are long, and thin like blades or microblades, often coming to a distal point, but are not do not exhibit the characteristic trapezoidal cross-section of blades and microblades. Some are roughly circular in cross-section, while others are more triangular (see Figure 44, left). In the case of quartz specimens, a borer or awl may be of hexagonal cross-section because of the natural crystalline structure of quartz (see Figure 44, right-top and right-bottom).

Figure 44: a borer/awl of triangular cross-section from Unit 11 (left) and the proximal end of a borer/awl of roughly hexagonal cross-section (right top and right bottom). Scale in millimetres and centimetres.

Seven borer/awl tools (or fragments thereof) were recovered from the Grandfather Quarry, five (5) from Unit 11 and a further two (2) from Unit 3.

Burins

A *burin* is a blade-like tool with a sharp, chisel-like edge (Andrefsky 2005: 254, Whitehouse 1983: 77). Eleven formal tools from Grandfather Quarry – nine (9) from Unit 11 and two (2) from Unit 3 – strongly resemble burins, in particular TP3L1-9 (a.k.a. item #30434 – see Figure 45, upper photograph, upper-left artifact).

Scrapers

Scrapers are among the most common lithic artifacts. 'Scraper' is often a general term referring simply to a flake that has retouch on one or more edges (Whitehouse 1983: 454). Andrefsky goes further and specifies that the retouched edge usually has an angle of between 60 and 90 degrees (2005: 261). This is particularly important for scrapers used for cleaning hides, as a scraper with a sharper edge than this is likely to damage the hide.

Figure 45: Burins and a possible burin spall from the Grandfather Quarry (above), compared to Pre-Dorset examples (below). Lower images from Gordon (1996: 187 (l) and 179 (r)) and Copyright © 1996 by the Canadian Museum of Civilization. Used by permission.

Side-scrapers have this retouch along a lateral edge, and end-scrapers, naturally, have it on one of the ends (see Figure 46). Remembering the dynamic nature of a stone tool during its use life, it should be noted that, for example, a broken projectile point that still has a perfectly serviceable hafted end, may be retouched and repurposed as an end scraper.

Unknown Tools and Liquidation Fragments

Some artifacts, despite every effort to identify them, were clearly formal tools (as evidenced by retouch, shaping scars and/or use-wear), nonetheless remained ‘unknown’. Some of these may have been deliberately broken to liquidate perfectly serviceable raw material from worn out or broken tools.

Figure 46: an end-scraper from Unit 11 (left) and a side-scraper from Unit 3 (right).

Thirty-two (32) unknown tools or tool fragments (20 from Unit 11 and 12 from Unit 3), and fourteen (14) liquidation fragments, all from Unit 11, were recovered from Grandfather Quarry.

Summary

In this chapter, I presented the data generated by mass and attribute debitage analyses for the material recovered from Units 11 and 3. A number of similarities and differences between the units examined become apparent when we examine the patterns found in the data.

Frequency distributions of weight, size-grade and dorsal scar count show the same patterns in Unit 3 as in Unit 11; but there is a marked contrast between the units in terms of raw material quality and the proportion of debitage to debris. Unit 3 has a much higher percentage of total debitage accounted for by higher-quality raw material, and has a higher ratio of debitage to debris. In other words, Unit 3 has more debitage on a pro-rated basis than does Unit 11, and much more of that debitage is of a high quality raw material. In the case of dorsal scar count, although frequencies in both units cluster around 2 and 3 dorsal scars, the mode is higher in Unit 3 (mode=3) than in Unit 11 (mode=2).

Of the Grandfather Quarry units examined, the tool portion of the assemblage is clearly dominated by formal tools, which collectively account for 86% of the tools recovered; informal, or expedient tools account for just 14% (see Figure 47). There is evidence for tool liquidation and the manufacture of large numbers of bifaces, which form the single most common formal tool type collected from the study units. In the next chapter I offer interpretations of these data and test the research hypotheses identified in Chapter 5.

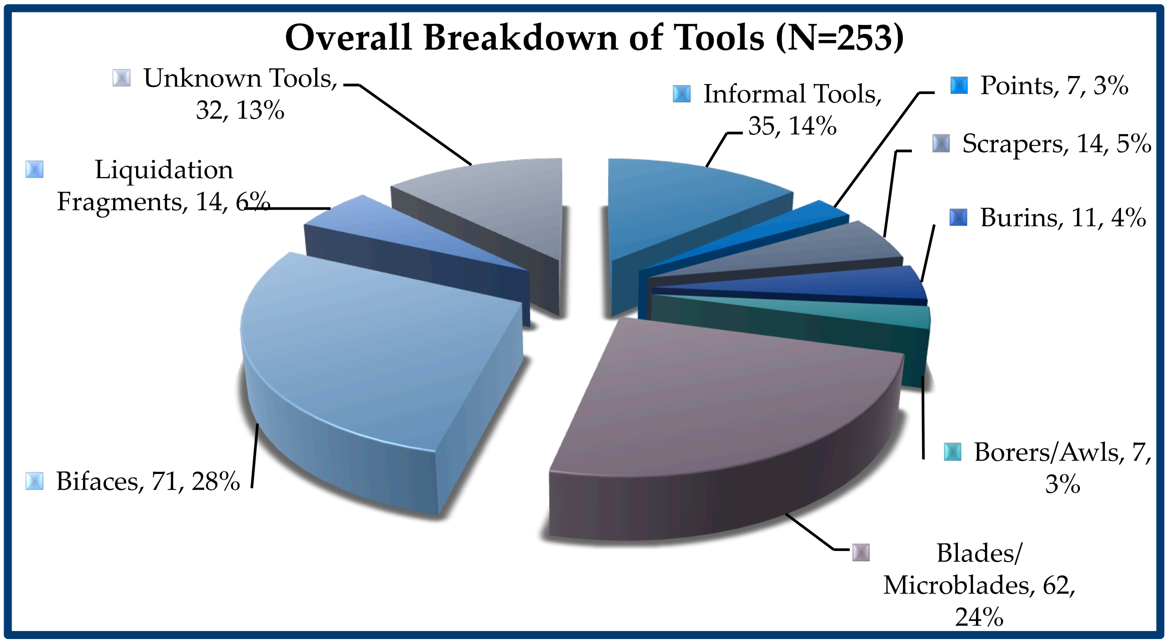


Figure 47: an overall breakdown of the tool assemblage from Units 11 and 3. Percentages are rounded to the nearest whole percent.

Chapter 7:
Data Analysis and Interpretation

What does it all mean?

Chapter 6 presented the data generated by mass and attribute analyses of the material from Units 11 and 3 of the Grandfather Quarry. This chapter presents my interpretations of those data and the patterns of variability isolated among them. This information is then used to evaluate the hypotheses presented in Chapter 5 so as to understand how the Grandfather Quarry was being used by local stone-tool using populations over time.

Debitage and Debris

The most immediately striking aspect of the debitage assemblage is its sheer enormity and the extremely high proportion of debitage flakes to other artifact types. More than half of the assemblage is debitage, resulting in a 1.2:1 ratio of debitage to debris and a 67.7:1 ratio of flakes to tools. These figures strongly indicate the intensive procurement and reduction of quartz over the Grandfather Quarry's use-life. This was no casual, occasional exploitation of an outcrop found by chance: the quarry's users were exploiting the site quite literally ‘for all it was worth’, indicating a high degree of raw material stress on the group’s part.

Weight Frequency Distribution

The debitage weight frequency distribution curve is heavily skewed toward the lighter end of the range, with the mode being the smallest weight category. This holds true for both units of the study sample even when the population is confined to debitage with a discernable striking platform, and to high-quality debitage with discernable platform (see Figure 48).

The predominance of lighter debitage flakes over heavier ones is highly suggestive of intensive mid-stage reduction carried out *in situ,* rather than at another location, which is to be expected in a residentially mobile hunting and gathering population with a curated lithic technology strategy.

Size Grade Frequency Distribution

Overall

The mode of the debitage size grade frequency distribution is 3 (0.25” < *n* < 0.50”). This, together with the marked bias toward the lower end of the size grade frequency distribution range, is indicative of a later stage of reduction than would be expected if toolstone were plentiful (see Figure 49).

Unit 11

Once again, the mode of the debitage size grade frequency is 3 (0.25″ < *n* < 0.50″), and the distribution is skewed toward the lower end of the range. Unit 11's size-grade frequency distribution mirrors that of the overall study sample, which is not surprising given that nearly 89% (N = 27903) of the material recovered from the quarry comes from this locus.

Unit 3

It is noteworthy that Unit 3 departs from the size-grade pattern exhibited by the overall sample and by Unit 11. Unit 3's size grade frequency distribution shows the same bias toward the smaller end of the scale, but in this case the mode is Size Grade 2, the smallest effective size grade, when filtered for high-quality debitage with discernable striking platform. This suggests that the higher quality raw material in this locus was being reduced further than it was in Unit 11.

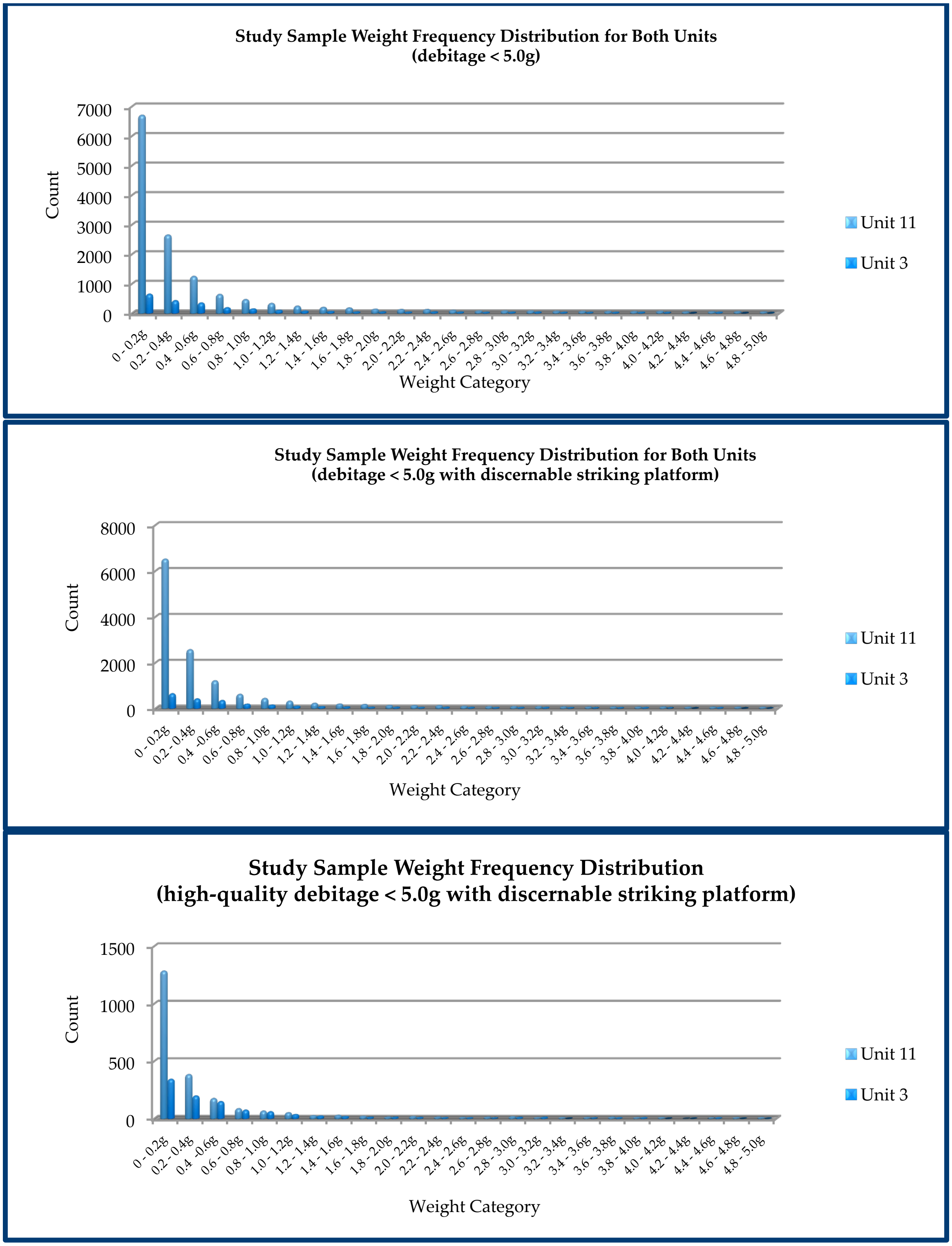
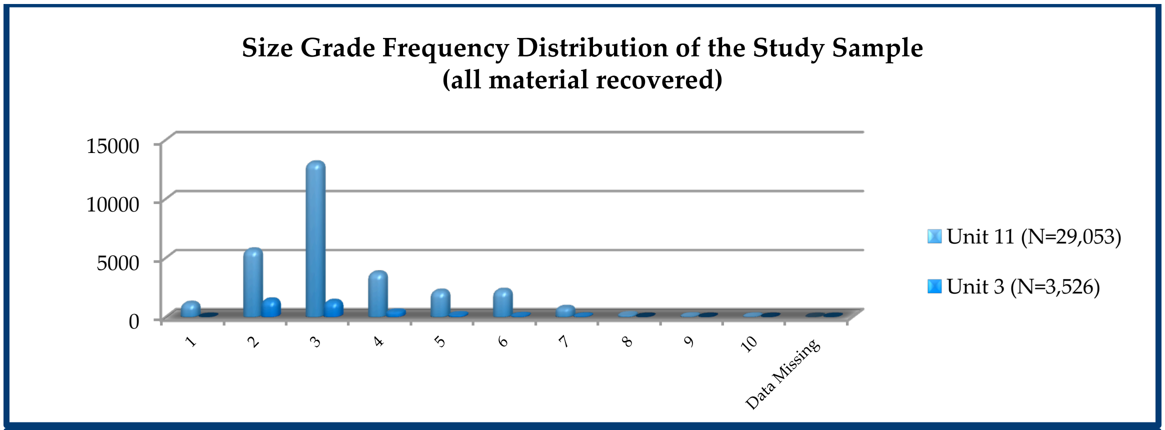
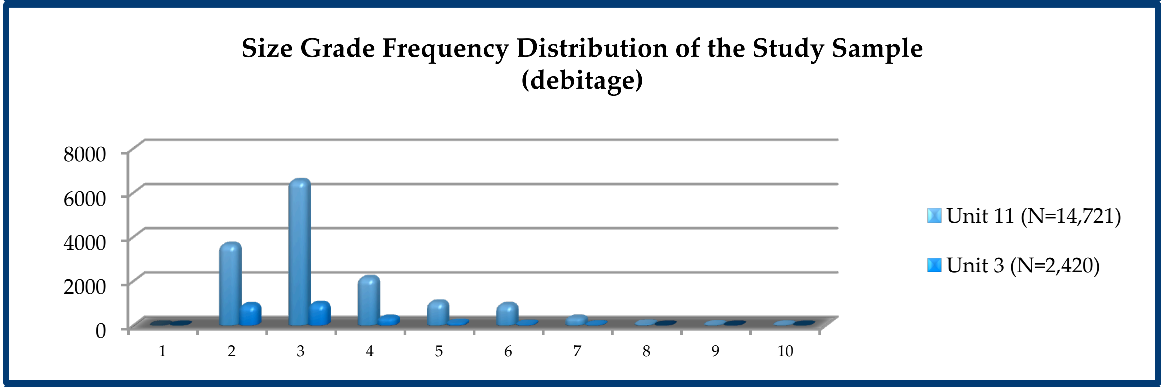
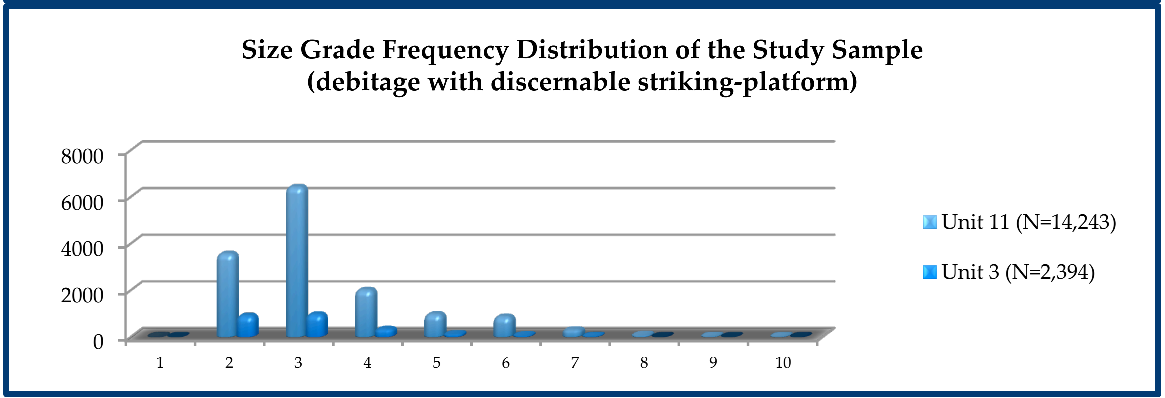


Figure 48: weight frequency distributions for both units of the study sample.


Size Grade Frequency Distribution of the Study Sample (all material recovered)


Size Grade Frequency Distribution of the Study Sample (debitage)


Size Grade Frequency Distribution of the Study Sample (debitage with discernable striking-platform)

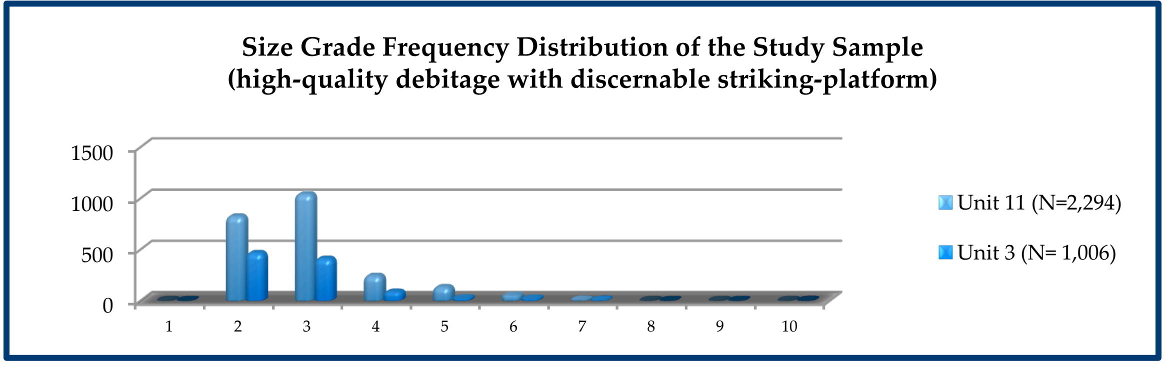

Size Grade Frequency Distribution of the Study Sample (high-quality debitage with discernable striking-platform)

Figure 49: size grade frequency distributions for both units of the study sample.

Dorsal Scar Count Frequency Distribution

Overall

There is an overall predominance of flakes with two and three dorsal scars, with the mode being two (2), regardless of the presence or absence of a striking platform. However, when the population is confined to high-quality debitage flakes (rm_qual = 4 or 5) with platforms, the mode becomes three (3). See Figure 20. This would suggest that higher quality raw material was further refined than lower-quality raw material prior to removal from the quarry.

Unit 11

As with weight and size-grade, the dorsal scar count frequency distribution of Unit 11 debitage mirrors that of the overall study sample. Again, this is not surprising given the proportion of material recovered that comes from Unit 11.

Unit 3

Again, the pattern displayed by Unit 3 differs from that of Unit 11 and of the overall study sample. Here, the mode for dorsal scar count is 3, regardless of whether or not a platform is present and regardless of quality (see Figure 50). This suggests that Unit 3 was a locus where raw material was further reduced than it was in Unit 11, which in turn may indicate that Unit 3 may have been a special activity area dedicated to reduction and shaping.

Raw Material Quality

Overall

Interestingly, the proportion of debitage to debris suggests intensive procurement and reduction, *despite* the generally poor quality (mode = 2, "poor") of the quartz. Despite the fact that taken together, higher quality (4, "good" and 5, "excellent") raw material comprises just 13% of the material recovered (see Figure 22 on page 138), the users of this quarry nonetheless exploited this resource heavily. It may be that the bulk of the material was simply being 'tested' in order to locate that smaller quantity of better quality material (see Hypothesis 1, Expectations 6 and 7 on page 107). This may account for the relatively high proportion of debris in the assemblage.

As noted on page 133, the fact that debitage with discernable platform, and of debitage with platform and four (4) or more dorsal scars tends toward the higher end of the quality range suggests that although the quartz from this site was heavily exploited regardless of quality, the higher-quality quartz was being further reduced *in situ*.

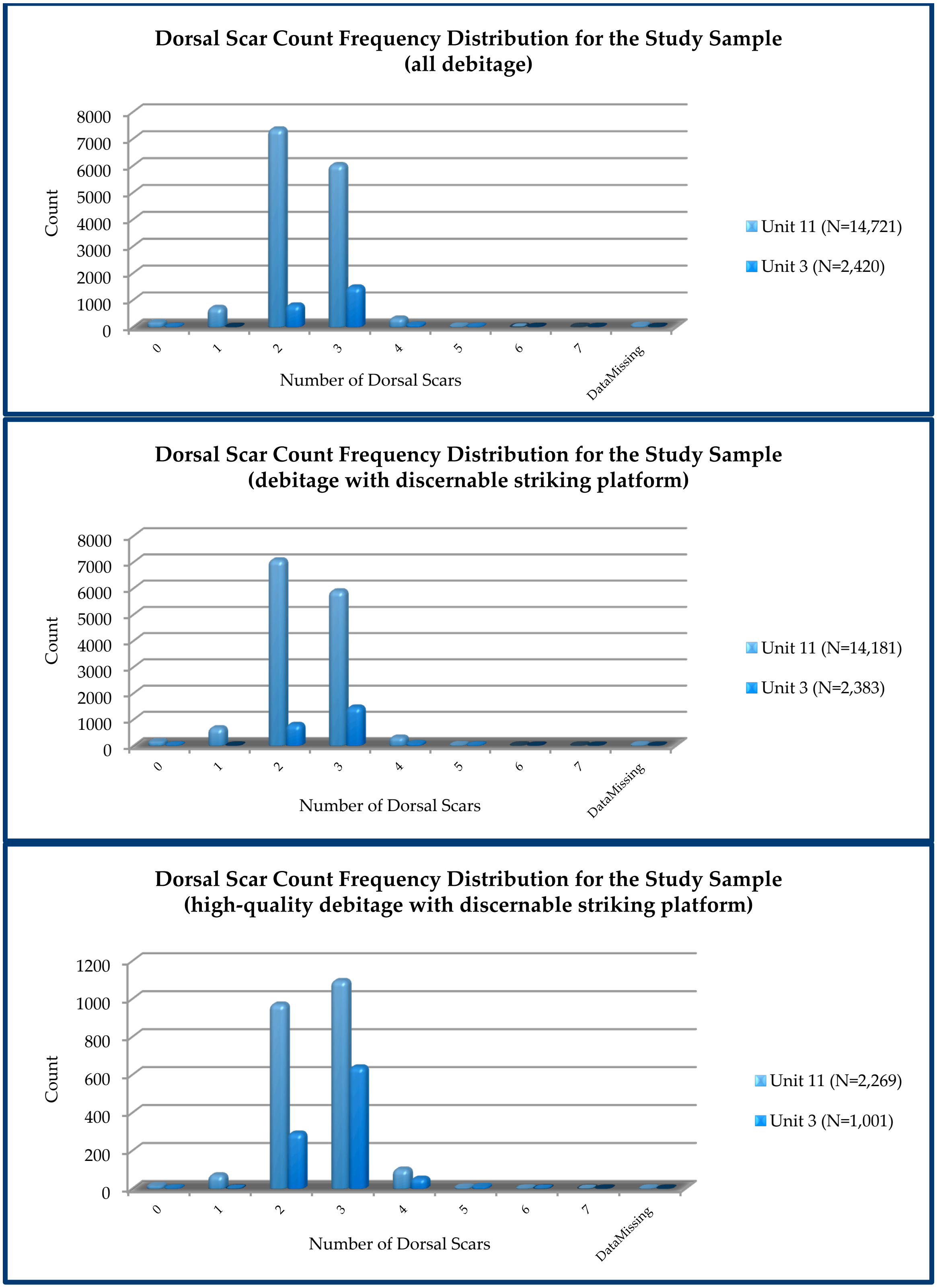


Figure 50: dorsal scar count frequency distributions for the study sample.

Unit 11

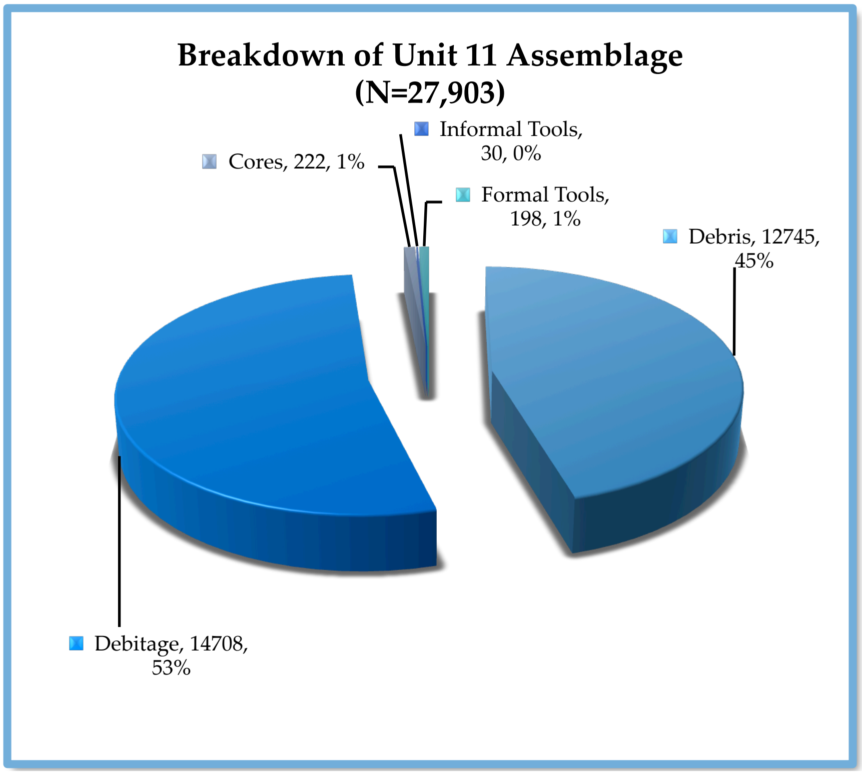
As with previous variables, the raw material quality distribution in Unit 11 is virtually identical to that of the overall sample. As noted on in Chapter 6 (see Figure 32 on page 150) higher-quality quartz (rm_qual ≥ 4) accounts for 16% of the debitage from this locus; but when the sample is constrained to more intensively reduced flakes (i.e. dorsal scar count ≥ 4), 32% are of higher quality. This supports the proposition that higher quality stone was reduced further on-site than was the inferior stone, and suggests that better quality quartz was being sought to make tools – likely bifaces – for transport elsewhere.

Unit 3

Unit 3 displays a different quality pattern from both Unit 11 and the study sample as a whole. Debitage here accounts for fully 69% of the assemblage, as opposed to just 53% in Unit 11 (see Figure 51). The debitage-to-debris ratio of 2.4:1 indicates that raw material in Unit 3 was much more intensively reduced than in Unit 11. There is a bias toward the higher end of the quality range, and a higher quality mode (3, “fair”). More highly reduced debitage has a quality mode of 4 (“good” – see Figure 52). Higher quality raw material in Unit 3 accounts for a greater proportion of the overall toolstone at this locus – 42% – and when the sample is constrained to flakes with 4 or more dorsal scars, this figure increases to 63% – nearly two-thirds (see Figure 39 on page 158). This not only supports the claim that higher-quality toolstone was reduced further than was inferior stone, but also suggests that higher quality toolstone played a more central role in activities at this locus. In other words, it appears that higher quality toolstone was removed from the quarry and taken to Unit 3 for further reduction, perhaps with greater care and precision.

Debitage and Debris – Summary

The sheer volume of debitage, the proportion of debitage-to-debris, and the fact that the entire range of usable raw material (rm_qual ≥ 2) was exploited despite the poor overall quality of the toolstone from this quarry clearly indicates that all usable toolstone, regardless of quality, was intensively exploited.



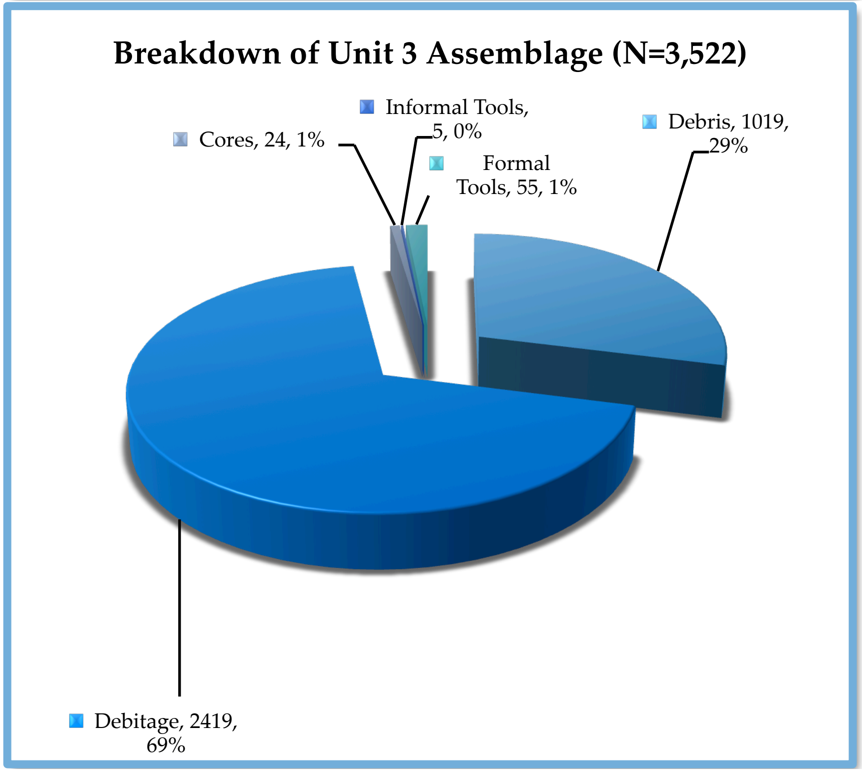


Figure 51: pie-chart breakdowns of the Unit 11 (above) and Unit 3 (below) assemblages. Note the markedly higher proportion of debitage to debris in Unit 3 than in Unit 11.

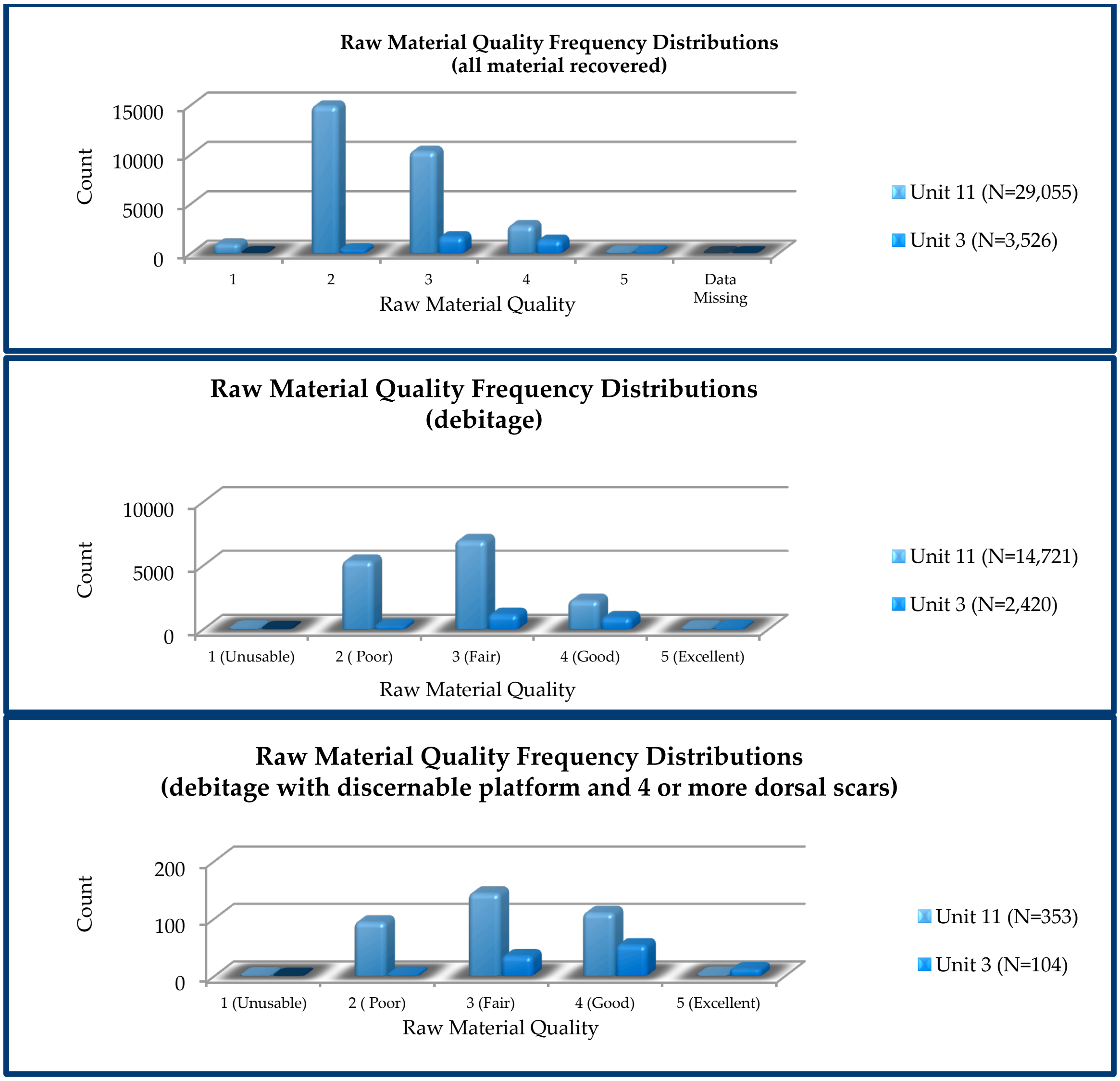


Figure 52: raw material quality frequency distributions for the study sample.

The proposition that higher-quality quartz was being reduced further *in situ* than lower-quality quartz is supported by a weak negative correlation between flake size and raw material quality in both Unit 11 ($\rho_s = -0.21$; $\gamma = -$

0.28) and Unit 3 ($\rho_s = -0.22$; $\gamma = -0.29$). The weakness of the correlation may be because lower quality quartz comprises by far the majority of the material recovered, diluting the signal of the higher-quality quartz. Furthermore, the mode for raw material quality varies not only with level of reduction, but also with space: it is higher for further-reduced debitage and also higher in Unit 3 than in Unit 11 (see Figure 52). Thus, all usable material was probably reduced at least sufficiently for transportation, but higher quality toolstone seems to have been removed to Unit 3 outside the quarry pit, and reserved for further reduction and finishing on-site so that maximum efficiency could be attained in transporting this heavy and cumbersome, but nonetheless crucial, resource (Beck, et al. 2002).

The Non-Debitage Artifacts

Although the focus of this research is the debitage, 2% of the assemblage falls into neither the debitage nor debris categories. This tiny portion of the assemblage is divided approximately equally between cores and tools (including bifaces), and can provide useful supplementary information to that provided by the debitage data.

Cores

The presence of cores and core remnants is indicative of the preparation of raw material for a long journey, as cores are an efficient way to transport toolstone that allows for an easy supply of flakes for the creation of flake tools in the field. Their raw material quality distribution is skewed toward the higher end of the spectrum, indicating a preference for higher-quality raw material for the manufacture of cores (see Figure 53). Of the 248 cores and core-remnants recovered, 17 were identified as blade or conical cores for the preparation of blades and microblades. Among this last type of core, raw material quality distribution was skewed even more pronouncedly to the higher end of the range (see Figure 53), indicating not only the presence of microblade technology, but also a preference for the very highest quality quartz for the manufacture of blades and microblades.

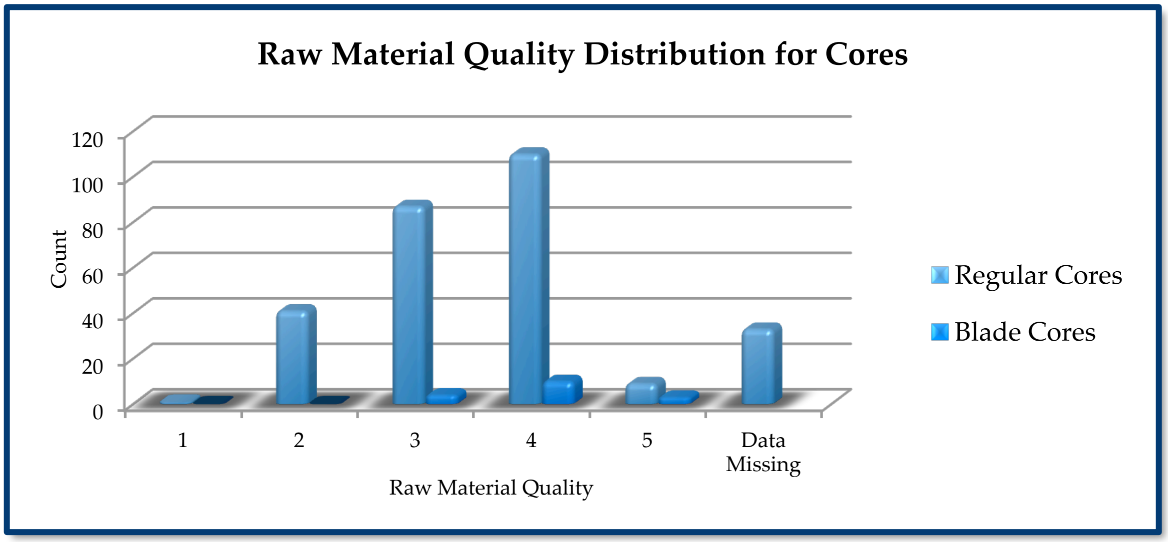


Figure 53: Frequency distribution of raw material quality for cores and blade-cores.

Informal Tools

Because informal or expedient tools are relatively wasteful of raw material, they tend to be found only where raw material is plentiful and easily accessed. Although as has been noted, mobile hunters and gatherers tend to utilize a curated lithic strategy dominated by formal tools, Andrefsky (1994) has argued that it is a combination of factors, including not only residential strategy but also raw material availability and quality, that influence the organization of lithic technology (see also Figure 54). While a group is present at a raw material source, toolstone is, at least for the moment, plentiful. Raw material quality and availability stress may therefore be relaxed, at least in the manufacture of tools for immediate, on-site requirements.

Thirty-five (35) informal tools were identified, and their raw material quality distribution exhibits a strong bias to the high end of the range, with the mode being 4 ("good"). This may mean that the users of the quarry felt that, while toolstone was temporarily plentiful, higher quality stone could be used to meet their immediate, expedient tool requirements.

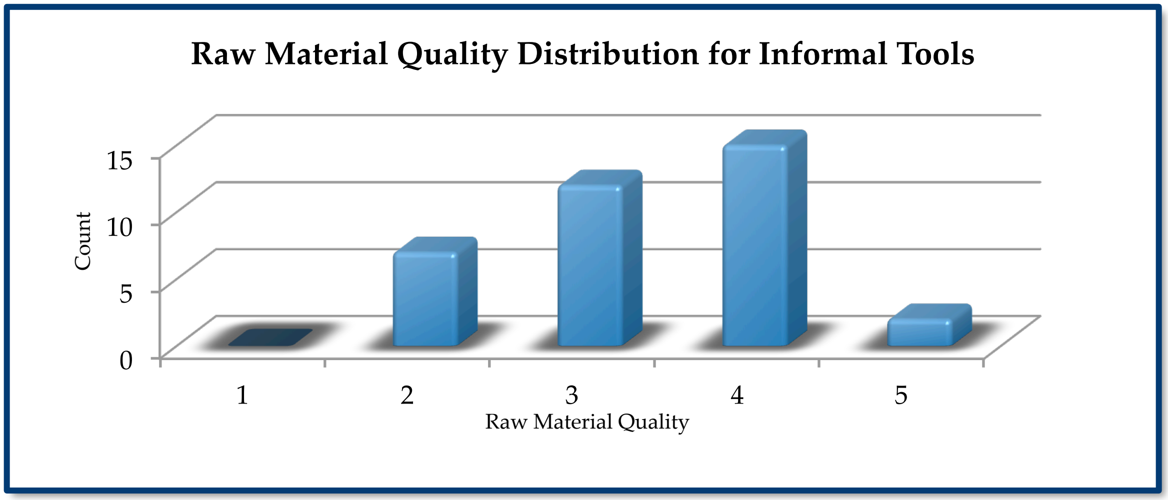


Figure 54: Frequency distribution of raw material quality for informal tools.

Formal Tools

The dominance of formal tools in the non-debitage assemblage is expected given the residentially mobile strategy employed by the inhabitants of the Churchill River Basin. Further, according to Andrefsky's model (1994), the predominance of formal tools is usually seen when high-quality toolstone is available, but in low abundance (see Figure 8 on page 47). This is indeed the case at the Grandfather Quarry, where most of the toolstone is of lower quality, but where there are also some veins of higher quality quartz. The raw material quality distribution for tools is slightly skewed toward the higher end of the scale, but not as strongly as the debitage quality distribution is (see Figure 55). This is to be expected, however, when we consider that only fragments of failed and broken tools are likely to have been left behind when the group moved on; but the debitage from manufacturing tools of high-quality raw material would remain in any case.

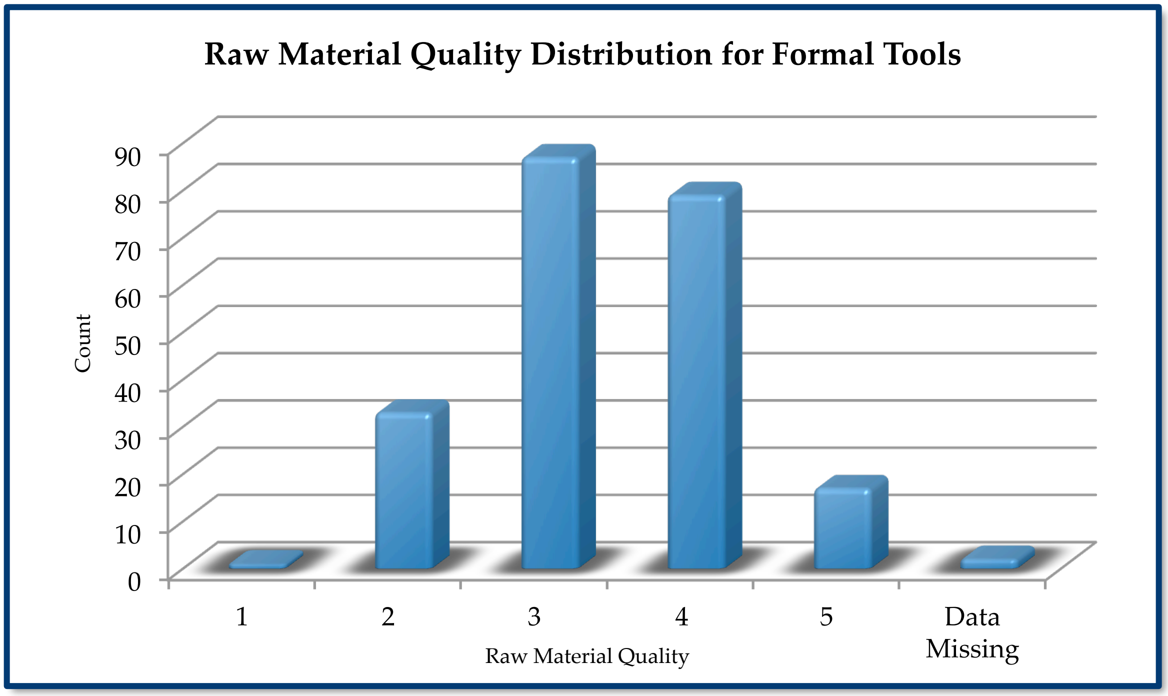


Figure 55: Frequency distribution of raw material quality for formal tools.

Bifaces

Of particular interest among the formal tools are bifaces, which form the single-most ubiquitous tool type at Grandfather Quarry. Andrefsky (2005: 192-193) has argued that because of their flexibility and transportability, bifaces are the ideal form for residentially mobile hunters and gatherers, who require a toolkit that can be adapted at short notice to a wide variety of tasks and requirements at great distances from any source of toolstone.

Most of these are small, falling into size grades 4 (0.5″ < n < 0.75″), 5 (0.75″ < n < 1.0″) and 6 (1.0″ < n < 1.5″), which is more characteristic of the

Arctic Small Tool tradition than of the Shield Archaic, although some appear to be fragments of larger specimens and may be attributable to the latter tradition (see Figure 56). Thus the cultural affiliation of the bifaces is ambiguous at best.

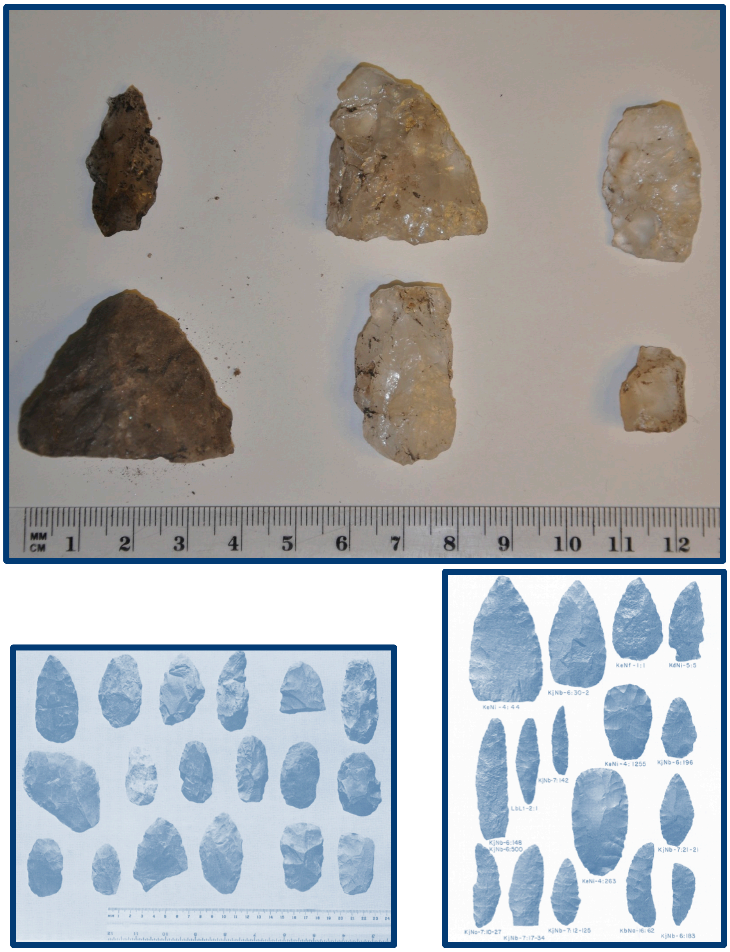


Figure 56: bifaces from the Grandfather Quarry (top) compared with bifaces from the Shield Archaic (Hlady 1970a: 99; bottom left) and the Pre-Dorset (Gordon 1996: 157; bottom right). Bottom left image Copyright © 1770 by the Manitoba Archaeological Society and used by permission; bottom left image Copyright © 1996 by the Canadian Museum of Civilization and used by permission.

The ubiquity of bifaces and biface fragments, together with the sheer volume of small debitage – a signal associated with their manufacture (Stahle and Dunn 1982) – is highly suggestive of the intensive manufacture of bifaces at the quarry. The raw material quality distribution for bifaces is skewed toward the higher end of the quality spectrum, but not as heavily as the smaller debitage is (see Figure 57). As with formal tools overall, this is easily explained when we consider that successfully manufactured, high-quality bifaces would certainly be taken with the group when it moved on; only failed and broken bifaces would be left behind, as is the observed case at the Grandfather Quarry. The resulting high-quality micro-debitage, however, would be left where it fell, or swept into the quarry pit when the group left, leaving behind a higher quality signal in the archaeological record.

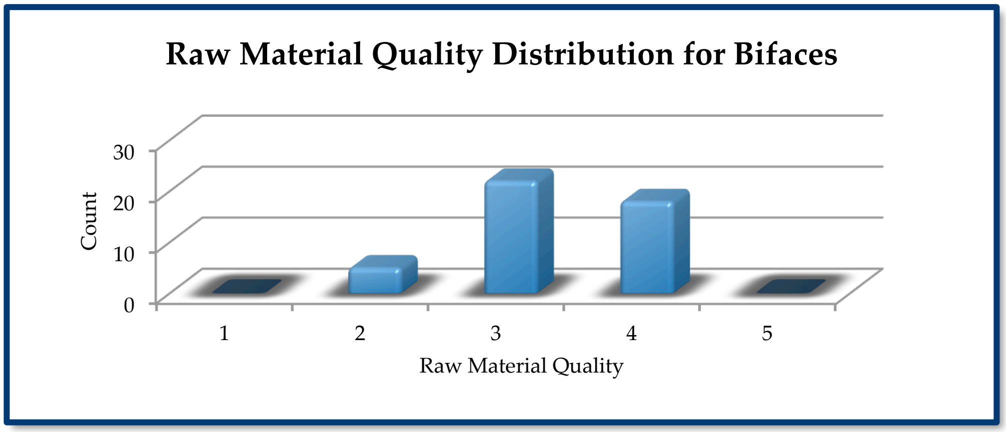


Figure 57: Frequency distribution of raw material quality for bifaces.

Microblade Technology

An unexpected surprise was the presence of microblade technology at the Grandfather Quarry, where blades and microblades comprise the most ubiquitous tool type after bifaces. Microblade technology is not found in single-component Shield Archaic sites, but it is characteristic of the Arctic Small Tool tradition (Maxwell 1985, McGhee 1996, Milne and Park In Press), for which there is precedent in the Churchill River Basin and nearby areas of northern Manitoba (Dickson 1980, Kroker 1990, Nash 1969, 1970).

Blade cores (see above) are not as ubiquitous as blades and blade fragments, presumably because this was a raw material procurement site – blade cores successfully prepared would be taken away to supply future requirements, and not left behind at the quarry unless failed or broken (on the one hand) or exhausted and discarded in favour of making new ones to replace them (on the other).

As with formal tools overall, and with bifaces, the quality distribution of blades and microblades is skewed toward the higher end of the scale, but not as dramatically as the small debitage (see Figure 58). Once again this is likely because the best finished specimens would have been taken when the group moved on, either as finished microblades, or, more likely, in the form of blade cores, but with the debitage left behind.

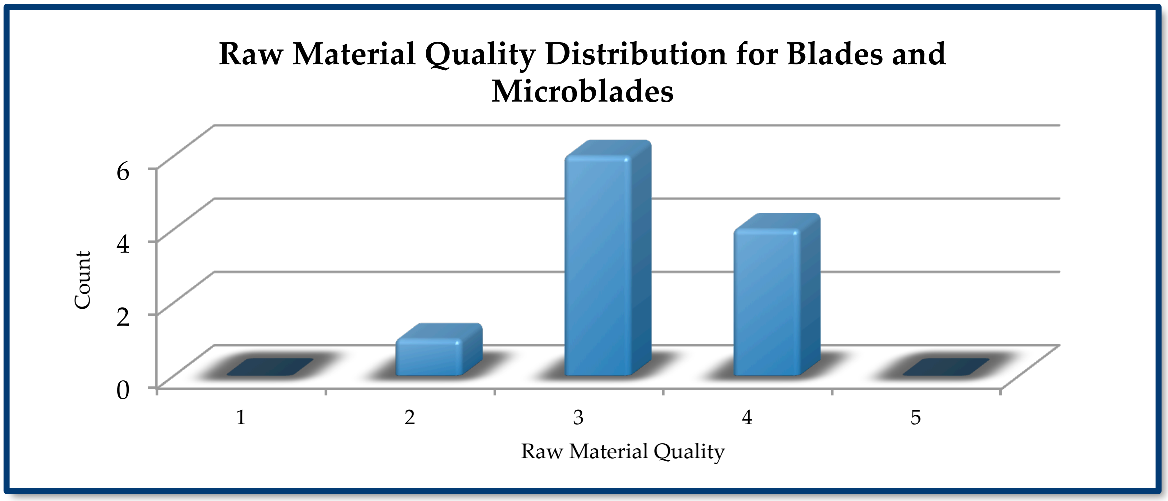


Figure 58: Frequency distribution of raw material quality for blades and microblades.

Testing the Research Hypotheses

Hypothesis 1

According to *H_1*, the Grandfather Quarry was the only location in the region where usable toolstone could be reliably obtained. If this was the case, the lithic assemblage should exhibit a mix of informal tools for immediate use alongside formal types such as blanks, cores and preforms for future use away from the quarry. These would be manufactured from better quality toolstone, while inferior stone would have been used for such implements as flake tools and scrapers. Formal tools should dominate the tool portion of the assemblage.

This is in fact the case. Both formal and informal tools are present; but while formal tools account for 85% of the tool assemblage in Unit 11 and 91% in Unit 3, informal tools account for just 15% and 9% respectively. A preference for higher quality toolstone is evident in the manufacture of bifaces and cores for future use away from the quarry, despite the fact that all usable toolstone, regardless of quality, was exploited intensively. Contrary to expectation, utilized flake (expedient) tools are of a superior quality. This may be due to the temporary relaxation of raw material quality and availability stress while the group was at the quarry.

According to this hypothesis, there should also be evidence of discarded tools with evidence of intense curation and/or use wear, as well as broken or failed bifaces, blanks and other preforms begun as an attempt at resupply for a long journey. As expected, discarded tools are worn and/or fragmentary, and cores and bifaces are among the most ubiquitous types recovered.

Also as expected for this hypothesis, debitage does indeed reflect early and middle-stage reduction, along with some later-stage reduction resulting from tool/preform shaping.

H_1 predicts little or no evidence for bi-polar reduction, with few liquidated tool fragments of a quality superior to that generally available at the quarry. Observations bear out this prediction: just fourteen (14) tool liquidation fragments were identified, and these are indeed of a far superior quality to that found at the Grandfather Quarry (see Figure 59).

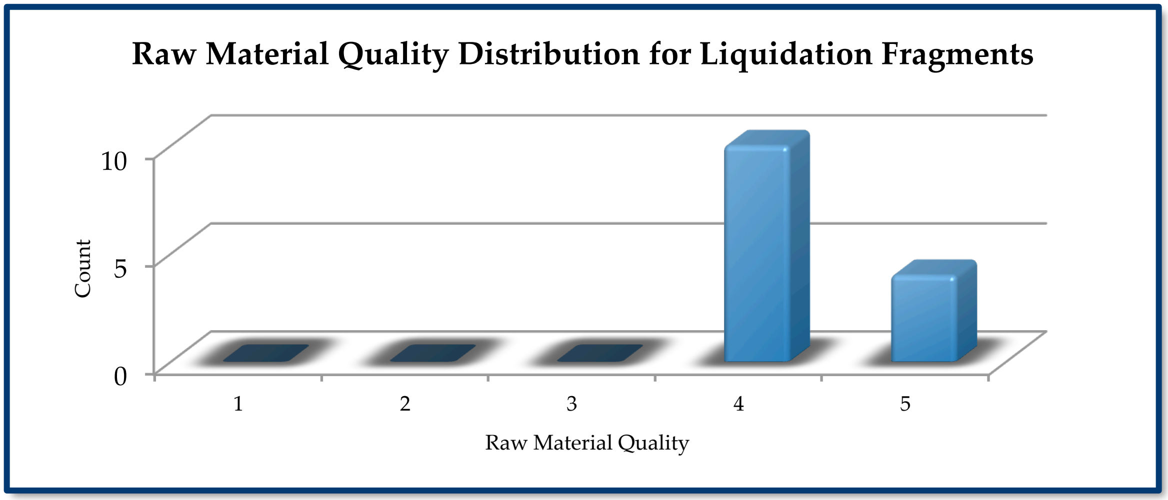


Figure 59: Frequency distribution of raw material quality for tool liquidation fragments.

Lastly, if *H_1* holds true, there may be evidence of different quarrying activities at different loci within the site as particularly suitable nodules were removed to another area for reduction with greater care, precision, and perhaps with the use of other tools. This too is evidenced by the markedly contrasting debitage and raw material quality patterns of Unit 11, representing the main quarry pit, and Unit 3, at the quarry pit's northern edge.

Alternatively, if the Grandfather Quarry was the *preferred* location for quartz procurement, where better quality raw material was available than was to be had elsewhere, it is expected that there would be evidence of substantial discard for the sake of obtaining proportionately fewer pieces of better quality raw material, which would be used to make standardized formal types such as bifaces or microblades. Later stage and/or small debitage should exhibit higher frequencies of higher quality, with higher frequencies of inferior raw material at earlier stages of reduction.

While it is true that higher quality quartz appears to have been reserved for formal types such as bifaces and microblades, the proportion of debitage to debris clearly indicates that all usable quartz, regardless of quality, was heavily exploited. Although there is a negative correlation between debitage size and raw material quality, this correlation is weak, reflecting that inferior quality quartz was not discarded but was fully exploited alongside the better quality stone, which was used primarily for formal types. Alternatively, the high proportion of inferior quality debitage may indicate that this material was being "tested" in order to locate and exploit the relatively smaller proportion of higher-quality quartz.

Hypothesis 2

Under H_2, useable quartz was readily available throughout the Churchill River Basin, and the inhabitants of the region did not use one source preferentially over any other source. Quartz would be plentiful throughout the area and an expedient, more wasteful reduction strategy would have been employed.

If this hypothesis is true, then there are three primary expectations: first, debitage reflecting early stages of reduction should dominate. Second, there should be little or no evidence of formal tool discard, since these types would be retained and used more intensively. Third, the tool assemblage should be dominated by expedient, informal tools.

As the data above show, none of these expectations are, in fact, the case. Debitage reflects both early and middle stage reduction, with some later stage reduction in evidence resulting from the shaping of preforms and blanks. Failed and broken formal tools dominate the assemblage and there is evidence for some tool liquidation, possibly an attempt at resupply for a long journey.

Hypothesis 3

H_3 states that the earliest users of the Grandfather Quarry were one of the Shield Archaic peoples, while subsequent users were the Woodland cultures of that were descended from them. If this hypothesis is correct, then the tool (i.e. non-debitage) assemblage from the Grandfather Quarry should show multiple components associated with the quarry's users at each cultural phase present in the Manitoba Boreal Forest, and should include artifacts diagnostic of the Shield Archaic, Woodland and later Cree occupations. Because of multiple usages through time and the difficuly in isolating distinct temporal strata inherent in quarry sites, considerable variability should be apparent within the assemblage (Beck, et al. 2002: 481-482, Gramly 1980b, Holmes 1897, Johnson 1984, Raab, et al. 1979). In other words, because quarries may be used over millennia by different groups of people, their assemblages are often characterized by mixed technologies, artifact types and cultural traditions.

In the case of the Grandfather Quarry, this expected variability is simply not there. The only striking example of such variability is in raw material quality and in the proportion of debitage to debris at each of the excavation units studied, and this is attributable to differential activity at these loci within the site.

Moreover, the only unambiguously artifacts present are the microblades and their associated cores. These are attributable to various northern cultures across the continent, including Alaska (e.g. Ricklis and Cox 1993, Giddings 1964, Cook 1968), the northwest coast (e.g. Saskatchewan Heritage Online 2005: 93, Carlson 1996: 217) and the eastern Arctic and Greenland (e.g. Maxwell 1985, McGhee 1996, Milne and Park In Press). None of the literature, however, attributes microblade technology to the Shield Archaic or later Woodland traditions.

In making inferences about the users of the Grandfather Quarry within the context of the Boreal Forest Shield Archaic, as important as what was found is what was *not* found. The Shield Archaic period is characterized by various scrapers and side-notched points, uniface blades and biface blades. Bifaces and unifaces are not unique to the Shield Archaic, however, and the presence of bifaces does not, in and of itself, indicate a Shield Archaic presence. In the Shield Archaic, lithics tend to be large, with some scrapers exceeding 15cm in length and points around 10cm in length (see Figure 56, lower left, and Figure 60).

The biface assemblage from the Grandfather Quarry may bear some resemblance to a group of Shield Archaic bifacial blades reported by Hlady (1970a), but could just as conceivably be attributed to the ASTt (see Figure 56).

Wright (1970: 44) argues that the Shield Archaic continued as the later Laurel (Woodland) tradition – beginning in the early centuries of the first millennium BC (Milner 2005: 54) -- "with the addition of ceramics and possibly some lithic traits." Yet none of these lithic types, broken or whole, have been found so far in the Grandfather Quarry assemblage. Nor have ceramics of any kind been uncovered at the site – unlike at other sites in the Churchill River Basin and Granville Lake vicinity (see ten Bruggencate, et al. 2013: 2703, Dickson 1977, 1980, Kroker 1990). Additionally, there is no indication of the Oxbow culture which, although typically found further south, has been noted as far north as the vicinity of the Grandfather Quarry site (Petch, et al. 1998).

Nonetheless, the absence of evidence is not necessarily evidence of absence, and future research will no doubt present us with a clearer picture in this regard. The test for Hypothesis 3, then, is guardedly inconclusive, although the lack of artifacts unambiguously diagnostic of the Shield Archaic points toward its failure.

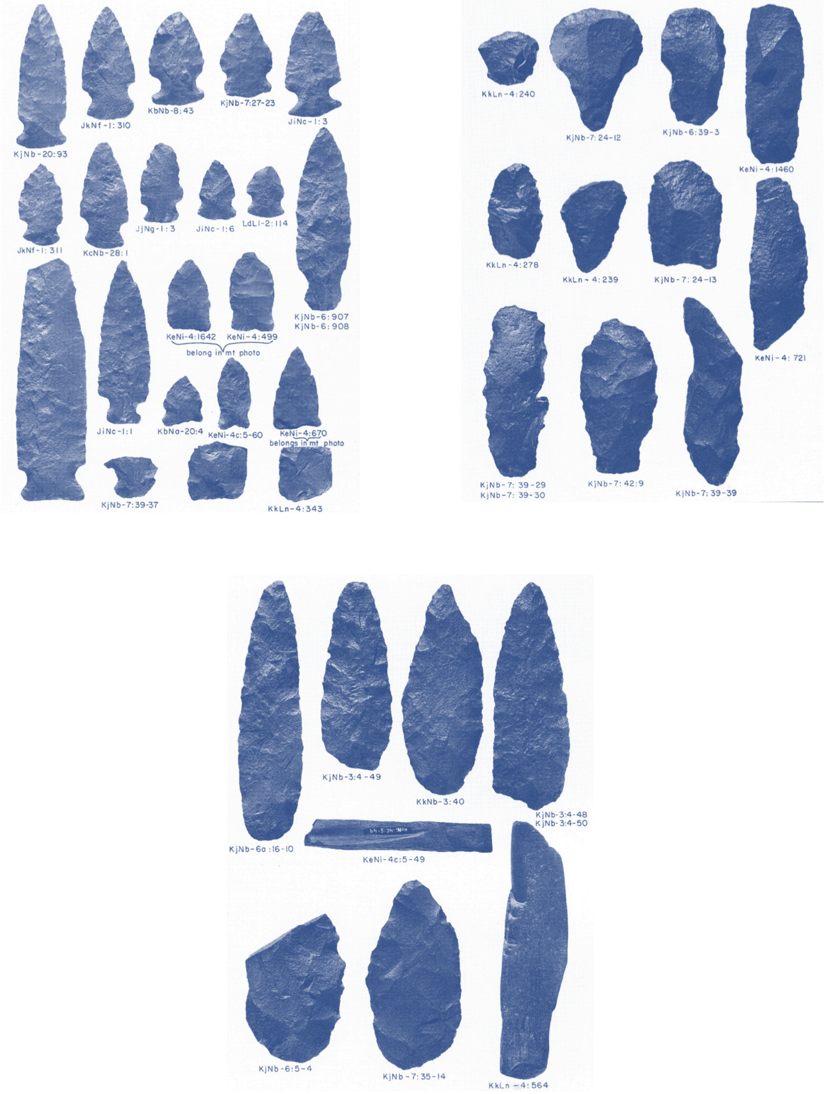


Figure 60: Shield Archaic projectile points and wedges (above left), 'bent' knives and scrapers (above right), and symmetric knives and whetstones (below). From Gordon (1996: 202, 204, 207). Images Copyright © 1996 by the Canadian Museum of Civilization. Used by permission.

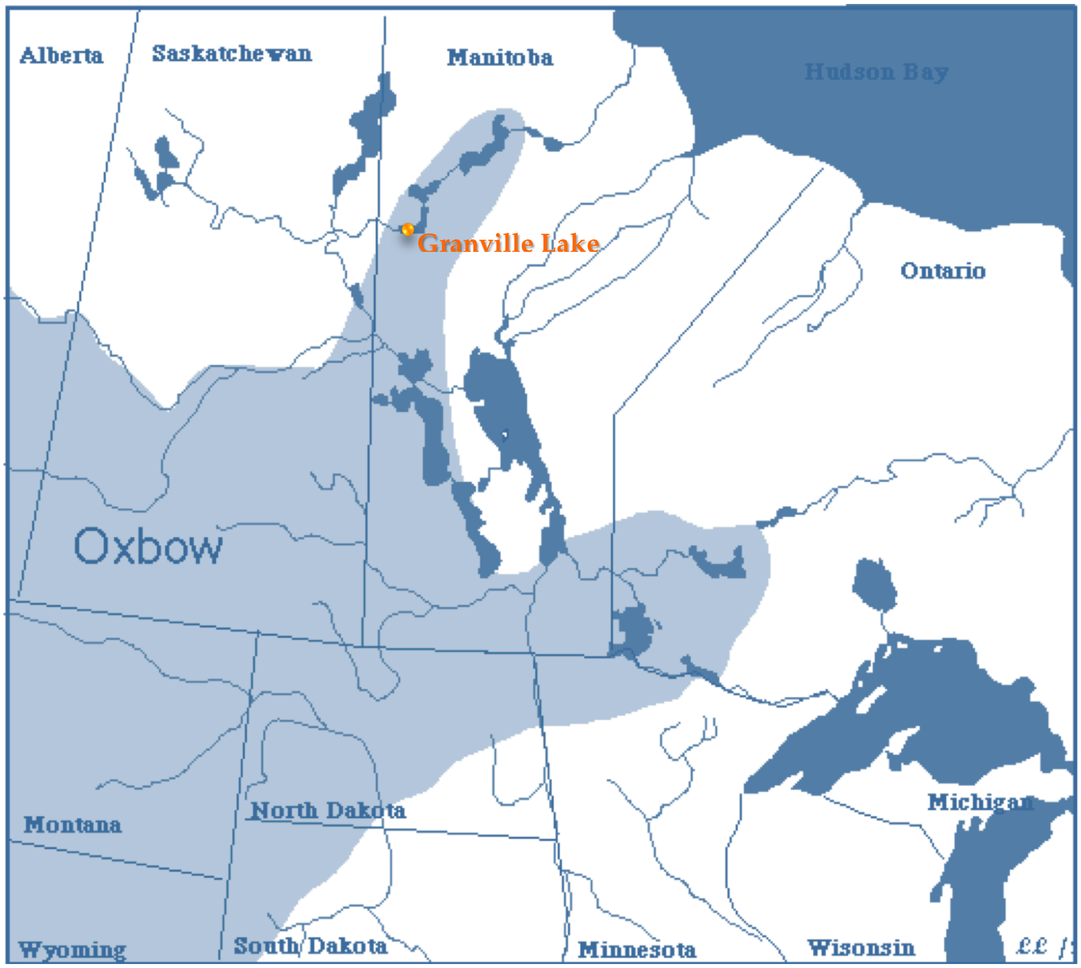


Figure 61: Map showing the distribution of the Oxbow culture complex (from Petch, et al. 1998). Copyright © 1998 by the Manitoba Archaeological Society. Used by permission.

The Null Hypothesis

H_0 states that there was a wide variety of toolstones, including, but not limited to quartz, available in the study area and that these were acquired by the toolmakers using direct and/or indirect means. It further states that toolstones not available locally, but acquired indirectly through exchange would be comparatively rare and therefore heavily curated.

Even without foreknowledge of the geological evidence presented by ten Bruggencate et al. (2013), the null hypothesis, quite simply, fails: the only non-quartz artifacts found at the Grandfather Quarry are a few anvils and sandstone pecking-stones, and one possible sandstone abrader (see Figure 15 on page 126).

Summary

In this chapter I have offered my interpretations of the data generated by a simultaneous mass and attribute analysis of the debitage and tool assemblages of the Grandfather Quarry (HbMd-4). These data show intensive procurement and reduction of quartz at the Grandfather Quarry, regardless of the quality of the stone. Debitage size grades indicating predominantly early and middle stage reduction are present in abundance, with some later reduction indicated, possibly resulting from the shaping of blanks and preforms. Rare instances of higher quality raw material appear to have been reserved for the manufacture of bifaces, cores and microblades for transport elsewhere, and broken and worn formal tools were discarded at the quarry.

A highly mobile group is indicated. This is evidenced by the dominance of formal tools in the assemblage, together with failed and broken bifaces and cores of mostly higher quality toolstone; and it is in concurrence with the established culture history of the Churchill River Basin.

Of the hypotheses presented, the first one best fits the evidence: namely, the Grandfather Quarry was the only reliable source, or the preferred one of a very few such sources, of toolstone in the area. Hypothesis 3, which attempts to ascertain the cultural identities of the toolmakers at the quarry over time, was largely inconclusive, since the only unambiguously diagnostic items recovered were those pertaining to microblade technology. In this regard, all that can be said with certainty at this point is that at some time in the quarry's use-life, a group possessing microblade technology exploited the quartz here. Additional research, focusing on culture-history and tool typology may shed more light on this problem in the future.

Chapter 8:
Summary and Conclusions

My research has addressed three key issues faced by archaeologists in the pursuit of lithic analysis. It is one of a number of studies (e.g. Carr and Bradbury 2001, Magne 2001, Rasic and Andrefsky 2001, Wenzel and Shelley 2001, Andrefsky 2004, Larson 2004, Shott 2004) using multiple methods to generate independent lines of evidence to more accurately interpret patterns of variability identified in the Grandfather Quarry quartz assemblage. However, my approach is different from these in two respects.

First, it applies these methods to a quarry assemblage. Since quarries are fixed locationally while most seasonally abundant food resources in northern latitudes are not, the procurement of toolstone must therefore be "factored in" to strategies used in the procurement of other essential resources (e.g. Bamforth 1991, Binford 1979, Nelson 1991, Milne 2003: 70). Source areas for useable toolstone are therefore the logical starting point for the study of how past societies organized their technology in accordance with their subsistence and social needs. This dissertation represents the first study of its kind for an archaeological quarry assemblage from the northern Boreal

Forest of Manitoba, in order to reconstruct the technological organization of residentially mobile peoples in this region.

Second, the raw material examined in this study is quartz. The most commonly examined lithic assemblages are comprised of crypto-crystalline raw materials such as chert, flint or chalcedony. This has had the effect of imposing a bias toward such materials (Knutsson 1998), under which materials such as quartz, which have different fracture properties, are avoided as being ‘troublesome’. Alternatively, they are analyzed under the uncritical assumption that the same classifications and analytical methods used for flint-like materials are appropriate, without considering how quartz’s different fracture properties might affect the resulting manufactured tools.

Methodological Contribution

The Grandfather Quarry (HbMd-4), near Granville Lake, Manitoba, provided an opportunity to examine these issues together, by applying mass and attribute analyses to a quarry site with an assemblage that is almost exclusively of quartz. My research demonstrates that mass analysis works effectively on quarry assemblages when modified and combined with an analysis of secondary attributes.

Chapter 8

Summary and Conclusions

Using the quartz assemblage from the Grandfather Quarry as a test-case, my research suggests that Ballin (2008: 91) is correct in his claim that quartz assemblages can, in fact, be analyzed using the same methods and classifications as tools made of other raw materials. It is important to remember, however, that the fracture properties of quartz must be borne in mind – particularly with regard to debitage dorsal scar counts. This knowledge is significant for future analyses of lithic assemblages and possible source locations in this region given the lack of other useable toolstones available.

One of the purported advantages of mass analysis (Ahler 1989) was lost in modifying the technique for this research: hand-fitting each piece to a geological sieve of the appropriate mesh-size did in fact require the handling of each piece. Nevertheless, it was still faster and less labour-intensive than measuring each piece with a pair of calipers. Furthermore, the benefits of doing so outweighed the disadvantages: handling each piece allowed me to collect a large amount of secondary attribute data to provide multiple lines of evidence. It also enabled me to more accurately assign each piece to its appropriate size grade, because long, thin pieces would not end up in a size-grade smaller than their longest dimension simply by slipping length-wise through the mesh into a smaller size-grade. Modifying the technique in this way thus helped to address Andrefsky's (2007) concerns with mass analysis.

Andrefsky's concerns are further mitigated by the fact that the assemblage in this case comprised a single raw material: quartz. As I have demonstrated in my study, mass and attribute analyses are as applicable to quartz assemblages as to assemblages of chert, flint or chalcedony. Andrefsky's requirement to stratify the sample into artifacts of the same raw material prior to using mass analysis is thus eliminated in this case. This is particularly important for future quarry studies in the Churchill River Basin, where quartz is the only naturally-occurring toolstone (ten Bruggencate, et al. 2013): the fact that prospective quarries in this region are likely to have assemblages comprised of just one raw material enhances the demonstrated viability of mass analysis as an analytical technique in this particular area.

The Grandfather Quarry and its Users

Overall, the Grandfather Quarry assemblage suggests the intensive knapping activity of a population under raw material stress. Regardless of actual quality, any and all useable quartz appears to have been extracted and roughed out for transport. Rare veins of moderate to high quality quartz appear to have been reserved for utilized flakes, microblades and microblade cores, and especially bifaces, which appear to have been knapped on the spot to obtain maximum efficiency and transportability. This suggests a residentially mobile population, which in fact supports existing archaeological interpretations in the Manitoba Boreal Forest region (e.g. Dickson 1980, Hlady 1952, 1970a, 1970b, 1971, Kroker 1990, Nash 1970, Petch, et al. 1998, Wright 1970).

The suggestion of a residentially mobile population is also supported by the high frequencies of bifaces and the massive quantities of small debitage associated with their manufacture (Stahle and Dunn 1982). As Andrefsky (2005: 192-193) notes, bifaces are flexible because they represent the basis of different tool forms suited to different functions. They are also maintainable, being easily altered or reworked to suit specific needs, and *portable.* This makes them ideal for hunter-gatherers populations who regularly pursue subsistence and other activities away from residential camps (Andrefsky 1993, Bamforth 1991) and who travel throughout the landscape on a seasonal basis and may be away from reliable sources of toolstone for extended periods. "As a result of all these conditions, bifaces can potentially fulfill the tool requirements for unpredictable situations" (Andrefsky 2005: 192).

Chapter 8

Summary and Conclusions

Four hypotheses were constructed (see Chapter 5, pages 103- 110) and tested against the data generated by the mass/attribute analysis of the Grandfather Quarry quartz debitage assemblage. Hypotheses 1 and 2 are correlated in that they are both concerned with the availability and quality of quartz toolstone in the Granville Lake area of the Churchill River Basin. Hypothesis 1 states that the Grandfather Quarry was either the only source of readily available toolstone in the area, or at least was the preferred one of a very few such sources. Hypothesis 2 states that to the contrary, quartz toolstone was readily available throughout the Churchill River Basin and easily accessible to toolmakers.

Of these, two hypotheses, Hypothesis 1 best fits the data generated by this study. Debitage patterns clearly show a greater degree of lithic reduction of toolstone than are expected under Hypothesis 2; differential reduction and quality patterns within the quarry suggest more than one activity (i.e. more than just extraction and preliminary roughing out) at the quarry, and the lack of preference for higher quality toolstone in terms of overall procurement suggests the raw material availability stress characteristic of a group that must travel long distances to a particular location to obtain toolstone. At the same time, the reservation of higher quality raw material for further reduction, along with the copious production of later-stage bifaces (which are easier to transport and more efficient in terms of moving larger quantities of readily usable toolstone over long distances) is indicative of conservation behavior, again characteristic of a population under raw material stress.

Given the sampling strategy used and the confidence interval selected, I can assert that the patterns of variability identified are representative, 95 times out of a hundred, of the total variability present in the wider assemblage. The robustness of these results provide a high level of academic rigour and allow me to claim, that the Grandfather Quarry was if not *the* only source, then one of only a few sources, of readily available toolstone in the area. I can also claim that my modified mass analysis, combined with attribute analysis, is applicable to quartz assemblages as it is to chert assemblages (see, for example, Milne 2003, 2009).

This is particularly interesting considering that ten Bruggencate *et al.* (2013) have reported on five quartz outcrops locally referred to as "quarries." In light of my findings, future research into these "quarry" sites is warranted to determine if they were in fact exploited by toolmakers since archaeological assemblages of toolstone reduction were not identified during survey in 2007 (Milne, personal communication, 2013). This work is essential to assess their importance, if any, as alternative sources of toolstone to populations in the area. The methodology devised in this study will be particularly effective for such future studies to assess the broader role of quartz in local lithic toolkits.

Finally, the unexpected and fascinating discovery of microblade technology at the Grandfather Quarry opens a new avenue for archaeological research in the region. This technology is not known to be a part of any Shield Archaic, nor later Woodland, lithic tradition. The geographically and temporally nearest populations known to make use of such technology in northern Manitoba were the Palaeo-Eskimos, and more specifically, Pre-Dorset and Dorset (Maxwell 1985, McGhee 1996, Milne and Park In Press, see also: Gordon 1996, Nash 1969, 1970). However, as has been noted (see page 92), quartz as a toolstone seems particularly well suited to microblade technology (see Powell 1965, Ballin 2008: 8, Bisson 1990: 137). Did the Palaeo-Eskimos venture even further south than their previously thought limits of Thyazzi and South Indian Lake from the Arctic barrenlands, or up the Churchill River from Seahorse Gully near Churchill, to exploit the quartz from Grandfather Quarry? If Dickson (1980) is correct that Rock Lake (approximately 32km north of Thompson, Manitoba) has an ASTt component, then this is certainly possible: Rock Lake is at approximately the same latitude as the Grandfather Quarry.

Or did the local Shield Archaic people develop microblade technology, either independently, or through diffusion, in response to the availability of quartz and the lack of other toolstones? These are questions for future research projects that will aim to further investigate how quartz toolstone was integrated into the ancient lithic technologies of peoples occupying regions within the Churchill River Basin since time immemorial.

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