PROPERTIES AND SOURCES OF SOME SASKATCHEWAN LITHIC

MATERIALS OF ARCHAEOLOGICAL SIGNIFICANCE


A Thesis

Submitted to the College of Graduate Studies and Research

in Partial Fulfilment of the Requirements

For the Degree of

Master of Arts

in the

Department of Anthropology and Archaeology

by

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## ABSTRACT

This study examines nine varieties of lithic material of archaeological significance. These materials were chipped into useful prehistoric artifacts and can be found in southern Saskatchewan. The identity of each variety has been determined by petrographic analyses and features useful for field identification have been described. The source of each material has been related to a geological formation.

For archaeological purposes, it is proposed that chalcedonic silica be regarded as a silica polymorph separate from quartz. This distinction permits more accuracy in developing concepts of rock identity. It also makes way for an explanation for the phenomenon of change in properties of certain varieties of rock by heating to a relatively low temperature. Chalcedonic silica is regarded as the active component of the kinds of rocks that are made easier to chip by heating. Many varieties of material were experimentally heated and the results provide strong support for this concept.

ACKNOWLEDGEMENTS

I would like to express my appreciation to the many people who have given me assistance and encouragement during this study. Foremost among them are the members of the thesis committee: Dr. Ernest G. Walker (supervisor), Department of Anthropology and Archaeology; Dr. Zenon Pohorecky, Department of Anthropology and Archaeology; Dr. Urve Linnamae, Department of Anthropology and Archaeology; Dr. W.A.S. Serjeant, Department of Geological Sciences. I also express appreciation to my mentor Dr. W.O. Kupsch, the external examiner. Dr. J.F.V. Millar of the Department of Anthropology and Archaeology also assisted in very many ways.

Other members of the Department of Geological Sciences have also graciously provided assistance. They include Dr. W.G.E. Caldwell, Dr. F.F. Langford, Dr. H. Hendry, Dr. W.K. Braun and Dr. James F. Basinger. Zbigniew Szczepanik and John Dubetz made the petrographic thin-sections that were so important to this study. Dr. Chris Gilboy gave immeasurable assistance by analysing these thin-sections, and Dr. David McNeil gave an important interpretation regarding microfossils. Allen Holsten made chemical analyses of the rock specimens, and Janet Gunn and Larry Craig helped in the interpretation of materials. Carol Beaulieu did the cartography, David Mandeville the photography, and Lynne Underwood typed the manuscript.

Finally, this study could not have been accomplished without the encouragement and support of my wife, Charlotte.

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CHAPTER 1


INTRODUCTION


Stone, a rock-like substance which usually embodies human use or modification, is one of the most important archaeological materials. It has been used as a tool material for probably millions of years, it can be shaped by several distinctive methods, and it is virtually imperishable. The form and ascribed function of artifacts and their quantity and location in a site contribute to information about past cultures and past activities. The intrinsic properties of the stone itself may also yield important information.

Undoubtedly, the availability of stone and the technology to shape it allowed humans to become active predators and to adapt to very harsh environments. The study of stone is inextricably related to that of the development of prehistoric humans, and it may assist in developing inferences about their cognitive processes and their social organization.

Although cobbles and fragments of stone occurring naturally can be used as simple tools without modification, human ability to shape stone gave a much greater control of the environment. Stone may be shaped by

several methods: by breaking, by pecking, by abrading and by chipping. Heat was used in some quarrying processes to detach portions from the parent rock but mechanical processes are the most important. The nature of the rock entailed the method of shaping. Slates could be split into thin pieces and ground to a desired shape and to produce a sharp edge. Massive granular rocks could be shaped by pecking, and tough materials such as jade could be sawed by slices of sandstone. Certain kinds of brittle rocks could be shaped by the removal of a succession of thin spalls. This process is called chipping.

The flake scars of a chipped artifact are highly distinctive as in the detritus from the manufacture of such an artifact. In some cases the mode of flake removal can be accurately surmised whether it be hard or soft percussion, or pressure flaking. The splitting of symmetrical pebbles or cobbles also represents a distinctive technology. When applied to a suitable rock, chipping is a labour efficient method of reduction and shaping. Chipping is an appropriate way of fashioning tools for cutting and scraping because spalls have naturally sharp edges, and sharp edges can also be easily formed on artifacts.

The class of rocks that may be usefully chipped must have certain properties. They must be hard and

brittle, they must be either fine-grained or amorphous and have no cleavage planes due to unit cell arrangement. Nor may they have voids, fractures or inclusions that unduly interfere with artifact design. Prominent among varieties of rocks that can be usefully chipped are: obsidian and basalt, chert, chalcedony, welded tuff, siltstone, quartzite, fused shale, and siliceous replacements of materials such as wood.

## 1.1   The Archaeological Significance of Lithic Materials

The forms and functions of artifacts and their spatial arrangement within a site provide an important source of information about ancient activities. Projectile point typology is an essential aspect of site interpretation as are observations of wear and breakage patterns. A knowledge of the lithic materials per se can contribute substantially to that derived from other studies of artifacts.

Archaeological lithic materials have been relatively unexamined but it is proposed that a knowledge of them can contribute in several ways. If the source of the lithic material be known, hypotheses regarding procurement patterns of the site occupants can be derived. Knowledge of physical properties such as ease of chipping, durability and strength may indicate reasons for the

selection and use of a specific material and insights
into the technology required to shape it.

Stone Axe Studies (Clough and Cummins, 1979) is an
excellent example of how a multi-disciplinary scientific
approach made it possible to identify the sources of stone
from which axes in northwestern Europe were made. This
degree of sophistication is rarely possible for materials
that can be chipped. Nevertheless if a lithic material
can be identified and related to a known source, addition-
al information is given about the users. For example,
Knife River flint is a lithic material from North Dakota
which occurs as artifacts and flakes in sites on the
northern Plains. It is apparent that some groups who
occupied Saskatchewan either had recently come from
North Dakota, or else had regular contact with this
source. Whether a certain cultural group used exotic
materials and whether they had become familiar with in-
digenous sources is useful in order to interpret their
travel or contact patterns. It is apparent that separate
cultural complexes used lithic varieties in very differ-
ent proportions and for different tools. Material use
by members of a specific cultural group may vary from
locality to locality for reasons that are not now appar-
ent. To elaborate, some Besant groups used virtually no
Knife River flint and others used it almost exclusively.

In many circumstances material selection must have

depended on local availability but it is the opinion of contemporary flint knappers that some styles of projectile points require a high grade material. A finely chipped Eden projectile point cannot be made from rough material nor is it possible to create the flute on a Folsom projectile point unless the stone chips well. Cultural traditions entailed the manufacture of certain styles of tools, and in some instances this must have entailed the procurement of certain exotic materials.

Varieties of stone vary considerably in the effort required to remove a spall of a given size. On one hand obsidian is very easy to chip, but on the other end of the scale are most andesites, diorites and quartzites. Hence, the end product will depend on the technology available to shape that kind of rock. The technology may be a matter of using or not using soft percussion or pressure flaking, and it may include knowledge of whether properties of a rock could be improved by heating and how to do it.

In summary, a knowledge of the source of a rock may lead to hypotheses regarding its procurement. Whether it be local or exotic will determine the nature of theories regarding its procurement system. It may be postulated that it was obtained in the course of seasonal movement, or that an exchange system existed, or that expeditions were sent to get desirable material. Know-

ledge of properties of a rock may permit its identification and to understand the technology that could have been used to fabricate it into desired artifacts.

## 1.2  The Goals and Parameters of this Research

This thesis will be concerned with the identification and description of those lithic materials which occur naturally in southern Saskatchewan which could be usefully chipped into artifacts.  Only those which appear in significant quantities in the archaeological record will be considered.

The objectives of the research are:

(i)  to determine which lithic varieties used by chipped-stone industries had sources within southern Saskatchewan.

(ii)  to locate the source or source area of each of these varieties and to correlate it to geological features or events.

(iii)  to determine by scientific and other methods the properties of each variety, especially those which may be useful in identification and recognition.

(iv)  to empirically evaluate the chipping properties of each variety, both in the natural and heated condition.

## 1.3 Previous Research

Even though the study of lithic materials in archaeology is still beset by problems, scholarly treatises have illuminated this field considerably. Those relevant to this study will be briefly commented on.

Classes of reports that are germane include: work done by others on specific materials that are studied in this research; reports of materials that are outside of Saskatchewan; geological reports; and archaeological site reports.

Campling (1980) presented The Identification of Swan River Chert in which he described this variable and widely dispersed material. His report included petrographic analyses and descriptions of macroscopic properties. As far as is known, this is the only published work to have approached from an archaeological viewpoint a lithic material useful for chipping that has a source at least partly within Saskatchewan.

Several important articles have been published which describe materials exotic to Saskatchewan. In 1970 Clayton et al published a classic work on Knife River flint. The authors described properties of this material and gave information regarding its presence in glacial drift and its assumed geological origin. Support was given by petrographic slides of thin sections. Knife River flint

is not known to be indigenous to Saskatchewan; although exotic, it is common as artifacts and flakes in Saskatchewan archaeological sites. Choquette (1980) examined Kootenay lithic materials found in southeastern British Columbia but so far they have not been recognized in Saskatchewan. Fenton and Ives (1982:166-189) described the geology, properties and distribution of Beaver River sandstone whose source is in the Fort Mackay district of northeastern Alberta.

Geological reports have described some lithic materials of value for chipping. Pierce and Hunt (1937: 242-244) described "pebble chert" and Broughton (1976: 1719-1722) described silicified peat, which he calls "silicified lignite," while Vonhof (1969) described the geology and lithology of Tertiary quartzites.

There is a great deal of variation in the ways in which archaeologists have dealt lithic materials. Wettlaufer (1960) gave brief descriptions of the following materials and indicated their representation in the various levels: chalcedony, jasper, chert, crystalline chert, agate, petrified wood, baked shale, quartzite and crystalline quartz. Some archaeologists have ignored lithic materials in their site reports, others such as Kehoe (1973) have devoted a chapter to a single material, in this case quartzite, and have dealt very scantily with others. There appears to be a lack of confidence in

using lithic materials as a source of information, or as a basis for developing theories about prehistoric activities. These deficiencies may be due to a lack of basic data regarding most lithic materials and their respective sources.

## 1.4  Problems in Lithic Identification

One of the major problems in studying archaeological lithic materials is to apply consistent names to specific rocks. On this matter Leonoff makes this appropriate observation:

> The consistent use of terms applied to raw material identification is the first necessary step [for future research]. It is meaningless to the researcher, when reading archaeological reports, to see a variety of terms applied to the same material or vice versa. The consistent use of terms has ramifications for other areas of research (Leonoff, 1970:80).

Several years later lithic identification was still regarded as a problem by Thomas who states:

> A final problem is the difficulty of comparing the

results of the analysis to existing data. Often, raw material data have been completely omitted from archaeological reports. When included, data on raw material selection are usually obfuscated by lack of clear descriptions of the materials and by idiosyncratic systems of lithic classification (Thomas, 1983:21).

The root of this problem lies in the lack of research into materials that are scarce and of no commercial value. Also, there is uncertainty as to what criteria are necessary to identify a specific variety of rock. The matter of identifying the material in artifacts and hand specimens may be especially difficult because rocks suitable for chipping are usually fine-grained or amorphous. Rocks such as granite may be classified according to the kind of minerals present and their proportion but, because individual minerals in chipping materials usually can not be discerned, this method is rarely suitable.

Some rocks have regular features that enable one to identify them but variability within other varieties increases the problem of identification. Swan River chert is an example of a rock that may have a wide range of colours, textures and structures. Campling (1980) raises the question whether it ought to be regarded as

one variety or several.

Heating may cause changes in colour and lustre so
that it may be necessary to make an assumption whether
a specimen had been heated or not before classifying it.
Weathering may also cause changes in appearance.

Where an outcrop of a rock is known to exist it
can be regarded as a source type and specimens can be
compared with it for identification. Unfortunately,
many of the rocks of interest have been distributed by
natural action and no primary source is known. Their
identification will therefore depend upon observations
of their intrinsic properties and by comparison with
similar known rocks.

Most of the rocks of value to a chipping industry
consist mainly of silica. The failure to distinguish
between quartz and chalcedonic silica (both are $SiO_2$)
can lead to misidentification or the application of a
less appropriate name. This matter will be discussed
more fully in a subsequent chapter.

Many terms in common use such as chert, flint,
chalcedony and porcellanite have vague or ambiguous mean-
ings. In particular, "chert" is commonly applied to a
fine-grained rock of uncertain identity. At times this
is justifiable, but in many instances more specific names
can be applied such as "chalcedony," "siltstone" or
"jasper," according to its properties.

Although archaeology relies on the science of geology for information about rocks, these sciences differ in the information that each requires. For geological purposes it is usually adequate to classify a rock according to the variety of which it is a member, but in archaeology it is not only desirable to indicate the variety but to relate it to a specific source. If a rock is referred to as "chert" a small amount of information is given about its properties, but if it can be called by a proper name such as "Knife River flint" a specific material is implied along with its source.

CHAPTER 2

PETROLOGY OF MATERIALS OF THIS STUDY

2.0  Introduction

In general, a rock is composed of one or more
minerals and its classification will depend on the kinds
and proportions of minerals in it, how it was formed and
what forces have subsequently acted on it.  Minerals,
therefore, are the basic building units of all rocks.
Hurlbut and Klein (1971:1) define a mineral as "...a
naturally occurring homogeneous solid with a definite
(but generally not fixed) chemical composition and an
ordered atomic arrangement.  It is usually formed by in-
organic processes."  Chalcedonic silica, even though it
has a regular composition ($SiO_2$), is not regarded by
these authors as a "mineral" because it lacks a recog-
nizable crystal structure.  However, this view is not
held by all petrologists and mineralogists.  No mineral,
apart from quartz and possibly chalcedony, is useful for
chipping.

Igneous rocks have been derived directly from a mag-
ma and they may be classified according to which minerals
are present, their proportions, and the size and arrange-

ment of the grains. The latter depend on the way the
magma cooled. One which cooled slowly would form a
coarse texture in which individual mineral grains could
be discerned but if the same magma cooled quickly it
would form a fine-grained or glassy rock because rapid
cooling does not permit individual minerals to segregate
as grains. Obsidian is a rhyolite glass that was much
used by chipped-stone industries. It was formed by the
rapid cooling of a siliceous magma as in volcanic extru-
sion, but if it had cooled slowly, it would be crystal-
line and called a granite.

The main igneous rock found in southern Saskatchewan
is granite but small amounts of basalt and vein quartz
also occur in the glacial drift. Porphyry is also pres-
ent in Tertiary gravels. Granite and basalt cobbles were
shaped by pecking to form mauls, and basalt and quartz
were chipped to form rough chopping tools.

Sedimentary rocks provided the greatest variety and
the greatest absolute quantity of lithic materials that
were used by chipped-stone industies. Two major classes
are: those of detrital origin, and those deposited from
aqueous solution. Detrital rocks include: quartzites,
sandstones, siltstones, wackes, argillites and tuffs.
All of these consist of small fragments of previously
formed rocks which have been lithified by cementation or
by the recrystallization of component materials. Silica,

in the quartz form, is the most common cementing material.
Chalcedonic silica is relatively rare as a cementing
material; rocks cemented by it are called "silcrete" by
Kempe and Harvey (1983:205). They have a distinctive
appearance when the chalcedonic silica patinates in con-
trast to the unpatinated quartz sand grains.

Sandstones consist of sand deposits of varying
lithology and consolidation. Quartzites are usually dis-
tinguished from sandstones when fractures go through
rather than around the sand grains. However, if materi-
als other than quartz (such as feldspar) are present in
sufficiently small quantities the rock may still be re-
garded as "sandstone." The Wentworth scale (Pettijohn,
1975:30) is useful for designating particle size as clay,
silt or sand. In this classification sand ranges from
1/16mm to 2mm. Hence lithified materials may be called
claystone, siltstone or sandstone. By definition wackes
are poorly sorted and are quite impure.

Sedimentary rocks may be formed by the deposition of
silica from aqueous solution rather than from the detri-
tus of other rocks. The chemically (or biologically)
formed varieties of silica such as chert, flint, agate
and chalcedony may be deposited as beds or nodules, or
as cavity filling, and silica may replace other materials
such as limestone, wood, lignite or peat.

Metamorphism embraces a wide range of conditions

which include great heat and pressure on one hand but exclude weathering and physical and chemical changes at low temperature and pressure on the other. The wide variety of metamorphic rocks include few that were of value to the prehistoric flint knappers of Saskatchewan. Some having suitable properties are quartzite, altered siltstone, hornfels and argillite.

## 2.1   The Quartz-Chalcedony Question

The nature of a rock will be determined by the minerals in it, their proportions, the sizes of grains and the grain to grain relationship. Chemical analyses indicate that most rocks of value to chipping industries consist mainly of silica ($SiO_2$). Quartz is the most common variety of silica but in archaeology it is quite apparent that some kinds do not behave like quartz. Work done in this thesis explored these anomalies. If the properties of a composite material are to be understood it is important to understand the properties of its components. Because of the importance of silica attention was focussed on the properties of its common varieties.

Hurlbut and Klein (1977:411) list nine polymorphs of silicon dioxide and there may well be several more. The best known of these polymorphs are low quartz, which is the form that we normally experience, and chalcedonic

silica. In archaeology it is important to recognize the differences between their respective properties, as well as to distinguish between materials that consist mainly of one or the other. The most important difference between them lies in their respective responses to certain degrees of heat. The high-low inversion of quartz (at about 573°C) has been much studied. Chalcedonic silica does not display this inversion but it does undergo an apparently permanent change in properties upon heating. Temperatures of 250°C cause a slight but noticeable change; heating to 300°C causes a marked decrease in tensile and compressive strengths and the scars of flakes removed after heating are more lustrous than the scar surfaces of flakes removed before heating. The significance of this property is that heating to within a certain range a lithic material that contains a significant amount of chalcedonic silica will make it easier to chip. A second important difference between quartz and chalcedonic silica lies in their comparative chemical stabilities. Quartz is very stable chemically as indicated by crystals in granite that has been exposed for a long time. They will be unpatinated and unaffected by weathering. However, exposure is probably a factor in causing chalcedonies to patinate in time. The kind of patination and the rate of patination depend somewhat on the variety of chalcedony and its impurities as well as some external

factors that are, at this time, not well understood.

The idea that chalcedonic silica ought not be re-
garded as simply a variety of quartz is by no means
unique or recent. Sosman states:

> There is enough difference, however, to justify the
> statement that chalcedony is not quartz, nor even a
> 'variety of quartz,' if we mean by 'variety' a modi-
> fication whose properties could have been foretold
> completely from the properties of the parent sub-
> stance (Sosman, 1927:154).

In further explication, Sosman states: "...the term
'chalcedonic silica' will be used herein as synonymous
with 'natural microfibrous silica'" and at a later date:

> The properties of chalcedonic silica more often
> approach those of quartz than those of any other of
> the principal phases. There are enough differences,
> however, to justify the statement that chalcedony
> cannot correctly be called a 'variety of quartz,'
> if by variety we mean a modification whose proper-
> ties could have been foretold completely from the
> properties of the type substance (Sosman, 1965:
> 219).

Pettijohn (1975:395) supports Sosman's view regarding the distinction between quartz and chalcedony, but does not employ the term "chalcedonic silica." He uses the term "chalcedony" to refer to "natural microfibrous silica."

Frondel defines the term "chalcedonic silica" in this way:

Most of the fine-grained types of quartz that have been distinguished by given names, including agate, carnelian, flint and chert, basically are aggregates of fibrous quartz, for which the term chalcedonic silica [emphasis added] is appropriate, and in a sense are variants of chalcedony (Frondel, 1965:171).

He gives furthers upport for the distinction between quartz and chalcedonic silica with this statement:

The anomalous optical properties, in particular the seemingly biaxial character, have led to the description of various types of fibrous silica [chalcedonic silica] as species separate from quartz (Frondel, 1965:198).

In the field of lapidary it is known that chalcedony

can be dyed, whereas quartz cannot unless "crackled." Crackling refers to heating the quartz and quenching it to produce fine fractures. This observation is a further indication of the porosity of chalcedony and the lack of it in quartz.

My experiments in heating fine-grained materials indicate that the materials that respond to heating to 300°C (i.e. become more glassy and easier to chip) are of chemical (or biological) sedimentary origin and are regarded as chalcedonies. Materials that respond include: Knife River flint (a replacement of lignite); Brandon, England floorstone which is commonly called a "flint" (a marine biological deposition); silicified peat (a replacement of organic material); Montana agate (a cavity filling of vesicles in igneous rock); also, some kinds of silicified wood (chalcedonic replacement of wood).

No quartzite, quartz, obsidian, or any material that was not a silica of low-temperature sedimentary chemical or biological formation showed any change in properties related to chipping qualities after being heated to 300°C. These observations give support to the concept that there are some basic differences between quartz and chalcedonic silica.

Many polymorphs of silica are known. A reasonable explanation for the behavior of chalcedonic silica is that it too is a distinct silica polymorph  but is one

in which a certain degree of heat causes a slight molecular adjustment which thereby permanently alters some of its properties.  Chalcedony and its variants consist basically of chalcedonic silica, therefore, in order to understand chalcedony it is essential to understand chalcedonic silica which is its main component, and to recognize that it does not behave like quartz.

Figure 1.   A map of Saskatchewan showing some geological features.

CHAPTER 3

THE GEOLOGY OF SASKATCHEWAN

## 3.0  Introduction

The properties of a rock depend on its composition
and the forces that have subsequently acted upon it.
Insights as to its source as a material for human use may
be derived from the geological formation which produced
it and the subsequent natural forces of transportation
which have acted upon it.  It is sometimes possible to
predict the source of a material from its geological ori-
gin.

## 3.1  The Precambrian Era

Rocks thousands of millions of years old form the
basement complex of northern Saskatchewan.  They are of
igneous, sedimentary and metamorphic origin.  Hundreds
of millions of years later glacial action ground down
the former mountains thus exposing many kinds of rocks
and transporting the detritus in a general south-westerly
direction into southern Saskatchewan.

Although the territory of the Canadian Shield is

outside the scope of this thesis, some of the rocks derived from it are of interest. Small amounts of quartzite, vein quartz and basalt were glacially transported to parts of southern Saskatchewan and were used for coarse chipped tools.

A pattern of lithic distribution for Saskatchewan (such as that done by Shetsen [1984] for southern Alberta) has yet to be undertaken, so it is not possible to relate a specific variety of glacially transported rock to its source in the Shield. It can only be noted that, as a matter of personal observation, quartzite, vein quartz and basalt are minimally present in west-central and central Saskatchewan but are apparently absent from most of eastern Saskatchewan.


## 3.2 The Cretaceous Period

During Cretaceous times much of Saskatchewan was inundated by vast inland seas which left a series of sediments (Byers et al, 1969:45).

Whereas the European chalk beds of the late Cretaceous period are well known for the flint they contained there is no evidence that such flint nodules were formed in Saskatchewan at this time. Cretaceous deposits in Saskatchewan, although generally devoid of lithic material suitable for chipping, do yield two distinctive materials.

One is a dense black, fine-grained material that will be
called "Gronlid siltstone." This material was found to
be present as nodules and lenses in a glacially trans-
ported mass of bedrock shale which is exposed a few kilo-
meters north of Gronlid. Foraminifera microfossils in
this shale suggest, but do not prove, an origin from the
Turonian Favel Formation (Second White-Speckled Shale).
[David McNeil, personal communication 1986]. Another ex-
ception is the silicified siltstone pebbles which occur
in western areas. They are present in some strandline
deposits of the western shores of what were probably
Bearpaw seas.

## 3.3   The Tertiary Period

During the Tertiary Period several useful materials
were either formed in or transported into southern Sas-
katchewan. Some of these materials are indigenous to
the deposits formed during a specific epoch.

In the Paleocene Epoch, which lasted from about 65
million years B.P. to 54 million years B.P., fine-grained
sediments were borne from the western mountains and formed
the Ravenscrag Formation of southern Saskatchewan. This
formation, as described by Kupsch (1956:24-27), consists
of silts, sands and clays, intercalated in places with
seams of lignite. None of these materials can be chipped

into tools. However, combusting coal beds fused the shale of the walls and vents into a hard, fine-grained material. This fused shale has been exposed near Rockglen, Big Beaver and Estevan.

The Eocene (54 million years B.P. to 35 million years B.P.) melds into the Oligocene (35 million years B.P. to 23 million years B.P.). The uplift of western mountains caused geological events that have been well described by Vonhof (1969). Vigorous rivers flowed north-easterly from what is now northwestern Montana and bore gravels from the Belt Formation into the Cypress Hills and Swift Current regions of Saskatchewan. These areas that are now uplands were river beds at that time. These gravels that now cap the Cypress Hills uplands are known as the Cypress Hills Formation and they consist mainly of quartzite. These quartzite cobbles are distinctively rounded and many bear circular or crescentic scars resulting from multitides of impacts during swift fluvial transport. Other materials such as silicified wood, porphyry and argillite are among these gravels but as far as is known none of these materials were used for making chipped tools.

The Miocene Epoch lasted from 23 million years B.P. to 4.5 million years B.P. The fluvial transport of gravels from northwestern Montana into southwestern Saskatchewan continued into the Miocene Epoch. The lithology of the gravels is similar to that of the Cypress Hills

Formation but the average size of the rounded clasts is significantly smaller. Miocene gravels comprise the Wood Mountain Formation which caps the plateau south of Rockglen. This plateau was not traversed by the Wisconsin glacier so it must be a relict of Tertiary deposits.

Quartzite cobbles and pebbles are abundant in the Wood Mountain Formation, but also present are siliceous replacements of wood and peat. Small fragments of silicified wood are relatively common, and tree stumps of over a meter in height have also been recovered. Nodules of silicified peat over .5m in length have been observed.

This thesis proposes that the silicified peat and silicified wood were formed in the locality after the deposition of the Wood Mountain gravels. The Wood Mountain gravels are well-rounded and have cortical chatter marks. The silicified wood and silicified peat tend to fracture easily and show no signs of rounding, hence, they could not have been transported for any significant distance by the same fluvial action that brought the quartzite. If the area was not glaciated then this material could not have been brought in by that means.

The Pliocene Epoch lasted from 4.5 million years to 1.5 million years ago. As deposits from this period are not recognized in Saskatchewan it will not be considered. Storer (1978:600) indicates that the Hand Hills Plateau of Alberta is Pliocene; deposits capping this plateau

yield a fine-grained lithic material known as Hand Hills
agate.

Exposed Tertiary deposits in southern Saskatchewan
were a source of several lithic materials that were
utilized by prehistoric people for chipped tools. Quart-
zite was abundant, and significant amounts of feldspathic
siltstone, silicified wood, silicified peat and fused
shale were also available.

## 3.4   The Quaternary Period

The Quaternary Period consists of the Pleistocene
and Holocene Epochs. The several ice ages of the Pleisto-
cene lasted from about 1.5 million years ago until glacial
retreat. Deglaciation took place in Saskatchewan some
10,000 to 20,000 years before present. The continental
glaciers of this period ground down the Canadian Shield
and transported the debris in a general south-westerly
direction. This drift constructs the landforms of south-
ern Saskatchewan with the exception of parts of the Cy-
press Hills which were lightly glaciated, and an area
south of Rockglen which was not traversed by the last
glacial event, the Wisconsin. The Quaternary was not a
rock-forming period, but it is of interest because some
rocks that could be chipped were transported from the
Shield into the area of this study.

CHAPTER 4

METHODS OF EXAMINATION

4.0  Introduction


This chapter will be concerned with the methods of
examination of lithic materials, especially those that
describe properties that are useful for identification
or which, in some way, indicate the value of a material
for making chipped artifacts.

Even though scientific geology has a long history
as a source of background information for archaeology,
many aspects of petrology (the branch of geology dealing
with the origin, occurrence, structure and history of
rocks) have been relatively neglected.  On this subject
Kempe and Templeman state:


> Today a wide variety of physical and chemical
> techniques exist which can assist the archaeologist
> in establishing the nature and provenience of his
> artifacts.  They range from simple physical tests,
> which require little or no special equipment and
> give results easily interpreted by the layman, to
> complex and esoteric methods, which often need

elaborate apparatus and considerable experience to
obtain and interpret meaningful results... (Kempe
and Templeman, 1983:26).


Tests for hardness and specific gravity are simple,
and are non-destructive if a scratch is acceptable.  Thin-
section microscopy and chemical analyses provide the most
important information about a lithic material but they
require special equipment and considerable interpretive
skill.  The petrographic microscope, which has been used
as a tool of analysis since the latter part of the 19th
century, can give important information about the composi-
tion of a lithic material by determining crystal forms
and optical properties.  "Wet" chemical analysis analysis
has also a long history as a reliable method but it is
being replaced by modern spectrographic techniques.

In selecting a test one must be concerned with the
kind of information that is required and the destructive-
ness of the test.  Thin-section analysis requires the de-
struction of a small amount of material, but it is capa-
ble of providing a great deal of information about the
composition of a material.  Most chemical analyses also
require the destruction of material.  Unless a small por-
tion can be removed and sacrificed, as has been done in
studies of European stone axes, such tests may not be
acceptable for artifact analyses.

A fine-grained lithic material, such as obsidian or chalcedony, may not be sufficiently distinctive under thin-section examination to relate it to a specific source but chemical analyses may make it possible. The presence of distinctive trace elements, or distinctive combinations of elements, may make it possible to relate a specimen to a known source.

Physical and chemical tests are valuable to obtain basic information about a lithic material, but the identification of some materials in artifacts or hand specimens may be accomplished by visual examination alone. Some rocks have features that make identification relatively easy, but many are difficult to identify unless further tests can be made. Identification is largely a matter of comparing an unknown variety with a known one and the greater the number of features in common, the greater the probability that the two are of the same variety.

Each lithic material of this study was examined with the objective of deriving information that will assist the archaeologist to identify it and to understand its properties. Apart from the similarity of the quartzites, little problem can be expected in distinguishing between the varieties themselves. However, some materials of this study may resemble an exotic variety. For example, the best quality of silicified peat may resemble Knife

River flint, and some fused shale and some siltstones
may resemble jasper. Jasper, an impure chalcedony, can
not have visible spherical pores as does fused shale, and
it will patinate whereas siltstones do not. Tests, such
as heating to 300°C, will enable one to distinguish be-
tween materials that are basically chalcedonic silica and
those that are not. Attention will be drawn to special
identifying features of each variety or rock in this
study.

## 4.1 Nomenclature of Lithic Materials

There are systems in several fields for naming lithic
materials. Minerals may be named by an international com-
mittee; the Commission on New Minerals and New Mineral
Names of the International Mineralogical Association.
Rocks may be named according to a type exposure or forma-
tion. Unfortunately for the matter of nomenclature, most
of the rocks that were used for chipping do not have type
exposures and only one, quartz, is a mineral. Thus, many
of them have been named by common usage or by first de-
scriptive publication. Unidentified fine-grained rocks
are commonly called "chert" or some other general name
but further examination may enable one to apply a more
specific name. Three of the rock varieties in this study
are siltstones and, with the exception of Gronlid silt-

stone, two of them are called descriptively "feldspathic siltstone" and "silicified siltstone pebbles," the third has been called "Gronlid siltstone."

In this report, the definition of chert by Pettijohn will be followed. He says:

> Chert is a dense rock composed of one or several forms of silica—opal, chalcedony (microcrystalline fibrous quartz), or microcrystalline quartz. It has a tough, splintery to conchoidal fracture. It may be white, or variously colored gray, green, blue, pink, red, yellow, brown and black (Pettijohn, 1975: 394).

This definition for chert excludes detrital rocks such as sandstones and siltstones. Although a chalcedony may be regarded as a variety of chert, any material that consists mainly of chalcedonic silica will be called chalcedony. The identities of sub-varieties of chalcedonly are based on colour or banding. Reddish colours may be called carnelian, brownish ones sard, and greenish chalcedony may be called chrysoprase or prase.

Because of the variety of meanings attributed the term "flint" it will not be applied to materials in this study except where it is part of a generally accepted name. This practise is in accord with the view expressed

by Pettijohn (1975:394). It is commonly applied to
European chalcedonies, and some regard flint as a "dark
coloured chert."

Although silica can replace many materials this re-
port will consider only those that have some significance
for chipped stone industries. Many cherts are replace-
ments of carbonate rocks or have been deposited contem-
poraneously with them. Silica replacements of wood, peat
and lignite will be called "silicified wood," or "silici-
fied peat" except where a proper name has been applied
or is in common use.

## 4.2 Prehistoric Use

The most important aspect of studies of an archae-
ological lithic material is the way it was used by pre-
historic people. It is apparent that there are temporal
as well as spatial differences in material use. Also,
some materials were used mostly for projectile points
and minimally for knives and scrapers. Other materials
were made into cutting and scraping tools but not points.
Different technologies are apparent from a study of arti-
facts and chipping residue. For example, some groups
practised thermal alteration while others did not, some
groups understood pebble splitting better than others,
some materials were shaped only by percussion methods

and rarely, if ever, by pressure flaking.  These matters
will be discussed more specifically as aspects of each
lithic material.


4.3  Specific Gravity


Specific gravity is the ratio of the weight of a
specimen in air compared to that of an equal volume of
water at room temperature.  A simple balance is used for
this determination and the procedure consists of weighing
the specimen in air, and then in distilled water at room
temperature.  From these measurements the specific gravi-
ty can be calculated.  When used for identification, the
specific gravity of the unknown material is compared
with specific gravities of known materials.  This test is
inexpensive, non-destructive and quick, but its utility
is limited because  many materials that can be chipped
consist mainly of chalcedonic silica or quartz.  Quartz
has a specific gravity of 2.65 and chalcedonies are
slightly lower (2.55 to 2.60), hence an accurate test
might distinguish between quartz and chalcedony but it
would not distinguish between varieties of chalcedony.
Opal, which may resemble chalcedony, is significantly
lighter (s.g. = 2.0-2.25), hence a specific gravity test
could distinguish between them.

## 4.4 Hardness

Hardness refers to the relative ease with which a material can be scratched.  The Mohs hardness scale represents a sequence of common minerals in order of increasing hardness as follows:

| | | | |
|---|---|---|---|
| 1. | talc | 6. | orthoclase |
| 2. | gypsum | 7. | quartz |
| 3. | calcite | 8. | topaz |
| 4. | fluorite | 9. | corundum |
| 5. | apatite | 10. | diamond |

The Mohs scale is useful for materials other than minerals but it can only indicate relative hardness.  Its usefulness lies in that it is very inexpensive, it is only very mildly destructive and can be used in the field.  Because of the narrow range of hardness of members of the chalcedony group, which are all very close to 7, it is of no value to distinguish between them.  However, opal has a hardness of 5-6, hence a scratch test may allow one to distinguish it from chalcedony which it resembles.  Ignimbrite, argillite and obsidian are about 6, hence they can be distinguished from members of the chalcedony or quartz varieties by scratch tests.

The Knoop test is capable of measuring hardness in

a quantitative way. The process consists of pressing a
diamond point into the specimen; the hardness of the spec-
imen is inversely related to the length of the indenta-
tion. This measurement along with the applied pressure
can give a quantitative value for hardness by means of
tables. The disadvantage of the Knoop test lies mainly
in the expensive machine that is necessary to do it.
Also, the size of the specimen is limited to about 3cm,
and the test can only be applied to a polished surface,
hence its value is limited for purposes of lithic identi-
fication. Knoop tests done by the Department of Mechani-
cal Engineering at the University of Saskatchewan indi-
cated a slight decrease in hardness of chalcedonies after
heating, but no change in the hardness of siltstones.
This is not conclusive but it gives support to the idea
that changes in mechanical properties take place upon
heating chalcedony but not other rock varieties.


4.5  Fracture and Chipping Quality


To be suitable for chipping, a rock must be hard,
brittle and free from inherent cleavage planes and from
fractures or other flaws that are unduly limiting. Ma-
terials that are glassy or fine-grained may have these
required properties and they can be rated according to
the ease with which they can be chipped.

Chipping refers to the process of applying a force to an appropriate platform on suitable rock so that a spall is removed. Failure in tension along the face of separation allows its removal. The chipping quality of a rock is one of the most important variables that determine the nature of spalls that can be removed by a specific process. The successful removal of a spall is also dependent on tool qualities such as hardness and shape, the direction and velocity of the force, and the degree of immobilization of the objective piece. A chipped artifact is formed by the removal of a succession of spalls in a planned manner. In general, a flint knapper will want to remove flakes that are long and thin compared to their thickness. This is so because thin artifacts are generally preferred to thick ones; hence desired flakes must be long compared to their thickness.

The evaluation of chipping quality was assessed according to these factors: (i) the tendency of flakes to be long compared to their thickness; (ii) the force required to remove a flake of given dimensions; (iii) the tendency of flakes to terminate in a certain way—feather termination is desired and step or hinge fractures are not; and (iv) the ability to sustain compressive force without crumbling as when applied to a small pressure platform.

Efforts to develop scientific, reproducible tests

of chipping quality have been made but they are inevitably
hampered by the lack of a useful theory of fracture.
Bonnichsen (1977) used a mechanical device which he
called a "stainless steel Indian" by means of which chip-
ping force could be varied and measured.  Bleed and Meier
(1980:502-507) tumbled uniformly shaped blocks of differ-
ent lithic materials and compared the sizes and weights
of flakes that were knocked off each material.  In prac-
tise, the evaluation of materials is done by experimental
chipping according to the above criteria.

The empirical assessment of chipping quality will
always be important but it may be possible to relate
measurable properties to chipping quality.  Some measur-
able properties are:  compressive and tensile strengths,
the ratio of stress to deformation, and elasticity.

Obsidian is one of the easiest materials to chip; it
rates high in the criteria outlined.  Chalcedony requires
somewhat more force than obsidian but, because the term
encompasses a wide range of materials, it is difficult to
apply anything more than a general relative rating.
Quartz crystal rates lower than chalcedony as it tends to
be brittle and it is not mechanically isotropic, that is,
flakes do not separate uniformly in all directions.  On
the more difficult end of materials that can be chipped
are the detrital rocks such as quartzites.  Basalts vary
widely—the fine-grained and glassy varieties chip quite

well, but coarser varieties are so tough that they make
excellent hammers.

The prehistoric flint knapper was commonly compelled
by circumstances to use whatever material was at hand
which, if it was tough to chip, resulted in artifacts
that may be regarded as crude. By means of stone-chipping
experiments inferences can be made about which materials
would be preferred for certain kinds of tools. It is ap-
parent that certain complexes required materials that
were of a very good quality in order to make artifacts
such as the finely-chipped Eden points or the Pelican
Lake points with deep, narrow notches. On the other hand
the sturdy basally-notched McKean points are commonly
made from materials that would not have been used for
points by other cultural complexes.

Specimens of lithic materials studied in this re-
search were fashioned into the types of tools and pro-
jectile points that were used by prehistoric people of
Saskatchewan. Where necessary, hard percussion was used
to split a pebble or cobble or to remove a large flake to
serve as a blank. Soft percussion modes for thinning
were done by a portion of antler stalk. Pressure flaking
by an antler time or portion of rib was used to finish
the artifact. The quality of a heated specimen was com-
pared with that of one in the natural state.

## 4.6  Changes in Properties due to Heating

It has been known for some time in archaeology that some properties of certain varieties of rock could be changed by heating.  It has been observed that some rocks became easier to chip and that this improvement was accompanied by a more vitreous appearance of scars of flakes removed after heating.  A change in colour sometimes accompanied these changes, but colour change is independent of changes in mechanical properties.  Thermal alteration is of interest as an aspect of prehistoric technology, but it is also culture-specific in that it was practised by some cultural complexes but not by others.  The ability to transform a tough material into one that can be more readily chipped widened the range of availability of lithic materials and facilitated the manufacture of better tools and weapons.  Because lithic materials respond in different ways to heat, the nature of the response (or lack of tangible response) can be used as a feature of classification.  As will be explained, chalcedony undergoes changes in properties when heated to 300°C, but materials that are not chalcedony do not.  The search for an explantion for this phenomenon has intrigued lithic experimenters such as Crabtree as well as many archaeologists.

Purdy and Brooks (1971:322-325) did an early, in-

depth research on the effects of heat on Florida chert
and other materials.  They concluded that:  "The critical
temperature for Florida chert is about 350°C to 400°C"
and that over 1100 ppm of iron was necessary for a colour
change to be caused.  Their explantion for the smoother
flake scars of altered lithic material was that the
grains of microcrystalline quartz were held more firmly
together in heated specimens.  They reasoned that fusion
had taken place at this very low temperature due to the
eutectic effect of impurities even though it was under-
stood that the melting point of quartz is over 1700°C.

Mandeville (1973:177-202) agrees with Purdy and
Brooks that impurities are the key to understanding
thermal alteration.  He expresses concern that the melt-
ing point of any of the impurities expected in chert is
too high for them to melt, but assumes that the lower
eutectic temperature of combinations may produce a "flux."
The disappearance of water in heated specimens is not re-
garded by Mandeville as a cause of change in properties,
but as a "peripheral phenomenon."

The eutectic flux explanation for changes in proper-
ties of some lithic materials must be questioned.  The
discrepancy between the melting temperature of silica
(over 1700°C) and the observed temperature of property
change is much too great to be explained by a eutectic
lowering.  Even if a solid state interaction could occur

between the silica and unspecified impurities, it would seem to be impossible for the marked changes in mechanical properties to be produced in the very short time which is necessary to cause a change in properties.

4.6.1 Experiments in thermal alteration were carried out as part of this research. Several independent variables must be taken into account when experimenting with thermal alteration of lithic materials. They are: the material type, the temperature range of the experiments, and the length of time for the application of heat. The materials selected for the experiment included: Knife River flint, Brandon (England) floorstone, Swan River chert, silicified wood, silicified peat, fused shale, quartzite, obsidian, Montana agate, and other agates and jaspers.

An electric oven designed for hobby enamelling and the burning out of investments in lost wax metal casting was used to apply heat in a controlled manner. The electric input can be adjusted by very small increments to regulate the rate of temperature rise. A pyrometer indicates the temperature in the top of the oven. Electrical input was adjusted to raise the temperature of the oven from room temperature to 300°C in approximately 90 minutes, and temperature was stabilized at 300°C for approximately 15 minutes. In order to minimize localized heat

shock the specimen of rock was wrapped in light sheet
copper. Even though the pyrometer registers accurately,
a polished steel strip was placed in contact with the
lithic specimen undergoing heating. The colour of the
oxide indicated the highest temperature that the specimen
reached during heating. A pale yellow indicated a temper-
ature of 226°C, and a dark blue indicated 298°C. Other
colours indicated intermediate temperatures (Johnson,
1980:82-88).

A hand held antler pressure flaker was used to re-
move spalls from the samples. Heated specimens were com-
pared with unheated specimens of the same material and
differences in the ease with which flakes could be re-
moved; differences in the lustre of new flake scars, and
differences in colour were observed.

The class of materials that showed significant
changes in properties included chalcedonies of chemical
or biogenic deposition (Knife River flint and Brandon
flint), chalcedonies of replacement (silicified wood and
silicified peat), chalcedonies of cavity filling (agates),
and chalcedonies of uncertain origin (jaspers). The
classes of rocks that were unchanged by heating include
detrital varieties such as quartzites and siltstones,
igneous rocks such as obsidian and basalt, and those of
other origin such as fused shale. The lack of response
of Swan River chert indicates that it consists mainly of

quartz rather than chalcedonic silica.

These experiments support the hypothesis that chalcedonic silica is the active component of rocks whose flaking quality can be improved by heating to 300°C. Experiments of heating chalcedonies to higher temperatures indicate that they deteriorate in quality by becoming too weak, and many cracked and shattered at higher temperatures.

An archaeological question remains regarding how prehistoric craftsmen attained this narrow temperature target. To be sure, not all chalcedonies were commonly heated. Knife River flint does not need heat treatment, nor do other high quality materials such as Brandon floorstone. On the other hand, tough materials such as silicified peat were nearly always heated before pressure flaking. A prehistoric craftsman, before heating a piece of rock, would have to weigh the chances of benefit against the risk of utterly ruining it unless he had great confidence in attaining the right temperature.

Contemporary experimenters bury lithic material under an intended fire pit. With experience it is possible to gauge matters such as depth and soil composition, and the duration of the fire in order to beneficially effect the chipping quality. Archaeological evidence that this method was actually practised by prehistoric artificers seems to be lacking. It is possible to anneal chalcedony

by holding a flake with tweezers of green wood near a
bed of hot coals. It is also possible to test the temper-
ature by the reaction of organic material such as hair
against the heated flake.

## 4.7  Petrographic Analyses

The petrographic microscope is designed to study
the crystal structure and optical properties of rocks
and minerals in thin-section. The identity of the speci-
men can be deduced from the information thus obtained.
However, glasses such as obsidian and some chalcedonies
are difficult to analyse as they lack a crystalline
structure. However, contained crystallites in some ob-
sidians make identification possible. Even with these
limitations, petrographic analysis is an essential pro-
cedure for analysing archaeological lithic materials.

Thin-section slides were made of each variety of
lithic material studied in this research and the analyses
of these slides provided information that was, for the
most part, not hitherto available. Some materials that
had been called cherts or quartzites were found to be
siltstones; organic substances that had been replaced by
silica were identified; and differences between Tertiary
and Quaternary specimens of quartzites could be distin-
guished.

## 4.8  Chemical Analyses

The chemical analysis of a rock will indicate the concentration of major elements (those that are greater than 2%), minor elements (from 2 to 0.01%), and trace elements (less than .01%).  The major elements determine the character of the material, while the trace and minor elements may help to ascertain its identity and even its source.  Clough and Cummins (1979) demonstrate how chemical analyses have made it possible to identify sources of the materials of stone axes in Europe.  However, they indicate that, at that time, the chemical analysis of flint was not sufficiently advanced to enable them to identify its sources.

Qualitative and quantitative analysis of rocks by the wet method has been almost entirely superseded by physical methods such as optical emission spectrometry, atomic absorption spectrometry, X-ray fluorescence spectrometry, and by neutron activation analysis (Tite, 1972: 259).

The compositions of rocks studied in this thesis were determined by the Geochemical Laboratory of the Saskatchewan Research Council by ICP/AA procedures described by Kempe and Harvey (1983:42-43).  The results of these analyses are presented in Table 1.  The determination of $SiO_2$ is not particularly accurate by these methods and

| Oxides | Montana Agate | Siltstone Pebble | Siltstone Pebble | Siltstone Pebble | Feldspathic Siltstone 1 | Feldspathic Siltstone 2 | Tertiary Quartzite | Knife River Flint patina only | Knife River Flint no patina | Gronlid Siltstone 1 | Gronlid Siltstone 2 | Silicified Peat | Swan River Chert | Dark Brown Fused Shale | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $P_2O_5$ | 0.010 | 0.020 | 0.010 | 0.150 | 0.050 | 0.040 | 0.010 | 0.000 | 0.000 | 0.020 | 0.010 | 0.020 | 0.020 | 0.180 | % |
| MnO | 0.011 | 0.002 | 0.002 | 0.002 | 0.017 | 0.020 | 0.002 | 0.001 | 0.001 | 0.020 | 0.002 | 0.002 | 0.003 | 0.160 | % |
| $TiO_2$ | 0.010 | 0.100 | 0.070 | 0.070 | 0.260 | 0.310 | 0.020 | 0.000 | 0.000 | 0.010 | 0.010 | 0.010 | 0.010 | 0.710 | % |
| $Al_2O_3$ | 0.100 | 0.100 | 3.100 | 1.900 | 12.10 | 12.00 | 0.600 | 0.300 | 0.400 | 0.900 | 0.430 | 0.500 | 0.600 | 17.50 | % |
| $Fe_2O_3$ | 0.530 | 0.010 | 0.590 | 0.150 | 1.590 | 1.530 | 0.100 | 0.010 | 0.010 | 0.320 | 0.350 | 0.120 | 0.050 | 6.880 | % |
| $Na_2O$ | 0.120 | 0.040 | 0.380 | 0.470 | 4.280 | 4.290 | 0.440 | 0.430 | 0.480 | 0.200 | 0.295 | 0.140 | 0.200 | 1.170 | % |
| CaO | 0.110 | 0.040 | 0.080 | 0.080 | 0.510 | 0.550 | 0.080 | 0.090 | 0.090 | 0.120 | 0.387 | 0.070 | 0.030 | 7.420 | % |
| MgO | 0.050 | 0.020 | 0.150 | 0.060 | 0.390 | 0.310 | 0.010 | 0.010 | 0.010 | 0.020 | 0.010 | 0.010 | 0.010 | 5.040 | % |
| $K_2O$ | 0.020 | 0.020 | 0.430 | 0.180 | 2.170 | 2.340 | 0.060 | 0.010 | 0.010 | 0.030 | 0.056 | 0.010 | 0.020 | 3.780 | % |
| Total | 0.971 | 0.352 | 4.812 | 3.062 | 20.28 | 21.39 | 1.322 | 0.901 | 0.991 | 1.680 | 1.560 | 0.882 | 0.943 | 42.84 | % |

Elements

| | Montana Agate | Siltstone Pebble | Siltstone Pebble | Siltstone Pebble | Feldspathic Siltstone 1 | Feldspathic Siltstone 2 | Tertiary Quartzite | Knife River Flint patina only | Knife River Flint no patina | Gronlid Siltstone 1 | Gronlid Siltstone 2 | Silicified Peat | Swan River Chert | Dark Brown Fused Shale | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mo | 10 | 51 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 5 | 18 | 5 | 17 | ppm |
| Zn | 25 | 16 | 7 | 1 | 20 | 21 | 4 | 1 | 1 | 35 | 25 | 4 | 2 | 103 | ppm |
| Cr | 737 | 171 | 68 | 18 | 20 | 18 | 4 | 2 | 4 | 15 | 2 | 5 | 1 | 81 | ppm |
| V | 5 | 60 | 84 | 22 | 16 | 19 | 3 | 3 | 3 | 38 | 17 | 2 | 2 | 94 | ppm |
| Be | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | ppm |
| Cu | 14 | 8 | 4 | 2 | 3 | 2 | 1 | 1 | 1 | 12 | 9 | 5 | 4 | 33 | ppm |
| Zr | 23 | 61 | 30 | 49 | 110 | 150 | 43 | 48 | 56 | 48 | 22 | 53 | 53 | 169 | ppm |
| Y | 1 | 3 | 7 | 5 | 20 | 20 | 4 | 2 | 4 | 2 | 2 | 7 | 10 | 37 | ppm |
| La | 1 | 1 | 6 | 8 | 103 | 88 | 5 | 1 | 1 | 16 | 1 | 2 | 2 | 39 | ppm |
| Th | 3 | 3 | 4 | 5 | 11 | 25 | 3 | 3 | 3 | 2 | 1 | 8 | 15 | 18 | ppm |
| Sr | 5 | 26 | 22 | 54 | 110 | 102 | 13 | 3 | 2 | 28 | 14 | 12 | 9 | 99 | ppm |
| Ba | 12 | 515 | 395 | 1414 | 823 | 734 | 288 | 30 | 27 | 262 | 26 | 280 | 20 | 788 | ppm |
| Co | 9 | 2 | 2 | 2 | 2 | 5 | 1 | 3 | 1 | 2 | 1 | 2 | 2 | 20 | ppm |
| Ni | 335 | 56 | 17 | 4 | 11 | 5 | 6 | 6 | 6 | 14 | 15 | 1 | 2 | 27 | ppm |
| Pb | 45 | 5 | 9 | 2 | 15 | 9 | 5 | 3 | 3 | 15 | 2 | 6 | 4 | 28 | ppm |
| Cd | 1 | 1 | 1 | 3 | 3 | 1 | 1 | 1 | 4 | 1 | 1 | 1 | 1 | 1 | ppm |
| C | | | | | | | | | | | | 1.5 | | | % |
| S | | | | | | | | | | | | 0.41 | | | % |
| Total ppm | 1227 | 1980 | 662 | 1596 | 1273 | 1205 | 387 | 113 | 122 | 495 | 144 | 396 | 133 | 1558 | ppm |
| Total ppm=% | 0.12 | 0.20 | 0.06 | 0.16 | 0.13 | 0.12 | 0.04 | 0.01 | 0.01 | 0.05 | 0.14 | 0.04 | 0.01 | 0.16 | % |
| Total impurities | 1.09 | 0.55 | 4.87 | 3.22 | 20.4] | 21.51 | 1.36 | 0.91 | 1.00 | 1.73 | 3.60 | 0.92 | 0.95 | 43.00 | % |
| $SiO_2$ | 98.91 | 99.45 | 95.13 | 96.78 | 79.59 | 78.49 | 98.64 | 99.09 | 99.00 | 98.27 | 96.30 | 99.07 | 99.05 | 57.00 | % |

Table 1. Chemical Analyses

they do not measure water, carbon or sulfur. In these
tests, the percentage of $SiO_2$ was calculated by subtract-
ing the total of all other materials from 100%. In
addition to the ICP/AA tests, the carbon and sulfur con-
tents of Gronlid siltstone were also measured.


4.9  Colour


Colour is the most striking property of most rocks
but it is not always a reliable means of identification.
Its limitations lie in the variety of colours that may
occur within a specific rock type and numerous materials
may have a given colour range.

Chromophores such as Fe, Mn, Cr, Co, Ni and U may
impart distinctive colours as do certain ionic groups.
Hematite is a very common impurity that imparts a red
colour, but iron sulfides produce black. Heat causes
some iron compounds to change colour to a reddish hue.
Multitudes of very minute cavities in milky quartz dis-
perse the light so as to impart a whitish appearance.
The black colour of some English flints is said to be
due to finely dispersed carbon particles, but this is dis-
puted by Shepherd (1972:23).

Colour may be a useful identifying feature if its
range for a specific variety of rock is known. For some
rocks this range is wide indeed as fused shale may occur

in yellow, red, brown, green, grey and black, or a single
piece may show several of these colours.  On the other
hand, Swan River chert may only be white or light shades
of practically all colours except green.  A wide range of
colours in a variety of rock indicates that it is chemi-
cally complex.

Colour charts such as Munsell are capable of indica-
ting the intensity of a colour as well as its hue.  It
has not been applied in this thesis because of the diffi-
culty in applying it to rocks that are not uniform in
colour.  Colours given are a matter of personal judgment.

## 4.10  Lustre

The reflectivity of a surface depends on the nature
of the material and the regularity of its surface condi-
tion.  Although some minerals have metallic, silky or
pearly lustres, these qualities are unlikely to be en-
countered in lithic materials that can be chipped.  Their
lustre may be classified as:

    vitreous - having the lustre of glass

    waxy - having a dull lustre such as that of wax

    earthy - not lustrous such as shale

Lustre is useful in rock identification.  Obsidian is
immediately recognizable because of its vitreous lustre.
A rock that consists mainly of chalcedony will usually

have a waxy lustre in its natural state, but heating to a certain range will cause fresh flake scars to be quite lustrous, even glassy.  The natural lustre may be increased by external factors such as use or sand polish.

4.11  Texture

The texture of a rock describes the micro-relief of an unweathered or unaltered surface of a break not controlled by joints or residual platy structures.  It depends on the following factors:  (Pettijohn, 1975:24-99)

(1) grain size

(2) grain shape

(3) degree of crystallinity (from glassy to
crystalline)

(4) contact relationship of the grains.

Texture terminology depends somewhat on the genesis of the rock.  Igneous rocks may be described as aphanitic where separate grains cannot be distinguished by the unaided eye; or phaneritic where separate grains can be visually distinguished.  Also, the texture may be holohyaline (glassy) in which separate grains are not formed.

Chalcedony has a characteristic smooth, fine-grained texture regardless of the way it was formed.  The presence of anhedral, subhedral or euhedral quartz in cherty rocks usually imparts a rough texture to fractured surfaces

such as is common in Swan River chert.

Sandstones have a distinctly granular texture, but the intergrowth of sand grains in many quartzites makes it difficult to recognize grains as separate entities. Quartzites fracture with a rough texture that depends on the sizes of the grains and the processes of lithifaction.

4.12  Structure

Whereas texture describes the grain-to-grain relationship within a rock or the absence of visible grains, structure refers to the larger features such as bedding, flow banding, parting and brecciation. Ideally, the brittle rocks that are suitable for chipping into artifacts are massive, nevertheless, the structure of a rock may provide clues for its identification. For example, silicified peat commonly has a distinctive structure of sub-parallel parting planes and some silicified woods have planes of weakness along growth rings. Vugs or cavities lined with quartz crystals are distinctive structural features of some rocks.

Spherical cavities in a rock indicate that it is of igneous origin or has undergone a melting process. Commonly basalts have such a structure, and small spherical voids may enable one to identify fused shale. Although chalcedony can have sub-microscopic pores, those that

are visible with low magnification or by the naked eye
are invariably irregular.  The distinctive shapes of
voids enable one to visually distinguish between jasper
and fused shale.

## 4.13  Cortex

The cortex is the naturally formed exterior layer of
a nodule.  The cortex often has differences of colour,
texture and structure that set it apart from the basic
material of the nodule.  Some rocks do not display a cor-
tex, but other varieties have a cortex sufficiently dis-
tinctive that it is a useful feature of identification.
Pristine nodules of Knife River flint commonly have a
light-coloured, opaque cortex that contains relict plant
forms, and Tertiary cobbles commonly have cortical impact
scars which are highly distinctive.  Cortex ought not be
confused with caliche, a carbonate that forms and adheres
to a rock under certain soil conditions, nor is cortex a
patination which is an external layer of the material
that has become altered.

## 4.14  Patination

Patination refers to environmentally induced visible
changes, usually a whitening, of surface layers.  As some

rock varieties patinate and others do not, they can be classified accordingly. Those that patinate can be classed according to the rate and nature of the change. The reasons for patination are not well understood but it is apparent that different materials may patinate for different intrinsic reasons and under different circumstances.

The patination of chalcedony is of special interest to archaeology. Van Nest (1985:336) offers this explanation for the patination of Knife River flint which is basically a chalcedony: "Dissolution of silica is seen to be an important process acting to produce the optical effect we perceive as patination." Chemical analyses of Knife River flint and its patina, as shown in Table 1, show virtually the same composition and give support to the concept of Van Nest. That chalcedonic silica is porous, as explained by Folk and Weaver (1952), and that it is soluble in water, as stated by Frondel (1962:154), also support the solubility hypothesis. However, observations of patinated Knife River flint artifacts indicate that more information is necessary regarding the processes that cause patination. Recently exposed nodules of Knife River flint are not patinated, nor are projectile points of it that are of types less than about 2000 years old. Many have observed that Cody artifacts are commonly heavily patinated and that patination may be present on one or both sides. One may assume that if conditions within the

soil were the only factors causing patination then such artifacts would be uniformly patinated on all sides. These observations do not discount the solubility theory, but suggest that other factors—exposure and time—are also necessary.

4.15   Special Identifying Features

Distinctive features may aid in the identification of some fine-grained lithic materials.  These features may be structural such as pores or vesicles, vugs, phenocrysts, fossils or healed fractures.  They may also be diaphaneity, triboluminescence, or unusual colourations.

Rapidly cooled igneous rocks commonly contain spaces left by bubbles of gas.  Some of these vesicles, as in basalt, may be quite large and subsequently become occupied by other materials.  Spherical pore spaces, sometimes discernible only with the aid of magnification, indicate that the rock had undergone melting and relatively rapid cooling.

Chalcedony cannot have visible spherical voids, but it can have ones that are irregular.  Irregular voids, called vugs, may be distinctive, and in some rocks they are lined with drusy quartz.  Drusy vugs are common in Swan River chert and are one of its identifying features. Geodes of agate were formed by the filling of voids by

chalcedony in rock such as basalt.  Such geodes commonly
have a lining of quartz crystals.

Some chalcedonies were formed by the replacement of
other minerals or organic material by silica, hence
pseudomorphs of crystals and plant forms may provide
features of identification.  Silicified wood is a replace-
ment of wood cells by silica.  Knife River flint, which
is regarded as a replacement of lignite, may contain fos-
sils of plant material as does silicified peat.  Fossils
of marine organisms are present in many European flints
and in Gronlid siltstone.

A distinctive feature of some rhyolites and many in-
trusives are phenocrysts.  They are usually of feldspar
which fuses at a high temperature and thus forms crystals
at an early stage of cooling.  The light coloured inclu-
sions in some nodules of Knife River flint are apparently
unique to that variety of rock and their presence enables
one to identify it with some confidence.

Diaphaneity refers to the ease with which one can
see through a material.  Most lithic materials are trans-
parent to translucent in thin-section, and diaphaneity
varies inversely with thickness.  Unless the thickness
of a material be given and the amount of light transmitted
per unit area be measured, diaphaneity can only be des-
cribed in rather imprecise terms.  In this thesis four
grades of diaphaneity are used.

#1  Transparent:  as clear as window glass; objects can be clearly discerned on the other side.  Quartz crystal has this rating.

#2  Translucent:  admits the passage of light but objects on the other side cannot be clearly discerned.  Colourless Montana agate and light coloured Knife River flint are examples.

#3  Slightly translucent:  the edges of thin flakes transmit light.  Dark Knife River flint would be an example.

#4  Opaque:  no light is transmitted, even along flake edges.  Basalt is an opaque material.

When certain lithic materials are vigorously rubbed or crushed, light is produced on the contacting surfaces. This light is called "triboluminescence" and it is due to concentrations of electrons which leap across the space between the faces under stress.  This phenomenon can also be observed when cutting with a diamond saw.  Unlike the spark produced by striking with steel, the light produced is cold.  This property is displayed by relatively few rocks such as quartz and sphalerite, hence it may be of value as an identifying feature.  Quartzites are strongly triboluminescent, chalcedony slightly less so, but this property is absent in obsidian and in most other rocks of archaeological interest.  To test for triboluminescence, portions of the same material may be rubbed together and its presence or absence observed in darkness or low light.

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## 4.16 The Shapes and Sizes of Rocks

The shape of a pebble or cobble may be likened to a regular geometric shape such as a sphere, ellipsoid, cylinder, cube or prism, but in general, shapes are difficult to describe. A quality that is apart from shape is roundness which applies to the sharpness of edges and corners of clastic fragments. This property is useful in describing the form of a rock. Pettijohn (1975:56-57) classifies this feature as: angular, subangular, subrounded, and well-rounded. Roundness comparisons have some value in distinguishing between quartzite cobbles of Tertiary and those of Quaternary deposits. Tertiary cobbles, in general, are well-rounded whereas those of Quaternary deposits are generally subangular to subrounded. Hence, shape may be used to indicate the probable source of a quartzite cobble.

Pettijohn (1975:30) gives the following size ranges for rocks:

| | |
|---|---|
| boulder | 256mm and over |
| cobble | 64mm to 256mm |
| pebble | 4mm to 64mm |

This classification, which follows the Wentworth scale, will be used to indicate size ranges in this

thesis. The size of clasts or nodules of lithic material
as well as their shapes controlled the kind of artifact
that could be made from them.

## 4.17  Known Sources

Apart from fused shale which occurs as a bedrock
outcrop, all other materials described in this thesis
are secondary deposits and have been transported by na-
tural action from their primary sources. Figure 2 shows
known sources of lithic materials of this study. The
map shows only those locations where I have observed
specimens of material that I was confident had occurred
there naturally. Nodules that showed signs of human
working did not necessarily indicate that their prove-
nience coincided with their natural deposition and were
not considered.

As previously mentioned, the distribution of some
materials by glacial action aggravates the problem of
defining a source. Swan River chert was particularly
troublesome in this regard. It is apparent that it was
widely transported by humans but pristine nodules were
observed only at the places indicated which are the
Armit River region, the Coronach district, and a gravel
pit north of Preeceville.

Gronlid siltstone can be ascribed with some confi-

dence to the Turonian Favel Formation of the Upper
Cretaceous. Much of this formation was ground up by
glacial action and the siltstone was distributed in a
region that so far lacks clear definition. The discovery
of a plate of it near Wynyard and the report by artifact
collectors that it was observed in the vicinity of Lake
Lenore indicates that there was a small but possibly
significant deposit in that area.

Figure 2 represents a simplification of the map of
Bedrock Geology from Richards and Fung (1969:46-47). It
shows some Tertiary exposures which, as has been pointed
out, yield specific varieties of rock studied in this
thesis. A shaded area indicates possible sources of
quartzite in the Shield, but this is admittedly imprecise
and probably not complete. It purports to indicate that
quartzite, as found in glacial drift in southern Saskatch-
ewan, could have come from many places in a very wide
area. It must suffice at this time to indicate that some
rocks that could be usefully chipped had their origin in
the Shield and were transported to southern Saskatchewan
by glacial action.
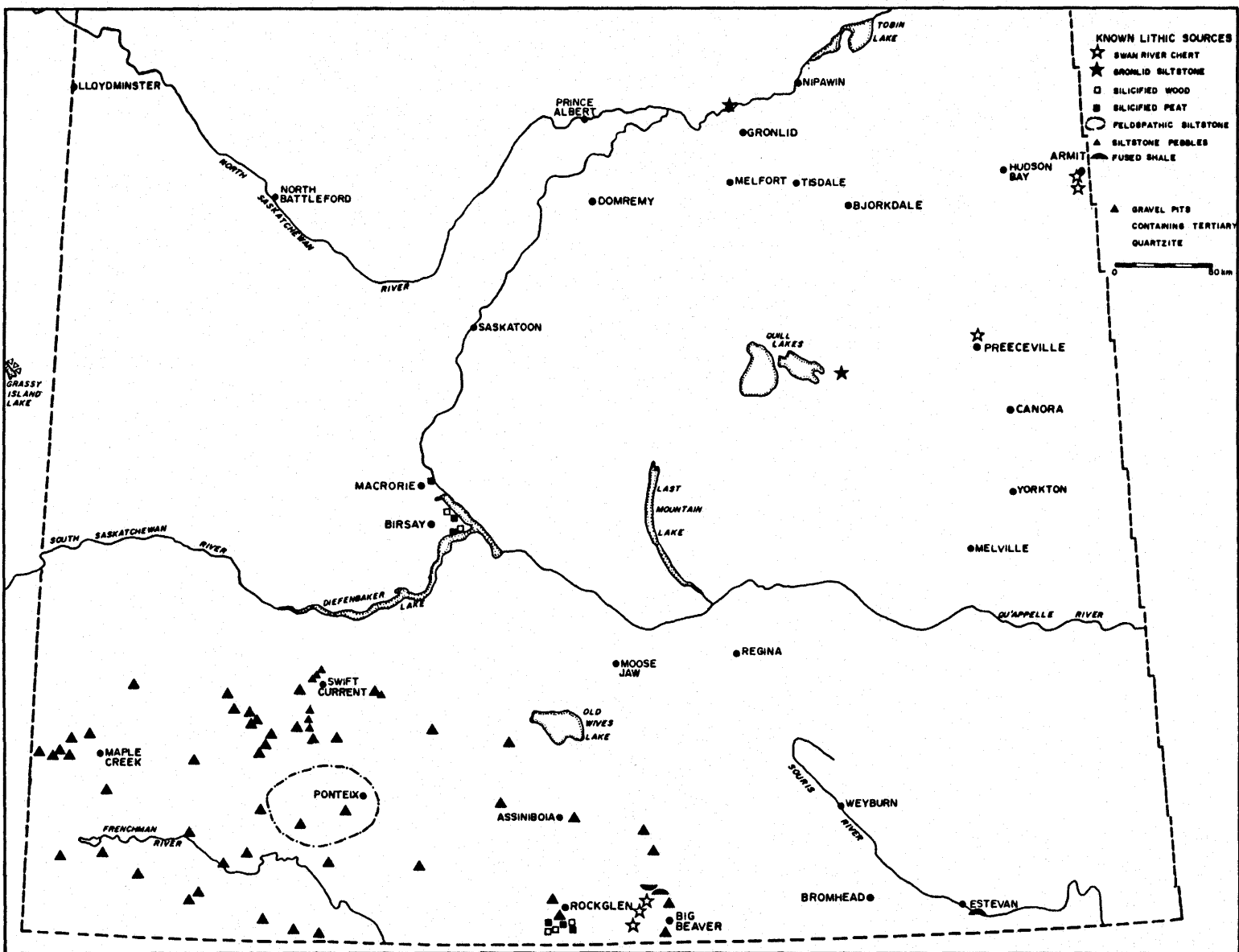
Figure 2. A map of southern Saskatchewan indicating known sources of lithic materials of this study.

CHAPTER 2

DESCRIPTIONS OF LITHIC MATERIALS OF THIS STUDY

5.0  Introduction

This chapter consists of a presentation of the information derived about each of the nine varieties of rock examined in this research.

5.1  Athabasca Quartzite

1)  Name:  This rock is simply known as quartzite.

2)  Prehistoric use:  Quartzite is the most common lithic material in archaeological sites in southwestern Saskatchewan but it is much less common to absent in sites in east-central areas.  It was used for coarser tools such as choppers and scrapers but was very rarely made into projectile points.  Grooved mauls were made from cobbles which had suitable sizes and shapes, and unmodified and slightly modified cobbles were used as percussors.

3)  Specific gravity:  2.65

4)  Hardness:  7

5)  Chipping quality:  This quartzite is tough, and

detritus from chipping indicates that hard percussion was the main mode of manufacture.

6) Response to heating to 300°C:  No change in properties, except reddening of some specimens.

7) Petrographic analysis:  Tests of specimens EJ-5 and EJ-6 from Boutin's gravel pit at Domremy indicate that they were derived from a metamorphic source area (C. Gilboy, personal communication, 1986).

8) Chemical analysis:  Not available.

9) Colour:  Tan and white are the most common colours, mauve is also present.

10) Lustre:  Fractured quartz sand grains have a glassy lustre.

11) Texture:  Fractures have a rough texture and individual sand grains usually cannot be distinguished.

12) Structure:  Massive, occasionally with colour banding.

13) Cortex:  This material does not have a distinctive cortex.

14) Patination:  This material does not patinate.

15) Special features:  Strong triboluminescence.

16) Size and shape of clasts:  Clasts range from pebble to boulder size; the typical shape is subangular to subrounded (Pettijohn, 1975:57).

17) Source:  The primary source of this quartzite is the Precambrian Shield of northern Saskatchewan.  Expo-

sures of psammites (which include quartzites) are shown
by Whitaker and Pearson (1972) in the vicinity of Wollas-
ton Lake and Geikie River, and in an area east of LaRonge.
Glacial flow was in a general south-westerly direction,
thus quartzite was transported as part of the glacial
drift to southwestern Saskatchewan.

## 5.2  Rocky Mountain Quartzite

1)  No specific name has been applied to this variety
of rock; it is simply called "quartzite."

2)  Prehistoric use:  Quartzite artifacts and flakes
are common in archaeological sites in southern and western
Saskatchewan.  Artifacts of quartzite consist mainly of
coarser tools, but some projectile points were made from
this variety.

3)  Specific gravity:  2.6+

4)  Hardness:  7

5)  Chipping quality:  In general this quartzite is
tough, but fine-grained specimens can be shaped by soft
percussion and by pressure flaking.

6)  Response to heating to 300°C:  None, apart from
reddening of rocks that contain iron compounds.

7)  Petrographic analysis:  A specimen indicates
that sand grains maintain their individual nature, thus
suggesting sedimentary formation.

8) Chemical analysis: +98% silica; minor elements are P, Ti, Al, Fe, Na, Ca, Mg, K and Ba. Trace elements are also present.

9) Colour: Tan is most common, but white, shades of blue, grey, purple and pink also exist.

10) Lustre: Fractured sand grains have a glassy lustre.

11) Texture: Sand grains are well-sorted but individual grains usually cannot be distinguished without magnification.

12) Structure: Massive, colour banding is common.

13) Cortex: Because these rocks have been fluvially transported a considerable distance from their primary source, they have well polished surfaces. A significant proportion show impact scars, also called percussion marks, which are vestiges of Hertzian cones resulting from innumerable forceful impacts against other rocks. Their presence indicates high velocity flow in a rocky environment (Pettijohn, 1975:63).

14) Patination: This rock does not patinate.

15) Special identifying features: Symmetrical, well-rounded shapes; impact scars; slightly translucent; strongly triboluminescent.

16) Size range and shapes of typical rocks: The size ranges from pebble to boulder; clasts are typically symmetrical and well-rounded.

17)  Known sources:  The uplands of the Cypress Hills
are capped by gravels transported in Eocene-Oligocene
times by fluvial action from the Belt Formation in north-
ern Montana.  These gravels are mainly quartzite whose
composition and transportation have been described by
Vonhof (1969).  The gravels that cap much of the Wood
Mountain area are of Miocene deposition, and likewise
consist mainly of quartzite but are generally of a smaller
size range.  These materials were transported from the
southwest by vigorous fluvial action due to western up-
lift at a time when the elevations of the Cypress Hills
and Wood Mountains were possibly much lower than their
present-day heights.  Gravel deposits such as those west
of Ponteix on SW 31 T9 R12 W3 and north of Cadillac on
NW 17 T10 R13, and east of Buffalo Gap on SW 2 T2 R26 W2
have been reworked by glacial action yet consist predomi-
nantly of Tertiary quartzite.  Mollard (personal communi-
cation, 1984) has indicated that Tertiary gravels in the
form of gravel deposits of commercial significance are
present in a block consisting of townships 1 to 8 in
ranges 22 to 30 west of the 2nd meridian, and a block
consisting of townships 1 to 16 in ranges 1 to 30 west of
the third meridian (see Figure 2).

The abundance of quartzite in Tertiary deposits can
account for its presence in most sites in southwestern
Saskatchewan.

## 5.3  Swan River Chert

1) Name: Swan River chert derived its name from Swan River, Manitoba where it was observed as a distinctive lithic material. There is no essential relationship between Swan River chert and the Swan River Formation. The report by Campling (1981:291-301) on Swan River chert will provide the basis for this section.

2) Prehistoric use: Even though Swan River chert is rather difficult to work and nodules are commonly unsound due to many voids, it has been used by all the prehistoric cultural complexes that have occupied southern Saskatchewan with the apparent exception of the fluted point traditions. Swan River chert was used for the manufacture of all types of projectile points common to this area and for choppers and cutting and scraping tools as well. The dominance of Swan River chert as a lithic material in east-central Saskatchewan is shown by the high proportion of it in collections from this area. The proportion of it dwindles in collections that are farther south and farther west. The collection of S. Durr of Bromhead consists of artifacts mainly of Knife River flint; very few are of Swan River chert. Similarly, the collection of H. Liboiron of Ponteix contains very few that are of this material. It is estimated that about 2% of artifacts from central and west-central Saskatchewan are made

from Swan River chert.

The large amount of detritus of Swan River chert on the Campbell strandline of Lake Agassiz, where it meets the Armit River, indicates that natural deposits of it had been abundant in the vicinity, and the abundance of coarse flakes and shatter indicates that extensive reduction and probably tool manufacture had been done there. Swan River chert flakes comprise the most obvious archaeological residue in many fields and sites in east-central Saskatchewan, and cores of Swan River chert in western Saskatchewan, where pristine nodules have not been found, strongly indicate an extensive pattern of human transportation far from its known source.

3) Specific gravity: Variable due to porosity, about 2.6

4) Hardness: 7

5) Chipping quality: Generally, Swan River chert is difficult to chip. Fine-grained varieties chip reasonably well, but the more crystalline varieties are very difficult to work.

6) Effects of heating to 300°C: No improvement in flaking quality has been observed due to heating.

7) Petrographic analysis: Campling has noted the tri-modal crystallinity of Swan River chert and makes this statement about it:

Swan River chert is macroscopically variable but microscopically distinctive. Under cross polarized light, it exhibits a tri-modal crystallinity of granoblastic quartz, chalcedony spherulites and anhedral crypto-crystalline quartz. Varieties of chert not exhibiting this crystallinity are not considered to be Swan River chert (Campling, 1981: 301).

From the thin-sections of two specimens, Gilboy (personal communication, 1986) has observed that there are several distinct generations of quartz.

8) Chemical analysis: 99% silica, minor elements are P, Al, Ti, Fe, Na, Ca, Mg and K. Several trace elements are also present.

9) Colour: Swan River chert is mainly light colored but there may be cortical tinges of black. Shades of pink, orange, grey and blue are common, and it may have mottled colours or banding.

10) Lustre: The fractured surfaces of quartz crystals have a glassy lustre; fine-grained specimens have a waxy lustre.

11) Texture: The texture ranges from very fine-grained to coarsely crystalline.

12) Structure: Most Swan River chert is porous and vuggy. Vugs are commonly lined with subhedral quartz

crystals. The best grade is amorphous and is usually pink in colour.

13) Cortex: Swan River chert does not have a distinctive cortex.

14) Patination: Swan River chert does not patinate.

15) Special identifying features: Light colour, drusy vugs and crystalline texture. Opaque and strongly triboluminescent.

16) Size range and shape of typical nodules: Cobble to boulder. Nodule shape is angular to subrounded.

17) Known sources and geological origin: Campling describes a material which has wide variability and which occurs naturally in a large area which has yet to be reasonably well defined. No formation has so far been discovered which yields _in situ_ nodules of Swan River chert in bedrock outcrop, hence there are problems in giving this variable material a real identity. The wide distribution of Swan River chert in glacial drift exacerbates the already difficult problem of identity.

It is generally assumed that Swan River chert is a replacement of limestone or that it was formed by cavity filling in the limestone which has since disappeared. The location of its formation is uncertain but it was probably in west-central Manitoba and the chert nodules were transported southward and westward by glacial action. Campling (1980:292) states: "It [Swan River chert] is

especially abundant in archaeological deposits in the re-
gion west of Lakes Manitoba and Winnipegosis." Unworked
nodules of Swan River chert have been observed in the bed
of the Armit River and its vicinity. Cobbles have been
recovered from a gravel pit north of Preeceville and from
piles of rocks collected from fields in the vicinity of
Coronach. Boulders of Swan River chert have been observed
in the riprap lining the banks of the causeway over the
Little Poplar River. It must be concluded that these
specimens of Swan River chert were deposited in this area
by glacial action rather than by human transport. The
presence of Swan River chert is very uneven as it appeared
to be absent from gravels at Canora. The actual sources
of Swan River chert that existed must have been very sub-
stantial and it is possible that in some areas this re-
source has been entirely depleted by prehistoric users.
It is apparent that better quality material was heavily
exploited because the only nodules that can be found to-
day are very low grade.


5.4  Silicified Peat


1)  Other names:  Petrified bog, silicified lignite,
South Saskatchewan River chalcedony, petrified wood and
sard.

2)  Prehistoric use:  The utility of silicified peat

for projectile points is limited by its inherent parting planes, hence large points are rare. Projectile points classified as Duncan, Hanna, Pelican Lake, Besant, Avonlea, and late side-notched made of silicified peat have been recovered as well as numerous cutting and scraping tools. Artifacts made from silicified peat are common in sites along the shore of Lake Diefenbaker, and are present in many collections in southern Saskatchewan. A distant recovery of this material was made at an Avonlea site at Turtle Lake. This material was usually heated before pressure flaking. There is evidence that nodules were subjected to heat which caused them to disintegrate into thin fragments. These thermally altered fragments could then be pressure flaked to form artifacts.

3) Specific gravity: 2.59

4) Hardness: 7

5) Chipping quality: Even though natural silicified peat is fine-grained it is tough to chip. Sound portions have a good conchoidal fracture. Inherent parting planes may limit the usefulness of the material in any specific nodule but, on the other hand, where the parting planes were suitably spaced and reasonably parallel, they permitted a nodule to be separated into thin pieces that could be shaped by pressure flaking without resort to percussion modes.

6) Response to heating to 300°C: Heating silicified

peat to 300°C permits a reduction in the force required to remove a flake of a given size and there is less tendency for hinge fractures to occur; fresh flake scars will be lustrous and the cortex may take on a reddish hue.

7) Petrographic analysis: Thin-section specimen EJ-6 is described as follows:

Under crossed polars, the rock is seen to be made up of a very fine-grained mosaic of quartz crystals with intermittent thin layers dominantly composed of flaky minerals—probably illite. Granular opaque minerlas of unknown composition are concentrated along foliation planes cutting across the foliation. Several ovoid patches of coarser-grained silica may represent silicified organic matter. A veinlet of fibrous quartz is oriented sub-parallel to the planar fabric of the rock (Gilboy, personal communication, 1986).

8) Chemical analysis: A chemical analysis of silicified peat showed 98% silica. There were 280 ppm (parts per million) of barium, 0.5% of $Al_2O_3$, 0.12% of $Fe_2O_3$, 0.14% of $Na_2O$, and small amounts of other metals and ions.

9) Colour: The range is from a greyish tan to dark brown.

10) Lustre: Waxy in the natural state to glassy

Sweet are the uses of adversity;

Which, like the toad, ugly and venomous,

Wears yet a precious jewel in his head;

And this our life; exempt from public haunt,

Finds tongues in trees, books in running brooks,

Sermons in stones, and good in everything.


William Shakespeare.  <u>As</u> <u>You</u> <u>Like</u> <u>It</u>.  ActII, Scene 1

after heating.

11) Texture: Fine-grained.

12) Structure: Silicified peat typically separates along irregular, sub-parallel parting planes which may be so close and so irregular as to render the material nearly useless for the manufacture of chipped artifacts. Fossil plant forms are commonly recognizable in the material as well as in the cortex. Vugs and other voids have not been observed.

13) Cortex: Commonly a tan coloured cortex is present on unworked nodules. Fractured nodules will usually have this cortex on opposite parallel faces thus indicating that the material was formed as a bed. Portions of fossil plants may be discerned in this cortex which has some resemblance to that of Knife River flint.

14) Patination: Silicified peat patinates to a white to creamy colour which is commonly mottled or uneven. It is assumed that exposure to atmospheric conditions for an extended period of time is necessary to induce patination as freshly exposed clasts or nodules are not patinated. Pelican Lake type points and those that are older are usually patinated but more recent types do not have patination.

15) Special features: Irregular parting planes, plant fossils in cortex, strong triboluminescence.

Slightly translucent to opaque.

16)  Size and shape of nodules:  Tabular nodules of
silicified peat of over 500mm have been observed.  How-
ever, most silicified peat represents fragments of such
nodules, and they are commonly of cobble size.

17)  Source and origin:  Naturally deposited nodules
and clasts of silicified peat have been observed (i) south
of Rockglen, (ii) on portions of the western shore of Lake
Diefenbaker, and (iii) in gravel deposits in the vicinity
of Macrorie.

Although it might be assumed that silicified peat was
transported from northern Montana as part of the Tertiary
gravels, there is good reason for inferring that it was
formed _after_ this deposition.  Vonhof (1965) and (1969)
has convincingly explained the geological reasons for the
presence of the gravels that cap the uplands of the Cy-
press Hills Formation and the Wood Mountain Formation.
He states that western uplift of the Rocky Mountains
caused vigorous rivers that transported gravels, which
consist mainly of quartzites, from northern Montana into
the region of southwestern Saskatchewan.  These events
took place during the Eocene-Oligocene and Miocene Epochs
of the Tertiary Period.  The clasts thus transported are
well-rounded and many show the circular scars derived
from innumerable impacts against other rocks.  Whereas
the fluvially-transported gravels borne from northern

Montana are well-rounded, the nodules of silicified peat
show no evidence of battering and are sometimes of con-
siderable size. Broughton (1976:1719) reports clasts
that have an area of .28 m². Fragments of nodules are
angular and in no way show the rounding and battering of
fluvial transport. Furthermore, the tendency of silici-
fied peat to separate into thin layers argues against
the fluvial transport of intact pieces for any signifi-
cant distance. The Wood Mountain uplands were not modi-
fied by the Wisconsin glacier and they show none of its
deposits. It must be assumed that silicified peat was
formed, more or less _in_ _situ_, in the Wood Mountain region
in post-Miocene times, and that it was not transported
there by either fluvial or glacial action. Murata (1940:
586-596) has described the role of volcanic ash as a
probable factor in the replacement of organic material
by silica, and Crawford (1955) has noted the presence of
pumicite near Rockglen and at other places in southern
Saskatchewan. A reasonable hypothesis is that silicified
peat, which may now be found amongst the Wood Mountain
gravels, was formed at some time after their deposition,
but the presence of this material in the Birsay-Macrorie
district awaits a more detailed geological explanation.

## 5.5  Silicified Wood

1)  Names:  Sometimes called petrified wood or aga-
tized wood.  If the rock was formed by the replacement
of the wood cell structure by silica, "silicified wood"
is preferable to the term "petrified wood" because the
latter includes replacement by materials other than sili-
ca such as carbon or goethite.

2)  Prehistoric use:  Silicified wood is relatively
common in archaeological sites in southern Saskatchewan
both as artifacts and as chipping debris, but it is un-
certain how much of the material is from a source within
Saskatchewan.  Two distinct varieties of silicified wood
have been observed and it is probable that intermediate
varieties exist.  The distinction lies in the form of
silica in the replacement; it may be in the chalcedonic
or the quartz polymorph.  The chalcedonic-replacement
variety is of good quality and was used for projectile
points and for cutting and scraping tools, but the extent
that the quartz-replacement variety was used is quite un-
certain.

3)  Specific gravity:  2.56-2.60

4)  Hardness:  7

5)  Chipping quality:  The chalcedonic silica variety
of silicified wood chips quite well even if not heated,
but heating makes it chip much easier.  The flaking

quality of the quartz replacement is very poor as it is very tough and the material separates in a blocky way so that pieces of a usable size and shape are exceedingly difficult to obtain.

6) Effect of heating to 300°C: Chalcedonic silica replacements become easier to flake, flake scars are more lustrous, and shades of brown become somewhat redder. Heating the quartz replacement variety has no apparent effect on chipping qualities.

7) Petrographic analysis: A thin-section analysis of specimen "Rockglen 1" (a chalcedonic silica replacement) includes the following statement:

The original wood's fine-laminated texture is well preserved.

Specimen "Rockglen 2" (mainly a quartz replacement) shows a more clearly defined cell structure; the quartzitic nature of the cell replacement is indicated by the following statement:

Open vugs in the rock are lined first by finely-radiating quartz crystals upon which are developed either large, clear quartz crystals with euhedral terminations facing into open space or, when vugs are completely infilled, polygonal, unstrained

quartz grains (Gilboy, personal communication, 1986).

8) Chemical analysis: Not available.

9) Colour: Chalcedonic silica pseudomorphs after wood are generally translucent and may be white or have shades of brown or grey. Annual growth layers may not be apparent in hand specimens. This material resembles agate, hence may be called "agatized wood."

Much more common than the wood replaced by chalcedonic silica is the variety which has been replaced by quartz. Its colour is commonly shades of brown or grey, it is usually opaque, annual growth rings are prominent and usually represent planes of weakness. Commonly sparkles from minute subhedral quartz crystals can be discerned. As previously stated it is uncertain that this variety was used for chipped tools.

10) Lustre: The chalcedonic silica replacement variety (agatized) has a waxy lustre, but that of the quartz-replacement type may be waxy but it also has sparkles from the reflection from its subhedral quartz crystals.

11) Texture: Chalcedonic silica replacements have an amorphous texture; those of quartz replacement commonly have a gritty or granular texture.

12) Structure: Chalcedonic silica replacements usually do not separate along annual growth layers but

they may have random fractures. On the other hand, the quartz replacements separate along growth rings in such a way as to make the value of this material very limited or even useless for chipping purposes.

13) Cortex: Neither variety of silicified wood has a distinctive cortex.

14) Patination: Chalcedonic silica replacements patinate to a white or creamy white upon exposure to atmospheric conditions. Silicified woods formed by quartz replacement do not patinate.

15) Special features: It is justifiable to apply the term "silicified wood" to a lithic material if a wood structure can be recognized either microscopically or macroscopically.

16) Nodule size: Chalcedonic silica pseudomorphs of wood have been recovered that have a maximum dimension of 30cm and a weight of 10kg. This is not to say that such pieces are sound throughout. Quartz replacement tree stumps of a meter in height have been recovered south of Rockglen and small fragments of this material are common on uplands in the vicinity of Eastend.

17) Sources and geological formation: The Wood Mountain Formation south of Rockglen is well known as a source of silicified wood. It is impossible for it to have been transported by fluvial action to its present-day provenience, and it is unlikely that it was brought there

by glacial action. Therefore, the best _a priori_ hypothe-
sis regarding the presence of silicified wood in the
Rockglen area is that it was formed approximately _in situ_
at some time after the deposition of the fluvially trans-
ported gravels of the Wood Mountain Formation. It is
possible that the silicified wood was formed at the same
time and due to similar conditions as was silicified peat.

## 5.6  Silicified Siltstone Pebbles

1) Names:  Quigg (1978) refers to "pebble cherts;"
Pierce and Hunt (1937:242) call them "chert pebbles,"
They are also called "black pebbles."

2) Prehistoric use:  The maximum size of these
pebbles limits the type of artifact that can be made from
them.  Small to medium-sized projectile points and end-
scrapers are common in artifact collections from western
Saskatchewan.  Recoveries have been made of silicified
siltstone points of Oxbow type and of all later cultural
complexes that occupied this region.

The first necessary step in chipping these pebbles
was to split them through their major axes.  Knowledge of
how to do this was not possessed by all the groups who
used them, and to judge by the detritus from working them,
this skill may be culture-specific.  A poor technology re-
sulted in many orange-segment shaped fragments and a high

proportion of unusable pieces.  A successful technology shows evidence of a high proportion of splits through the major axes of pebbles.  The desired result is to split a pebble to produce similar halves, or at least to drive off a long, thin spall.  These portions can then be shaped by pressure flaking to form tools or projectile points.  The pitting on some stone mauls suggests that they were used as anvils for pebble splitting.

3)  Specific gravity:  2.55 to 2.61

4)  Hardness:  7

5)  Chipping quality:  After having been split, a pebble can be pressure flaked without undue difficulty, and feather-terminated flakes can be removed.

6)  Response to heating to 300°C:  No change in mechanical properties was observed.

7)  Petrographic analyses:  Analyses of thin-sections of specimens EJ-1, EJ-2, EJ-3 and EJ-4 indicate that these pebbles are silicified siltstone rather than chert.  Silica has replaced other materials in some places, and traces of zircon, probably chlorite, probably epidote and apatite have been observed (C. Gilboy, personal communication, 1986).

8)  Chemical analyses:  These siltstone pebbles are high in silica—95% to over 99%.  Barium is a prominent minor element—up to 0.14%; $Al_2O_3$ ranges from 0.10 to 3.1% and $Fe_2O_3$ from 0.01% to 0.59%.  Many other metals

and metal oxides are also present as shown in Table 1.

9) Colours: The most common colour is black throughout, but grey or brown pebbles are also present. Some pebbles have a black coating and interiors of green, grey, tan, pink, red, yellow or mauve.

10) Lustre: Dull waxy.

11) Texture: Mostly amorphous, but some pebbles have a very fine-grained texture.

12) Structure: Massive, with no vugs, inclusions or parting planes.

13) Cortex: With the exception of the relatively few pebbles that are grey or brown, and those that are black throughout, silicified siltstone pebbles have a dense black cortex that is one to two millimeters in thickness. Pierce and Hunt (1937:244) suggest that this coating is black iron oxide. Pebble surface is well polished.

14) Patination: This material does not patinate.

15) Special features: The well-rounded ellipsoidal shapes are distinctive as is the cortex. The material is opaque, and is not triboluminescent.

16) Size and shape: The pebbles are of "pebble" size (i.e. up to 64mm maximum dimension), and the typical shape is a flattened ellipsoid.

17) Known sources: Silicified siltstone pebbles are sparsely present in the glacial drift of parts of

west-central Saskatchewan. They are fairly abundant on the shore of Grassy Island Lake which is east of Compeer, Alberta; many have been split or broken by human action. Quigg (1977) describes other areas in the Neutral Hills that yield these pebbles. Pierce and Hunt (1937:244) describe "chert pebbles" in Eagle sandstone and the Claggett shale of Montana.

Although black pebbles are common in some horizons of the Viking Formation, there is no reason to assume that they are the same as the silicified siltstone pebbles used as a prehistoric lithic material. Regarding the origin of the silicified siltstone pebbles it seems probably that they are part of an ancient formation and that they were washed down from western uplands during Cretaceous times and are now found in the gravels of the strandlines of these ancient seas (W.O. Kupsch, personal communication, 1967).

## 5.7 Gronlid Siltstone

1) Names: It has been called "altered felsic lava" and Meyer and Carter (1978:88) referred to "River House chert" that is probably Gronlid siltstone but this name has not come into common use. The name "Gronlid silt-stone" is applied in this thesis because of the bedrock erratic containing this siltstone which was discovered

north of Gronlid.

2)   Prehistoric use:   Projectile points are the
most common type of artifact made from Gronlid siltstone
and the oldest type recognized is Oxbow.   It was also
used for knives and scrapers.   The greatest proportion
of Gronlid siltstone in collections is in those of east-
central Saskatchewan.   For example, 2% of artifacts in
the collection of A. Campbell of Bjorkdale are made from
it.   An Oxbow point of Gronlid siltstone has been re-
covered from eastern Alberta and artifacts made from it
are present in collections from central and western Sas-
katchewan.

3)   Specific gravity:   Not available.

4)   Hardness:   6

5)   Chipping quality:   Gronlid siltstone is rather
brittle, but long, thin, feather-terminated flakes can be
removed by soft percussion and hand-held pressure modes.

6)   Response to heating to 300°C:   No discernable
change in properties, but nodules freshly exposed from
the shale bedrock emit a rubbery odour upon heating.

7)   Petrographic analyses:   The grey siltstone which
embeds the black Gronlid siltstone has the striking micro-
scopic feature of clear circular patches which consist of
a single, clear carbonate crystal.   Some of the carbonate
has been replaced by silica, but the groundmass is mainly
made up of microcrystalline carbonate.

Regarding the "cherty layer" (Gronlid siltstone)
Gilboy states:

This is texturally similar to the adjacent silt-
stones, especially in that the dominant microscopic
features are clear circles (cross-sections of
spheres), which here are made up almost entirely of
quartz, with microcrystalline rims enclosing coarser-
grained, radiating-fibre interiors. All the carbon-
ate in the siltstone groundmass has been replaced by
pale brownish microcrystalline silica, with opaques
and dusty ore minerals about as abundant as in un-
silicified areas (C. Gilboy, personal communication,
1986).

8) Chemical analysis: A specimen of Gronlid silt-
stone consisted of 96% silica; minor amounts of $Al_2O_3$,
$Fe_2O_3$, $K_2O$, $Na_2O$ and $P_2O_5$. CaO made up 0.387%, and there
was 1.5% carbon and 0.41% sulfur. Water was not measured.

9) Colour: Dense, opaque black.

10) Lustre: Waxy.

11) Texture: Amorphous.

12) Structure: Massive, with no vugs, pores, spaces
or banding. Some specimens have small chalk specks.

13) Cortex: A light-coloured calcareous shale ad-
heres to nodules which have been recently exposed from

the bedrock.  A remnant of this shale remains on pristine

nodules as a gritty, buff-coloured cortex.  Some cortex

may remain on artifacts and, where present, positively

identifies the material as Gronlid siltstone.

14)  Patination:  Gronlid siltstone has a distinctive

patination consisting of a very fine mottling which gives

the material a grey appearance.  Freshly exposed nodules

are not patinated, but Oxbow points show patination

which indicates that exposure plus time are factors in

causing patination.

15)  Special identifying features:  Where present,

the mottled patination gives positive identification;

the gritty grey cortex is also distinctive.  The material

does not display triboluminescence and it is opaque.

16)  Size and shape of nodules:  Gronlid siltstone

was formed as lenses in the embedding shale, but tabular

masses may also have been formed.  Stresses in the shale

during glacial transportation have caused the fragmenta-

tion of nearly all nodules.  The greatest thickness known

is 50mm, and the piece with the greatest known lateral

dimensions measures 150mm by 109mm by 15mm.  This piece

was recovered from the SE-SE S27-T33-W3 but it is uncer-

tain whether its presence there is due to human or natur-

al action.

17)  Formation and source:  Recent petrographic

analyses of Gronlid siltstone indicate that it is a silt-

stone in which silica has replaced carbonate material. Minute carbonate spheres, which are probably the remains of coccolithophorid algae (Caldwell, 1982:298) are present in the enveloping shale and have been largely replaced by silica. The carbonate in the groundmass has also been largely replaced by microcrystalline silica.

Microfossils consisting of foraminifera suggest but do not prove an origin from the Turonian Favel Formation of the Upper Cretaceous and that the matrix is Second White-Speckled Shale (McNeil, personal communication, 1986).

James Finnigan, of the Nipawin Dam Archaeological Project, in 1985 reported an outcrop of shale on S24-T49-R18 W2 which yielded nodules of Gronlid siltstone. This site is on the north side of what was then the Saskatchewan River, and it lies some 32 km west of Codette. This body of shale is a bedrock erratic that has been transported by glacial action from its primary source that most likely lies in a north-east-by-easterly direction from this exposure.

Fragments of Gronlid siltstone are present in very small amounts in the glacial drift in an area that extends south-westerly from Nipawin; these small fragments have been observed as far away as western Saskatchewan.

## 5.8  Fused Shale

1)  Names:  Fused shale is sometimes called porcel-
lanite or silicified siltstone.  Of these names, "fused
shale" is preferable because of the variety of meanings
attributed to "porcellanite," a few of which are presented.
Pettijohn (1975:394) does not include fused shale among
rock varieties called porcellanite.  Although the Diction-
ary of Geological Terms (1957:338) includes "fused shale"
as one of the meanings of porcellanite, it also gives:
"A light-colored, porcellaneous rock resulting from the
contact-metamorphism of marls."  Nockolds, Knox and Chin-
ner (1978:291) state:  "Porcellanous chert or porcellan-
ite [emphasis added] is a porous rock of low density and
with dull fracture; it often contains fine clay or car-
bonate inclusions."  Kempe and Harvey (1983:177) refer to
"...a porcellanite resulting from the thermal metamor-
phism of an inter-basaltic soil horizon or bole...."
Thus, "fused shale" as a name is descriptive of the origin
of this material and is therefore preferable to a name
which simply indicates that it looks like porcelain.

2)  Prehistoric use:  Fused shale was popular for
the manufacture of projectile points and to a lesser de-
gree for tools for cutting and scraping.  A Folsom point
of fused shale was recovered from the vicinity of the
Great Sand Hills, and a Scottsbluff point was recovered

from the Napao site near Ponteix. Projectile points
made from fused shale from later complexes are relatively
common in artifact collections from southern and western
Saskatchewan. However, it is not certain how much of
this material has a source in Saskatchewan.

3) Specific gravity: Up to 2.6, depending on
porosity.

4) Hardness: 6 to 7

5) Chipping quality: Fused shale is not a uniform
material, but in general it has a good conchoidal fracture
and it can be chipped by percussion and pressure modes
to produce long, thin flakes.

6) Response to heating to 300°C: No changes in
properties have been detected.

7) Petrographic analysis: A thin-section of a
very fine-grained specimen, although clear under polarized
light, is virtually opaque under crossed polars. This
indicates that it had been converted to glass. Silt-
sized grains were barely discernable.

8) Chemical analysis: A specimen of dark brown
fused shale showed 57% silica, over 17% of $Al\ O$ , 7.4%
of $CaO$, 6.8% of $Fe_2O_3$ , 5.0% of $MgO$, and lesser amounts of
other oxides. Barium was high at 0.08%, other metals
were in the trace range.

9) Colour: Specimens vary immensely in appearance;
it can range from a light grey to black, and colours of

yellow, red, green and brown are relatively common.

10) Lustre: The lustre of fused shale may range from earthy for specimens that have not been highly heated, to glassy for those that have been heated to fusion.

11) Texture: The texture may vary from very fine granular to glassy.

12) Structure: Minute spherical voids can be detected with the aid of magnification in nearly all fused shale. Colour banding is not rare, and there may be a variety of colours in any one specimen.

13) Cortex: Outside layers may be more porous, but there is no cortex as such.

14) Patination: Fused shale does not patinate.

15) Special features: Fused shale is opaque, it is not triboluminescent, and can be distinguished from jaspers if spherical voids can be detected. The unusual colouration of fused shale may distinguish it from most other materials.

16) Size and shape of clasts: Because lumps of fused shale were broken or pried off the exposure of the main mass, they cannot be said to have any particular shape or size.

17) Known sources: Fused shale can be formed where ever coal beds combust and in doing so heat the walls of the bocanne to the point of melting. The Ravenscrag Formation of the Paleocene Era of the Tertiary provided coal

beds near the surface, hence, it is a source of fused shale in Saskatchewan.  Known exposures of fused shale are on NW 10 T3 R25 W2, and on SW 11 T3 R35 W2 and NE 1 T2 R8 W2.  The two sites northwest of the village of Big Beaver have been extensively exploited by prehistoric people.  The exposure on NE 1 T2 R8 W2 to the south of Estevan has been disturbed by the historic removal of the reddened, friable heated shale and it is uncertain that it was exploited by prehistoric people.  It can be assumed that other outcrops of fused shale have existed or still may exist in Saskatchewan in places such as along the Frenchman River valley but they have not come to my attention.

## 5.9  Feldspathic Siltstone

1)  Name:  Feldspathic siltstone is a generic name for a material which has been called quartzite, red quartzite, maroon quartzite or argillite.  As far as is known, it lacks a specific name in spite of its distinctive appearance.

2)  Prehistoric use:  Feldspathic siltstone was used for the manufacture of relatively large flaked artifacts.  The collection of Henri Liboiron of Ponteix contains Agate Basin, Hell Gap and other large points made of feldspathic siltstone.  Smaller points of Oxbow or

later types of this material have not been recognized

which indicates that percussion flaking was the main mode

of fabrication, and that pressure flaking was used mini-

mally if at all.  The most common artifact of feldspathic

siltstone is the large end-scraper which is usually be-

tween 50mm and 100mm in maximum dimension.

3)  Specific gravity:  Not available.

4)  Hardness:  6 to 7

5)  Chipping quality:  Finer-grained specimens chip

better than coarser ones.  Even the better qualities are

quite tough but they can be shaped quite well by soft

percussion.  Pressure flaking is difficult and, if one is

to judge by the dimensions and shapes of artifacts in

collections, prehistoric artisans did not use this mode

of reduction to any extent.

6)  Response to heating to 300°C:  No change in

properties has been observed.

7)  Petrographic analysis:  Gilboy (1986) presents

this interpretation of a thin-section:

About half the rock is composed of subangular to

angular detrital quartz grains which have well-

oriented long axes.  About 3 percent muscovite is

present, as well-oriented flakes, along with about

5 percent fresh to weakly-altered, multiply twinned

plagioclase (probably albite).  The remainder of

the rock is made up of fine-grained quartz and
clay minerals, as well as, possibly, altered feld-
spar, and about 3 percent opaque are grains which
also show parallel orientation of their long axes
where their shapes are not equant (C. Gilboy, per-
sonal communication, 1986).


8)   Chemical analysis:  A specimen of feldspathic
siltstone had 79% silica; 12% $Al_2O_3$, 4.29% $Na_2O$, 0.07%
barium, and other oxides and elements that are mostly in
the trace range.

9)   Colour:  Maroon is by far the most common colour,
but cobbles of a grey colour have been recovered.

10)   Lustre:  The basic material has a low lustre,
but unweathered fractures display small sparkles from
mica flakes.

11)   Texture:  Fine-grained, individual grains cannot
be discerned without magnifiation.

12)   Structure:  Macroscopically massive.

13)   Cortex:  Feldspathic siltstone does not have a
distinctive cortex, but many cobbles show impact scars
resulting from vigourous fluvial transport.

14)   Patination:  No patination, but weathered sur-
faces lose the mica sparkles displayed by fresh fractures.

15)   Special features:  Mica sparkles on fresh frac-
tures vanish on weathering.  Hertzian cone impact scars

on some cobbles.

16) Size and shapes of clasts: Clasts are mostly in the cobble size range; they are typically well-rounded.

17) Known sources: Feldspathic siltstone is a sedimentary rock consisting mainly of silt-sized particles. Feldspathic siltstone is present in Tertiary gravels which originated in the Belt Formation in northern Montana and were fluvially transported into southwestern Saskatchewan during Eocene-Oligocene and Miocene Epochs (Vonhof, 1969). This material is not particularly abundant but it is present in small but significant amounts in gravels in the Ponteix district and to a lesser extent in Tertiary gravels of other areas.

## DISCUSSION

Early immigrants to Saskatchewan must have been dismayed by the scarcity of lithic material suitable for chipping. Although quartzite is abundant in some areas, the fine-grained chalcedonies and like materials are very scarce and usually not of high quality. Lithic materials are an important source of information for archaeology and it is desirable in an early step in this type of research to distinguish between exotic and indigenous lithic materials. Because the indigenous lithic varieties are few in number and their properties are distinctive this task is made relatively easy in Saskatchewan.

This study has determined that in southern Saskatchewan there are nine archaeologically significant varieties of rock that can be usefully chipped. As part of the research their identities have been established by means of petrographic analysis. The corresponding macroscopic properties useful for the identification of materials in artifacts and hand specimens have been described. Also, the source and geological context of each material has been indicated, with the reservation that the provenience of most glacially distributed materials remains ill-defined.

The quest to identify lithic variety led to an examination of the main components of materials that can

be usefully chipped. Silica, as quartz or chalcedonic
silica, is a major constituent of most of these materi-
als. Although the concept of a distinction between
quartz and chalcedonic silica is by no means new, it has
rarely been applied to archaeological lithic materials.
This thesis proposes that chalcedonic silica is a poly-
morph or variety of silica distinct from quartz. This
theory largely originated as a result of the observation
that some silica materials undergo a change in proper-
ties upon heating quite different from that of quartz.
Many prehistoric artisans knew, and recent experimenters
have discovered, that heating causes some rock to be
easier to chip. My own experiments indicated that a
temperature range of 250°C to 300°C caused changes in
properties of rocks that consisted mainly of chalcedonic
silica. By distinguishing between quartz and chalcedonic
silica, it becomes possible to predict that only those
materials which consist mainly of chalcedonic silica
would become easier to chip upon heating.

Intrinsic information about a lithic material at a
site begins with its identification. An expanded way of
examining amorphous and fine-grained materials has been
presented in this research. These materials are commonly
difficult to identify and in many instances probability
is all that can be achieved. But the more features that
are observed, the greater the accuracy of identification.

If a lithic material at a site can be related to a
specific source, some information can be given about the
users of that material. Silicified siltstone pebbles at
a Saskatoon site, for example, indicate that the users
had contacts far to the west. The varieties of lithic
materials at a site may indicate whether the occupants
had recently arrived, or whether they had been able to
discover local lithic resources. Immigrants must have
brought with them raw materials and artifacts from their
parent territory. As they became more familiar with the
resources of an area, in this case southern Saskatchewan,
lithic materials were discovered. Thus, the indigenous
materials must show up at sites whose occupants had be-
come knowledgable about the lithic resources of this area.

Hunting economies are highly dependent on sharp
edged tools and the manufacture of such tools similarly
depends upon the availability of suitable rock. The need
for material that could be usefully chipped entailed a
system of lithic procurement. Those who failed to have
such a system in a lithic-deficient area had much reduced
chances of survival. The source of the lithic material
may be exotic or local; knowledge of its identity and
source can provide the basis for a theory of its procure-
ment system. Such a theory could postulate that some
groups had a transhumance pattern which included a lithic
resource. The considerable amount of Knife River flint

in Saskatchewan sites can be regarded as evidence of extensive trading. Furthermore, expeditions could have gone to sources of favoured material to bring back blanks and preforms such as those found in rare caches.

There is interest in the reasons why certain lithic materials dominate the residue of certain sites or of specific cultural groups. The properties of materials may provide a basis for preferential use by a cultural group or for certain tools. Edge durability is desirable for cutting and scraping tools, but this quality is not necessary for projectile points. The ease with which an edge can be rejuvenated will influence the selection of materials for scrapers. The structure and composition of a nodule will have a bearing on the amount of debitage from manufacture. A large quantity of detritus from manufacture may indicate not preference but a low material quality. The nature of Swan River chert is such that a nodule of a kilogram or more may produce very few flakes useful for further manufacture; the rest remains as residue.

In addition to the above, the properties of a rock, including its shape, may entail recognizable reduction procedures and shaping strategies. Tough rocks such as quartzite were shaped mainly by hard percussion. Ovoid pebbles required a splitting technique, and difficult chalcedonies were made more tractable by heating. High

quality materials like Knife River flint can be shaped by any chipping mode, without having been heated. Since it may readily be shaped by soft percussion, Knife River flint was especially desirable for large, thinned artifacts. It can also be pressure flaked to form Eden or deeply notched projectile points and it is suitable for the manufacture of fluted Folsom projectile points.

There is need for continuing research in archaeological lithic materials. A theory of fracture applicable to archaeological artifacts would enhance the interpretation of manufacture and breakage patterns. Many tests may be required before it can be resolved whether Athabasca quartzite is, in reality, distinguishable from the Rocky Mountains variety. It would also be worthwhile to examine sedimentary rocks for microfossils and pollen.

This work has made me aware of the extensive use of Swan River chert. Its presence, far from sources that are presently known, indicates that it was widely transported by humans who belonged to nearly all cultural complexes that occupied this province. This observation indicates that theories of lithic procurement systems and of diffusion of lithic materials are desirable in archaeology. The concept that chalcedonic silica is a separate variety of silica has been empirically supported, but further research in the fields of radiometry and electronic spin resonance research may provide a fundamental

explanation of the phenomenon of thermal alteration.
Even though basic research is essential, a major problem
confronting the archaeologist lies in making a field or
laboratory identification of lithic materials.  The com-
parison of field specimens with recognized varieties
should be more practically facilitated.  It is therefore
suggested that, along with continuing research pertaining
to properties, a repository of lithic specimens be estab-
lished.  Although this research is preliminary in scope,
it is hoped that it has made some contribution to under-
standing prehistoric lithic procurement and stone tool
production across southern Saskatchewan.

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Figure 3. An incomplete cobble of Athabasca quartzite. From Boutin's gravel pit, Domremy.



Figure 4. A typical cobble of Rocky Mountain quartzite showing percussion marks. From the Cypress Hills.
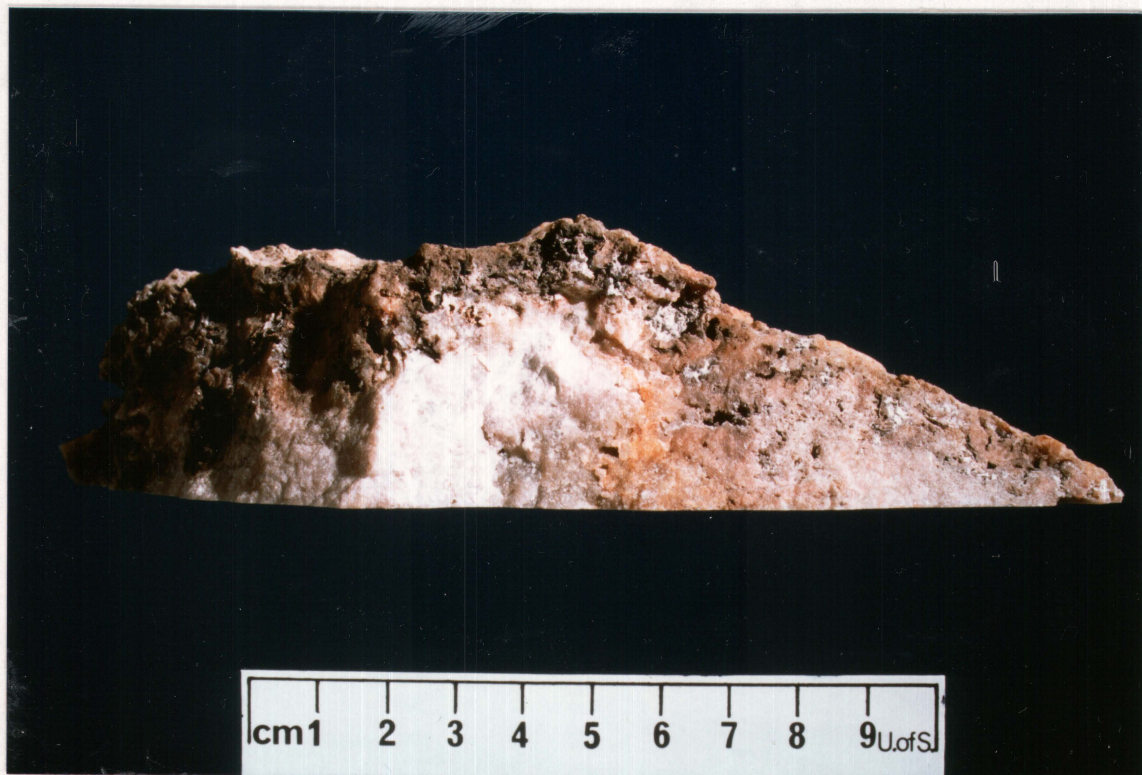
Figure 5. A portion of a boulder of Swan River chert. From near Armit.



Figure 6. A nodule of silicified peat. The flake beside it was struck off, heated to 290°C, and partially flaked. From south of Rockglen.

Figure 7. Wood replaced by chalcedonic silica. From south of Rockglen.



Figure 8. Wood replaced mainly by quartz. From south of Rockglen.

Figure 9.  Silicified siltstone pebbles, some of which have been experimentally split.  From Grassy Island Lake, Alberta.



Figure 10.   A broken nodule of Gronlid siltstone. From a glacial erratic exposure north of Gronlid on the Saskatchewan River.

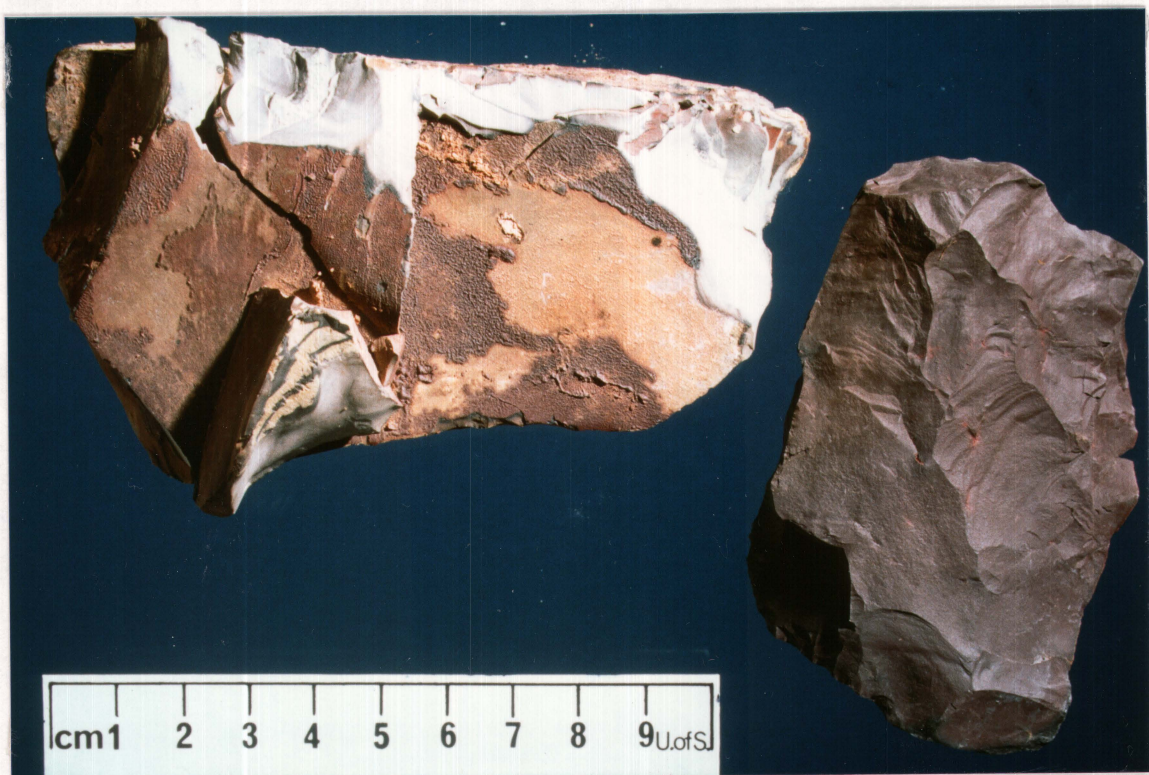Figure 11. A patinated fragment of Gronlid siltstone from western Saskatchewan.



Figure 12. Fused shale from an exposure north of Big Beaver.

Figure 13. Feldspathic siltstone cobble, and an experimentally removed flake. From a gravel deposit east of Ponteix.