ARCHAEOLOGICAL WORK AT TSE'K'WA

EDITED BY
JONATHAN C. DRIVER & MARIELE GUERRERO

Printed in Canada on acid free paper.
ISBN (print): 978-0-86491-383-8
ISBN (web): 978-0-86491-384-5
Printed by: Simon Fraser University Document Solutions

Compiled and edited by:
Dr. Jonathan C. Driver, Professor of Archaeology
Mariele Guerrero, Research Assistant

ARCHAEOLOGICAL WORK AT TSE'K'WA

EDITED BY JONATHAN C. DRIVER & MARIELE GUERRERO

CONTENTS

The Significance of the Fauna from Charlie Lake Cave

Stratigraphy, Radiocarbon Dating and Culture History of Charlie Lake Cave, British Columbia

Late Pleistocene Collared Lemming (Dicrostonyx torquatus) from Northeastern British Columbia

Raven Skeletons from Paleoindian Contexts, Charlie Lake Cave, British Columbia (7)

Stratified Faunas from Charlie Lake Cave and the Peopling of the Western Interior of Canada

Paleoecological and Archaeological Implications of the Charlie Lake Cave Fauna, British Columbia

Rise and Fall of the Beringian Steppe Bison

The Paleoindian Bison Assemblage from Charlie Lake Cave, British Columbia

FOREWORD

This collection of articles related to the Charlie Lake Cave archaeological site, or Tse'K'wa (the Rock House in Dane-zaa), is about the construction of place and the various ways people can imagine and interpret it, whether they are original First Nation inhabitants and caretakers, or archaeologists who have been propitiously tasked with deciphering and articulating the prehistory of Tse'K'wa, a sacred site in northeast British Columbia. The significance of Tse'K'Wa is complex, singular and takes on a different meaning for everyone , but is also uniquely binding and complementary in one mutual agreement: Tse'K'wa is Chqde Wuujo, a good place.

When Dr. Jon Driver requested I draft a foreword for this publication I was both honoured and perplexed. I, and the Treaty 8 Tribal Association and Tse'K'wa Heritage Society with whom I work, have been acutely aware of and grateful for the 30 plus years that Dr. Driver has devoted to capturing the heritage of Tse'K'wa. Over the last few years, our relationship with Dr. Driver has passaged into one of deep respect and unfettered support. The task of writing this letter seemed overwhelming due to site's historical and archaeological complexity and its significance for the Dane-zaa people, in particular their symbiotic relationship with ravens as part of ceremonies and their belief system. After spending too much time thinking about rather than writing about this relationship, I experienced Raven's trickster antics and knew that it was time to refocus my efforts to the construction of this letter.

One day as I was leaving my home, I watched Raven perform a frenzied dance across my tile roof. He concluded by landing, much too close, on a beam next to my head. During the same time, a book about ravens that I highly value disappeared, and a large sum of money placed in our kitchen cupboard vanished. Later that day, when going to the gym, a raven missing part of his beak attempted to land on my vehicle and, when I searched my gym bag, my runners were missing. At that moment, I knew it was time to concentrate on this foreword. I immediately drove home and began to write. Within a few days all the missing items reappeared.

This extensive collection, as presented by Dr. Jon Driver, presents a comprehensive assemblage of scientific research related to Tse'K'wa and will be invaluable for future researchers. In addition, it reaffirms our collective identity and connection, as First Nation people, to the land. I am honoured to know and provide this foreword to Dr. Jon Driver, not only a remarkable scholar, teacher and researcher, but also a compassionate and visionary colleague and friend who has demonstrated the importance of relationships and collaborations in our mutual effort to conserve and articulate the mosaic heritage of Tse'K'wa, a sacred place. [1]

-Karen Aird , Treaty 8 Tribal Association-

TSE'K'WA, A CHQDE WUUJO

The Dane-zaa people are of the Athabascan language group and have continuously occupied an expansive terrain along the Peace River region of Alberta and BC for thousands of years.[2]

In the past, travel and settlement patterns for the Dane-zaa were semi-nomadic, disseminating from camp to camp over an extensive territory - adjusting their travel patterns in accordance to changes in the landscape; social and political obligation; economic interests in trade and procurement; and to avoid exhausting resources. Camping locations were based on criteria such as being well sheltered and dry, often having aspen and spruce tree outcrops; easily accessible – close to the trail and open for camping; defensible; convenient (e.g., close to water, food, medicine and mineral – lithic sources); and a high vantage point, with a view of the surroundings. In some cases, supernatural forces reflected the selecting of camp locations, e.g., spiritual associations of a place might attract people to stay, such as dreaming areas. Spiritual beings, or harmful supernatural beings, could also cause a place to carry 'bad luck', thus, people would avoid the place.

Because the Peace River region was sparsely populated, with great distances between First Nation settlements, and the terrain was formidable to navigate due to harsh weather, insects and muskeg, the matter of well-defined and maintained travel corridors was crucial to the Dane-zaa.

---

[1] See http://agoodplace.ca/about-t8-engagement-hub/

[2] Dane-zaa means 'real people' and, historically were often referred to as the Beaver tribe.

These travel routes and cultural landscapes, such as the Charlie Lake area and cave site, are etched in Dane-zaa oral histories and traditions today.

While talking about the Charlie Lake region, Doig River First Nation Elder recently remarked:

> "One camp for two weeks and then they moved, they're gone all summer. There was no school at that time, we used to leave the cabin in Doig as soon as the snow was gone, April, when the ice breaks, the snows still on the ground, everybody moved out, cabin fever, and then they go trapping, all the men go trapping, come back right around in May, and then from there they start camping... In the spring time they go to Charlie Lake and they make fish dry meat, they get fish from Peace River here too, and then that's how it is, that's how they survive, from the fish from Charlie Lake and the Peace River. (Firelight, DR03 June 28, 2012)."

Elder Billie Attachie from Doig River First Nation added to this by stating:

> "Early spring, when the leaves start growing and the saps on the poplar trees, when the leaves are full grown and the sap is full, people all get together and move to Charlie Lake, where the creek joins the lake, where the town is now. Just a little ways up the creek, that's where they used to camp. People all together. All the older people, they all get together. ….. In Charlie Lake, when the leaves are small, people used to camp there for fish. … (Ridington, 2013: 238)." [3]

When interviewing the last Dane-zaa Dreamer, Charlie Yahey, Ridington commented that Charlie Yahey kept insisting that his real home was Charlie Lake, which was named for his stepfather Usulets (big Charlie) and possibly for his grandfather Charlie Aluulah (2013). Dane-zaa dreamers, or Naachin," are people who experienced the Trail to Heaven in person. Unlike ordinary people, who die once and do not return to the same body, Dreamers leave their bodies and grab hold of a song that carries them forward, and they return to the earth on the trail of that same song (Ridington, 1988: 77)." [4]

For the past 60 years, residential and the now encroaching commercial development around Charlie Lake has made it challenging for the Dane-zaa to access and continue to practice their tra-

---

[3] Ridington, Robin, and Jillian (In Collaboration with Elders of the Dane-Zaa First Nations). 2013. *Where Happiness Dwells: A History of the Dane-zaa First Nations*. Vancouver: UBC Press.

[4] Ridington, Robin. 1988. *Trail to Heaven: Knowledge and Narrative in a Northern Native Community*. Vancouver: Douglas and McIntyre.

ditional activities at the sacred site of Tse'K'wa (the Rock House in Dane-zaa), or the Charlie Lake Cave archaeological site. Tse'K'wa was significant for many reasons, such as its use as a gathering and fishing area; but it is the findings of two raven skeletons by Dr. Jon Driver and Knut Fladmark that confirmed the Dane-zaa's oral histories that distinguished this site as a uniquely spiritual place. Ravens are often associated with origin myths and with acting as the gatekeeper of the underworld, carrying messages between the spirit and with the natural worlds. In Dane-zaa oral history, Raven fulfills the role of Trickster and Transformer, imparting important moral lessons. There is a well-known Dane-zaa story about Raven/Crow, in which Raven/Crow kept feeding dry meat to his human wives, making them fat then smothering/killing each wife in a deep cache filled with meat (Ridington, 1967) [5]. When the humans chose not to supply Raven with any more wives, he scared away all the animals, expecting the humans to starve. In retaliation, humans carefully followed and observed Raven, mimicking many of his behaviours, in order to understand how and where he was procuring meat. After successfully collaborating on a plan and eventually trapping Raven, humans and Raven came to a truce and agreed to not bother each other, as long as humans left a little bit of food for Raven after each kill. Some of the tacit teachings derived from this story are: beware of gluttony (overeating) as it can lead to disastrous consequences; challenging situations are best resolved when parties work together; the importance of an Elder's guidance (in this case the Elder was a woman); and Raven, as a trickster, can be a cruel, surreptitious and a sapient teacher.

Goddard observed in 1913 that the Dane-zaa buried their dead by placing them on trees or on platforms; the bodies often rolled in birch bark before being disposed of in this way (1916) [6]. One of the reasons suggested for the platform burials was to protect the body from wild animals, and/or to provide a high vantage point where the souls of the dead could maintain a protective eye on their descendants (Goddard, 1916). Another explanation is that each soul has a spirit guide, who is often an avian species, and a platform burial enabled the soul to better access his/her spirit guide (Goddard, 1916). Today, Dane-zaa hunters continue to share many stories about ravens assisting them during hunts, by leading hunters to prey, while at other times, actively warning them about potential specters. For this reason, there are prohibitions and Indigenous legal traditions in place to prevent the harming ravens.

---

[5] Ridington, Robin, 1967. Notes from interview with Prophet River First Nation member Augustine Jumbie. Translated by Liza Wolf. (Unpublished).

[6] Goddard, P.E. 1916. The Beaver Indians. *Anthropological Papers of the American Museum of Natural History*, vol. X, pt. IV.

Although it is not possible to move beyond speculation on cultural activities that occurred at Tse'K'wa, it is conceivable that early Indigenous people used the landscape above and around the Cave as an idyllic camping location for gaining access to fish in the lake and creek nearby; hunting large prehistoric bison; and carrying out spiritual activities. During prehistoric times, the Dane-zaa would have taken advantage of the abundant and varied resources in the region by moving throughout their territory seasonally. Innate knowledge of animal migration routes, fertile gathering areas, frequented mineral licks, and reliable access to shelter and water would have been at the core of the Dane-zaa's seasonal rounds. Spears with Clovis points would have been a valued technology to kill animals once they were surrounded in a hunting blind, or driven from a cliff. In addition, as part of their seasonal rounds, the Dane-zaa may have met collectively at Tse'K'wa to celebrate - consuming large amounts of meat, fish, and plant foods; making important political, social and economic decisions; and holding ceremonies.

In 2012, the three Dane-zaa First Nation communities of Doig River, Prophet River, and West Moberly took the first step in reclaiming this heritage and spiritual place by collectively purchasing Tse'K'wa. The purchase of Tse'K'wa has catalyzed the First Nation communities in Treaty 8 of BC around a common vision to create the Tse' K'wa Cultural Museum and Interpretive Centre; to recognize and protect a historically and scientifically significant cultural resource that confirms the local Indigenous connections to the land for thousands of years; and the continuity of spiritual practices and beliefs. When completed, Tse'K'wa will be the first local facility devoted to conserving, promoting and transmitting Dane-zaa culture, heritage and arts, bridging non-Aboriginal and Aboriginal communities.

-Karen Aird , Treaty 8 Tribal Association

ACKNOWLEDGEMENTS

I am very grateful to my colleague, Dr. Knut Fladmark, who initiated and directed the 1983 work at Tse'K'wa and with whom I co-directed further work in 1990 and 1991. Major excavations at Charlie Lake Cave took place in 1983, 1990 and 1991. In each year the research was funded by the Social Sciences and Humanities Research Council of Canada. Dick Gilbert, a former archaeologist and school teacher from Prince George, participated in all three major excavations and Joe Stewart of Lakehead University joined the crew for the 1983 season. The other crew members included undergraduate and graduate students from Simon Fraser University, including Oslynn Benjamin, Diana Alexander, Gyles Iannone, Martin Handly, John Breffitt, Randall Preston, Sue Montgomery and Gregg Sullivan. During the excavation seasons the archaeological site was situated on property owned by John Cleeve (1983 and 1990) and Rory and Troy Henderson (1991). In 1991 the Huhn family was renting the house. All were generous in allowing us access to the site, and helping us in many other ways. People living around Charlie Lake were also very generous and helpful, and welcomed us to their community.

We would like to give special thanks to the various publishers who have given permission to reprint copyright material, the publishers are: Society for American Archaeology, NRC Research Press, Arctic Institute of North America, University of British Columbia Press, Society of Vertebrate Paleontology, Archaeopress, American Association for the Advancement of Science, Canadian Archaeological Association. This has allowed us to communicate information about the site to many people in the Peace River region who do not have access to university libraries or the internet, but are deeply interested in the history of this area. We would also like to thank the Simon Fraser University Summit, Institutional Research Repository for assistance compiling information about the site. Finally, I would like to thank my co-editor, Mariele Guerrero, for her dedication to this project and for her excellent editorial and project management abilities.

-Jonathan C. Driver

ARCHAEOLOGICAL WORK AT TSE'K'WA

INTRODUCTION

JONATHAN C. DRIVER

Tse'K'wa, formerly known as Charlie Lake Cave, has been visited by humans for more than 12,000 years and evidence of their presence is embedded in the layers of sediment that have accumulated at this location over thousands of years. As a result Tse'K'wa now preserves a long record of human activity that begins with some of the first people to enter the Peace River region when the last ice age was coming to an end, and concludes with the construction of the Alaska Highway in the 1940's. More than 500 human generations have lived in the Peace River region since the first people visited Tse'K'wa.

The cave at Tse'K'wa was probably formed by high pressure water under a glacier or ice sheet exploiting weaknesses in the sandstone bedrock and eroding out a small cavern. Today the mouth of the cave is in a small cliff on the side of a little valley. A few meters in front of the cave mouth is a very large sandstone boulder that was originally part of the cliff. This boulder probably detached from the cliff face at the end of the last ice age. When this happened, a deep gully was created between the cliff face and the back of the boulder. More details about how the site was formed can be found in some of the articles that are reproduced in this book.

Although archaeologists have excavated in the cave itself, the most interesting finds come from outside the cave mouth, in the deep gully between the back of the big boulder and the cliff face containing the cave. When the site was first occupied the floor of the gully was a mass of uneven boulders lying between two vertical rock faces. At this time the cave entrance would have been inaccessible, sitting a few meters above the floor of the gully. Over the years sediments were washed into the gully, covering the boulders and allowing soil to form and plants to grow. As more years went by, the gully was gradually filled with sediments until the ground was level with the cave entrance. We think the mouth of the cave would have been accessible to people and animals for at least the last three or four thousand years, but before that it may have been more difficult to reach.

THE REPRINTED ARTICLES

This collection of previously published work is intended to provide interested readers with access to scholarly publications about Charlie Lake Cave, now known as Tse'K'wa. Archaeological excavations ("digs") were undertaken in 1983, 1990 and 1991. The publications reproduced here were written over a period of more than 20 years, and work still continues on the materials excavated at the site. Many of these articles can also be accessed online through the Summit Repository of the Simon Fraser University Library website.

Scholarly publications can be difficult to access for two reasons. First, they are often published in journals or books that are hard to find outside of a university library and many online journals still block access to everyone except subscribers. This reprinted collection of publications has been made possible by the publishers of the material, who have generously waived their copyright and allowed us to make everything freely available to anyone who wishes to find out more about Tse'K'wa. Each publisher is acknowledged in the introduction to each reprinted piece. Second, because these publications are written for other scholars, they often used specialized language and make assumptions about a reader's level of knowledge on the subject matter. To assist the general reader in understanding the publications, we have written a short introduction to each paper that explains why it was written and summarizes the main points of the publication.

We have not been able to include every publication in the collection of papers that will be distributed as a printed copy, but we have added a list of other publications and theses about the site at the end of this collection.

Users of these publications should be aware that information and interpretations have changed over time. For example, we acquired more radiocarbon dates through the years, changed our interpretation of the stratigraphy after the 1991 season, and analyzed more material over time.

A SHORT HISTORY OF THE RESEARCH

Tse'K'wa was first brought to the attention of archaeologists when Simon Fraser University was undertaking a study of the area that would be impacted by the Site C dam on the Peace River in the 1970's. The archaeologists hired a number of local young people to help with the project, and one of them, a young First Nations man, told them about the cave, which was well known to people living around Charlie Lake.

The first excavation was a very small test hole excavated by the SFU crew in the summer of

1974. Another test hole was excavated in fall 1974 by a crew from University of Alberta, where one of the SFU team, Dick Gilbert, had gone to study for his master's degree. Both excavations went down just over a meter and recovered stone artifacts and animal bones, but stopped when the excavators ran into large rocks. A disappointingly recent radiocarbon date was obtained on charcoal and archaeologists lost interest in the site for a few years.

However, two former students on the 1974 project, Dick Gilbert and Diana Alexander, thought the site had potential and convinced Knut Fladmark, an SFU archaeologist involved in the Site C research, to apply for a research grant to conduct further work. Fladmark returned to the site with a small crew, including Alexander and Gilbert. Jon Driver was part of the team, invited to provide the analysis of the animal bones. Under Fladmark's persistent leadership the archaeologists dug through major rockfalls in the gully in front of the cave. These demonstrated that the layers extended down at least four meters and contained stone tools and animal bones all the way to the lowest deposits. Of particular importance was the recovery of a very early spear point ("fluted point") in association with butchered bison bones, making this an especially important early site for Canada for a number of reasons.

Various circumstances prevented further work at the site until the summers of 1990 and 1991 when Driver and Fladmark returned to the site. The goals of the second project were to open up a slightly larger area, to better explore the stratigraphy of the deposits, to make sure that the base of the deposits had really been reached in 1983, and to obtain larger samples of material, especially from the earliest periods.

Subsequent work has been on the materials collected in all three seasons, and no further excavations are currently planned.

ARCHAEOLOGICAL SIGNIFICANCE OF TSE'K'WA

It is not for me to discuss the importance of this site to First Nations people. However, I can comment on some aspects of the site that are especially relevant to archaeologists.

The feature of Tse'K'wa of greatest interest to archaeologists is the considerable age of the earliest materials at the site. In 1983 when news of the "fluted" spear point was announced, archaeologists flew up from Vancouver and Victoria to visit the site because no one in western Canada had ever found such an artifact in a layer that could be dated so precisely, nor had anyone in Canada found such an artifact in association with preserved animal bones. As archaeologists conduct further research on the materials from the site's early layers they have revealed other unique and unusual aspects of the cave. It is possible that the first use of the site was as a meat cache, and the presence of unique raven burials suggest the site could have been an area of sacred cultural significance.

Less often mentioned are other important aspects of this site. It preserves a long record of human use of this region in layers that can be dated by radiocarbon. As a result, we have a reasonable record of the changes in artifact styles through time in the Peace River region. This information can be used to date other sites in the area that cannot be dated directly using radiocarbon methods. It also preserves a long record of the animals that lived in the region, evidence for environmental change and stability.

A NOTE ABOUT DATING

The age of the various layers at the site has been established by radiocarbon dating. The principle of radiocarbon dating is fairly straightforward. A small amount of the carbon that makes up carbon dioxide in the atmosphere is radioactive – this is known as 14C or carbon 14. The amount of 14C in the atmosphere has remained relatively stable over time. Plants take in 14C through photosynthesis, and convert it to plant tissue; and animals take it in when they eat plants and convert plant food to tissues such as collagen and muscle. The 14C atoms "decay" to nitrogen at a predictable rate (the "half life"), which means that the percentage of radioactive carbon is gradually declining after an animal or plant dies and can no longer take in new carbon through photosynthesis or eating plants and meat. So if you know how much carbon is in a sample of old charcoal or bone, and if you know how much of that is radioactive, you can estimate how long it has been since the plant or animal was alive and taking radioactive carbon into its body.

When radiocarbon dating was invented, it was thought that the amount of radioactive carbon had always been constant in the atmosphere. Working with this assumption, the first radiocarbon dates were expressed as "years BP" – or Before Present – with the "present" conventionally set at the year 1950. Then some enterprising scientists decided to test the radiocarbon method. They sampled the tree rings in extremely old trees (bristlecone pine from California) and found that the radiocarbon dates on tree growth rings of known age got less accurate as you sampled further back in time. In fact, there was a tendency for the oldest tree rings to be dated a bit too young. Using a variety of similar methods, we can now extend these studies back tens of thousands of years and correct or "calibrate" radiocarbon dates against tree rings and other materials of known age. This allows us to assign approximate ages in real calendar years to material dated by radiocarbon.

As a result, earlier publications typically report "years BP" whereas more recent publications tend to calibrate the radiocarbon dates and provide an approximate age in calendrical years, such as "8000 calBC" (where 'cal' means that the date has been calibrated). Most of the publications here use uncalibrated years BP, so these are somewhat too young. In the table below I provide examples of typical radiocarbon dates and associated calibrated ages. You can use these to get an approximate corrected age of any radiocarbon date.

Radiocarbon "years" before present ("BP")	**Approximate age in calendar years**
1000 BP	1000 AD
2000 BP	25 BC
3000 BP	1225 BC
4000 BP	2500 BC
5000 BP	3800 BC
6000 BP	4900 BC
7000 BP	5900 BC
8000 BP	6900 BC
9000 BP	8100 BC
9500 BP	8900 BC
10,000 BP	9600 BC
10,250 BP	10,100 BC
10,500 BP	10,500 BC
10,750 BP	10,750 BC

THE PALEOINDIAN COMPONENT AT CHARLIE LAKE CAVE (HBR39), BRITISH COLUMBIA

KNUT R. FLADMARK, JONATHAN C. DRIVER, DIANA ALEXANDER

We kindly thank the publisher, Society for American Archaeology, for permission to reproduce this work.

This was the first major publication about Tse'K'wa and it focuses on what for many people was the most exciting find at the site – a very early occupation of so-called "Paleoindian" people.

There continues to be considerable debate about when the first people came to the Americas. In the 1980's (and continuing today), the weight of evidence supports a long-held belief that the ancestors of the indigenous peoples of the Americas made their initial migration from somewhere in northeast Asia. However, the timing of this movement, the context in which it occurred, and the date are still contentious. (It is, of course, a simplification to describe this as a single event. There is plenty of evidence for a number of major migrations across the Bering Strait, and it is likely that there was a flow of people and ideas in both directions over thousands of years).

In the 1980's, as today, virtually all archaeologists agree that "Paleoindian" culture dating to the end of the last glacial period (about 12,000 BC) indicate a well-established population throughout the Americas by that time, although there is still considerable debate about when the first ancestors of Paleoindians arrived in the Americas.

While the way of life of these peoples must have varied across different environments found in North and South America, the most distinctive Paleoindian artifacts in North America are a kind of stone spear point, known as "fluted points". Fluted points were chipped from fine-grained rocks, such as chert, jasper and obsidian, and generally had a long, lanceolate outline. In order to fit the base of the point into the shaft of the spear, it was thinned by striking off some flakes that ran from the base towards the sharp tip, creating a shallow channel or "flute" on one or both surfaces of the stone spearpoint.

Fluted points have been found in association with extinct animals, most commonly woolly mammoth and extinct forms of bison, but also with horse and camel, primarily in the central and western half of the USA. Due to different geological and soil conditions in eastern USA, most fluted point sites there do not preserve animal bone. In 1983 when a fluted point was found at Tse'K'wa, there was only one site in all of Canada where fluted points had been found in association with organic material that could be radiocarbon dated – at Debert, in Nova Scotia where charcoal in the soil provided some dates. Tse'K'wa was the first site in Canada that produced a fluted point in association with animal bones that had clearly been butchered by people – in this case an extinct form of bison – and the first site in Canada in which a fluted point was found at the bottom of a long sequence of later cultural periods. The unique soil conditions at the Tse'K'wa site have enabled archaeologists to use radio carbon dating on fluted points and animal remains to gain further insight into the lifestyles and timeline of early human occupation of Canada.

Also of significance was the location of Tse'K'wa just to the east of the Rockies. Archaeologists had proposed that one route into the Americas during the late ice age was between the Rocky Mountain glaciers to the west and the massive ice sheets that covered Canada to the east – this so-called "ice-free corridor" might have allowed early hunters to move from unglaciated areas of Siberia and Alaska into the vast uninhabited continents to the south of the ice. Although fluted points had been picked up from ploughed fields in BC and Alberta, before the excavations at Tse'K'wa none of them had been radiocarbon dated, and so it was difficult to relate them to known dates of glaciers and post-glacial landscapes.

THE PALEOINDIAN COMPONENT AT CHARLIE LAKE CAVE (HbRf 39), BRITISH COLUMBIA

Knut R. Fladmark, Jonathan C. Driver, and Diana Alexander

Charlie Lake Cave (HbRf 39) is a stratified site in northeastern British Columbia, Canada, containing a fluted-point component at the base of the excavated deposits. The small artifact assemblage includes a fluted point, stone bead, core tool, and retouched flake. A diverse associated fauna includes fish, birds, and mammals, indicating a more open environment than exists today. Radiocarbon dates suggest that the artifact assemblage was deposited about 10,500 years ago.

Fluted points are found in most areas of southern Canada, but with the exception of Debert (MacDonald 1968), none has been found in direct association with datable material. In Alaska fluted points may date as early as 11,000 B.P. (Clark and Clark 1983) but, as in Canada, these fluted-point sites tend to have shallow or compressed stratigraphy with the possibility of mixing. There are no fluted-point sites north of the 49th parallel which contain points and faunal remains in a securely sealed and dated context. Consequently, the excavation of a dated fluted-point component in an undisturbed deep stratigraphic position with associated fauna is of significance for the prehistory of northwestern North America. This paper describes the stratigraphic sequence at Charlie Lake Cave, associated radiocarbon dates, and the artifacts and associated fauna of the earliest cultural component known from the site.

SITE LOCATION, ENVIRONMENT, AND EXCAVATIONS

Charlie Lake Cave (HbRf 39) is located in the Peace River district of northeastern British Columbia, near the south end of Charlie Lake, 9 km northwest of Fort St. John (56°16′35″N, 120°56′15″W) (Figure 1). The site occupies the south-facing slope of a low, sandstone bedrock ridge above Stoddart Creek. The site lies at about 730 m a.s.l., and overlooks a flat-to-low relief plateau surface to the east and south predominantly composed of glacial and glaciolacustrine sediments (Mathews 1978). To the north and west the ridge merges with a complex of rolling, dissected uplands. Prior to modern land clearance, upland vegetation would have been spruce-dominated boreal forest, while south-facing slopes and the plateau would have supported a more open parkland community of grasses, aspen, spruce, and lodgepole pine (Farly 1979; White 1983).

Regional paleoenvironments of the late Pleistocene/early Holocene are known from geological and palynological studies (Mathews 1978, 1980; White 1983). The Charlie Lake area was covered by Wisconsin Laurentide ice. As the ice retreated, large lakes were formed, and most stages of glacial Lake Peace covered HbRf 39 (Mathews 1978, 1980). The Clayhurst stage of Lake Peace has shorelines of approximately the same elevation as HbRf 39. A small beach deposit just below the site probably dates to one of the Clayhurst stages (William H. Mathews, personal communication 1983). Mathews (1980:19) has suggested that Clayhurst terminated prior to 10,000 years B.P. The Clayhurst stage was followed by a number of stages with more restricted ice-dammed lakes, and it therefore is likely that the late Pleistocene/early Holocene human occupation at HbRf 39 took place in a landscape with a significant lacustrine component.

Palynological studies of the HbRf 39 sediments failed to yield more than a few grains of pollen. However, White's (1983) study of lakes about 120 km to the southeast provides data on the early

---

Knut R. Fladmark, Jonathan C. Driver, and Diana Alexander, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6

American Antiquity, 53(2), 1988, pp. 371–384.

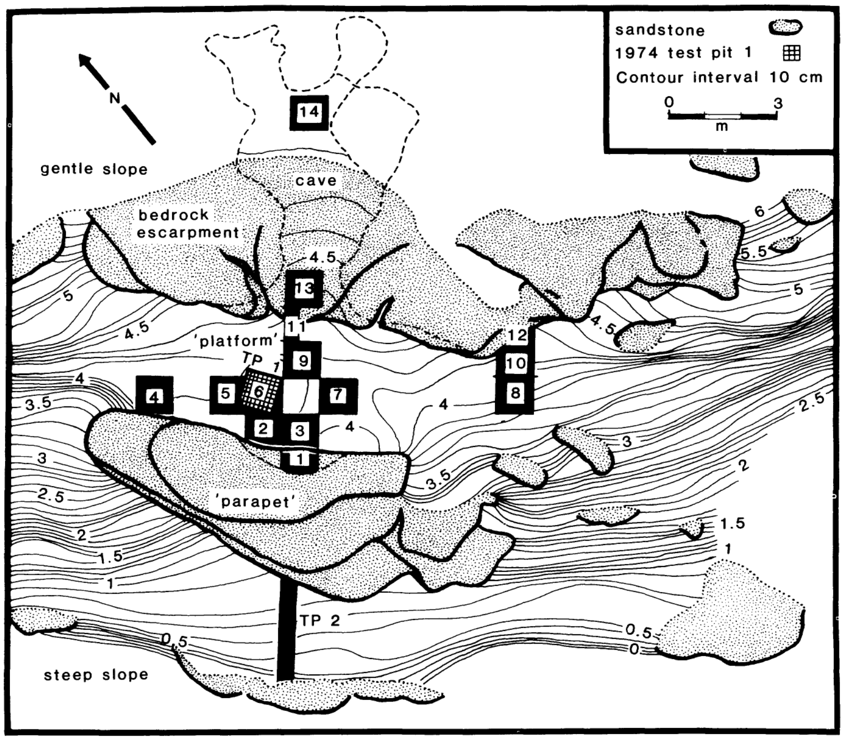


Figure 2. Local topography and excavation units, HbRf 39.

at 3.5 to 4.0 m below surface without reaching bedrock. Excavations in the cave itself demonstrated that deposits were shallow.

Most excavations were undertaken with trowel and ⅛-inch (3-mm) mesh screen. Large sandstone blocks were encountered in increasing numbers with depth, and were broken up with cold chisel and sledge hammer. Sediments at the base of the excavations contained considerable quantities of sandstone, and small picks were used in their excavation. Sediments for the most part were dry and fine (except for sandstone fragments), and were screened easily. Sediment columns were taken from a number of units for later processing. Excavations proceeded as far as possible by "natural" stratigraphic units. When these were thick, they were subdivided into arbitrary layers contoured to the upper contact of the layer, which often sloped quite steeply.

STRATIGRAPHY AND CHRONOLOGY

The sedimentary sequence at Charlie Lake Cave can be divided into five general stratigraphic zones traceable across the entire platform excavation area on the basis of visual interunit correlation of stratigraphic profiles. The zones and their contacts are defined by marked visual changes in texture and the relative proportion of organic and mineral constituents. Analysis of sediments from column samples supports the zonation. The stratigraphic zones are labelled I to V from bottom to top (Figure 3). Internal subdivisions exist within these zones, but will be discussed here only when relevant to the earliest cultural component.

All deposits are contained between Dunvegan sandstone, which forms the escarpment and the parapet. As can be seen from Figures 2 and 3, the parapet lies parallel to the escarpment, but the two are separated by a gully with slightly tapering vertical sides 2 to 3 m apart. Excavations have failed to find sandstone bedrock at the base of the gully, indicating that further excavation ultimately

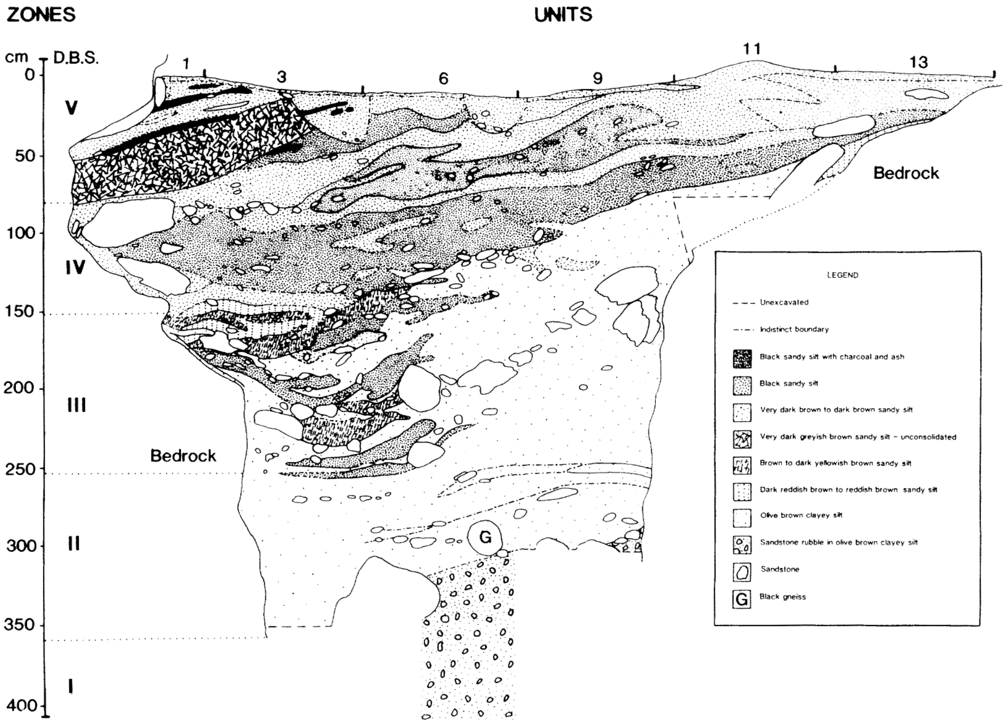


Figure 3. North–south stratigraphy, HbRf 39.

is required. Our current view is that the parapet represents a large slab of bedrock detached from the escarpment prior to 11,000 B.P., possibly by combined effects of solution (which formed the cave) and cryoclastic action. However, for present purposes, it is sufficient to note the presence of the gully and its infilling.

Zone I is the lowest stratum reached in excavation. It consists of an olive-colored, resistant sandstone rubble, with larger clasts ranging from boulders over 1 m in maximum dimension to granules. In the less than 16 mm range, mean particle size is about .55 mm (medium sand) (Figure 4). Excavation was very difficult, with the fine matrix appearing compacted or slightly cemented. The sandstone blocks were relatively unweathered, and could be broken only with extreme force, whereas boulders higher in the sequence could be cut with a cold chisel. Organic content generally is low, and decreases with depth, as do allochthonous pebbles of quartz, quartzite, and chert (Figure 4). The few small bones from this layer occur near or at the Zone I/II contact, and probably all are derived from Zone II. No artifacts or other cultural material were found in Zone I, but excavations penetrated only to a depth of 40 cm in a few test areas. Zone I currently is interpreted as a period of rapid bedrock spalling and weathering immediately following detachment of the parapet from the escarpment.

Zone II directly overlies Zone I, and Zone II was found in all units excavated in the platform area. It is an olive, pebbly, silty sand with mean particle size in the less than 16 mm range of .30 mm (fine sand) (Figure 4). Zone II is divided into lower (IIa) and upper (IIb) subzones, based on gradational changes in lithology and texture. These subzones also contain separate cultural components. The fluted-point assemblage is contained in IIa, the earliest known cultural component at the site. Sediments are characterized by a high proportion of allochthonous pebbles (quartz, quartzite, chert, shale, schist), with up to 60 percent of pebbles in the 2 to 3-cm size range of nonlocal provenience. Total organics remain low, but are still higher than in Zone I. Zone IIa also was difficult

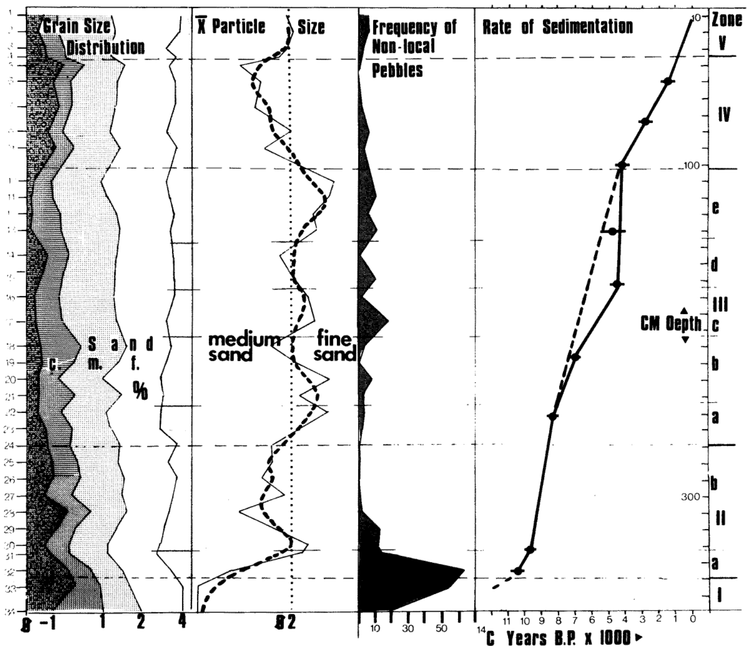


Figure 4. Sedimentology of column sample, unit 5.

to excavate because of the high silt/clay content, and material had to be broken into small fragments with a hand pick and then screened. Most bones and artifacts therefore were recovered from the screens. Examination of broken lumps of sediment indicated numerous small voids, possibly formed by decomposition of organics. These may be pedogenic features.

For Zone IIa, radiocarbon dates were obtained on bison bone collagen, producing values of 10,450 ± 150 B.P. (SFU 300) on a sample of bison tibia from the same unit and level as the fluted point, 10,380 ± 160 B.P. (SFU 378) on a bison ulna from the same unit and level as the quartzite core tool, and 10,770 ± 120 B.P. (SFU 454) from a bison humerus in the same unit as the fluted point from a stratigraphically contemporaneous level. These three dates provide an age estimate for the Paleoindian component. Two of the dates (SFU 378 and 454) are on bones which display cut marks. Two AMS dates were obtained from bone collagen in unit 3, which produced an abundant microfauna but no cultural material. A ground-squirrel femur from the lowest excavated level in this unit gave a value of 10,100 ± 210 B.P. (RIDDL 392), and a bison humerus from the uppermost Zone IIa deposits was dated at 9990 ± 150 B.P. (RIDDL 393). These dates suggest that Zone IIa deposition ceased at about 10,000 B.P. A bison bone-collagen date of 9760 ± 160 B.P. (SFU 355) was obtained from above the IIa/IIb interface, also suggesting that the interface dates to about 10,000 B.P. The inception of Zone IIa deposition must date to at least 10,500 B.P. One should note that all dates have been corrected for ^{13}C values except SFU 300. Assuming that the ^{13}C value is approximately the same as for other bison bones, this date would be older by about 80 years than reported here.

The Zone IIa/IIb boundary is gradational rather than sharply defined. Silt-clay content is reduced, and nonlocal pebbles decline markedly. Organic content increases. The upper limit of IIb is not well dated. However, two dates of 7800 ± 800 B.P. (SFU 370) and 8400 ± 240 B.P. (SFU 357) on charcoal from within Zone III suggest that IIb deposition had probably ceased by 8500 to 9000 B.P.

Zone III is characterized by alternately intercalated light-colored mineral beds and dark organic beds dipping from north to south. Angle of dip lessens with decreasing depth. Thickest organic deposits occur against the parapet, suggesting some downslope movement. In the less than 16 mm size range, mean particle size is .22 mm (fine sand) (Figure 4). Organics are common, and pH values decline. As discussed above, the base of the zone probably dates to 8500/9000 B.P. A radiocarbon date of 4400 ± 400 B.P. (SFU 385) in upper Zone III and a date of 4270 ± 160 B.P. (SFU 382) in lower Zone IV bracket the Zone III/IV boundary, and other dates within Zone III are consistent with this age.

Zone IV is a relatively thick, highly organic sediment, with much floatable organic material. It is suspected that packrat accumulations may have assisted considerably in the formation of this zone. It is capped by Zone V, distinguished only by the presence of historical period disturbance and artifacts. Mean particle size increases in these zones (Figure 4).

In summary, Charlie Lake Cave may have begun to form along a sandstone bedding plane or line of weakness prior to the detachment of the parapet. The main weathering mechanism for that event, as well as cave formation, probably was large and small scale cryoclastism. The parapet may have been detached at the end of the last major glacial episode, presumably after lake levels of Glacial Lake Peace had receded below 730 m a.s.l. because no lacustrine sediments were noted in Zone I. The deep gully created by the detachment of the parapet was infilled by coarse mass wastage and cryoclastic rubble, producing the resistant and sterile rubble of Zone I. In the early postglacial period, tills and glaciolacustrine sediments were washed into the gully from deposits on the hillside above the cave, producing the strongly nonlocal lithology of Zone IIa. This process certainly had begun by 10,500 years ago, and possibly as early as 11,000 B.P.

The first human use of the gully occurred during this time. It is possible that glacial Lake Peace had not yet drained completely at this period, and that the valley which now contains Stoddart Creek was a narrow arm of the lake. Zone IIb is characterized by continuing active weathering of sandstone. By about 8500 B.P. organic matter becomes visually significant in the profile, with richly humic beds intercalating with lenses and layers of sand. A major rock fall occurred at about 8100 B.P. Zone III generally is characterized by finer sediments and increasing organic content. After 4300 B.P. mean particle size increases, similar to that of Zone IIb, but with a much higher organic content. It is of interest to note that particle size at Charlie Lake apparently reflects the mid-Holocene "hypsithermal" climatic episode. After an initial period of active weathering, there is a trend toward reduced weathering rates, increased aeolian deposition, and higher organic content from 8,500 to about 4,000 years ago. This phase is followed by a return to more active weathering during the last 4,000 years.

Cultural Components

Eleven cultural components have been defined on the basis of the 1983 excavations, numbered from the bottom up. The following discussion deals only with the fluted-point assemblage—Component 1. The Component 1 assemblage contains four stone tools and six flakes, all found at the base of Zone IIa. These include a complete basally thinned or "fluted" projectile point, a retouched flake, and a perforated stone bead, all found within 1 m of each other in unit 5, a large, quartzite core tool from unit 4, and six small, black chert flakes found in units to the east. Radiocarbon dates SFU 300 and SFU 454 are associated with the artifacts in unit 5, while SFU 378 is associated with the artifact from unit 4.

The most diagnostic artifact is a stubby, extensively resharpened but complete lanceolate point of very dark gray chert (Figure 5.1). The point was broken during excavation of the hard basal sediments with a small pick, and all pieces were recovered from the screen. It weighs 6.7 g, is 39.3 mm long with a maximum width of 28.4 mm about 30 mm from the tip, and has a maximum thickness of 5.6 mm at the midpoint of the central axis. Hafting modification consists of a 6 mm deep basal notch and multiple, shallow basal-thinning flakes on both faces. There are five thinning flakes on one surface. Two initial-thinning flakes terminate in hinge fractures 19 mm from the base. A pair of second-generation flakes overlap these, but terminate 15 mm from the base, and a third flake to the left also is a second-generation flake. The opposite surface of the point retains the distal remnant of a single first-generation thinning flake, with possible remnants of two other flakes on

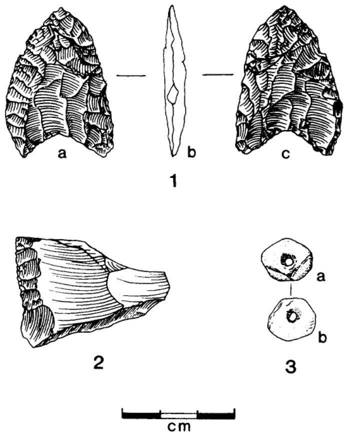


Figure 5. Artifacts from Component 1: 1, fluted point; 2, retouched flake; 3, schist bead.

either side. These are overlain by two shorter second-generation flakes. There is slight lateral-edge grinding, extending 13 mm up one edge and 20 mm up the other. Flake-scar ridges are lightly polished, a feature which also may relate to hafting.

In terms of overall shape, the point is asymmetrical. The straighter edge is worked steeply, while the opposite, excurvate edge is thinner. This asymmetry, coupled with the extensive resharpening, suggests that the specimen may have functioned as a hafted knife in its final stage of use.

The retouched flake (Figure 5.2) was found in situ in the same excavation unit as the projectile point just above the Zone IIa/I contact. It is a dark gray chert flake fragment with one edge retouched to an angle of about 50°.

The third stone tool was found about 2 m west of the point and retouched flake. It is a large "boat-shaped" or keeled core tool of light yellow, medium-grained quartzite (Figure 6). It measures 148.5 mm long by 60 mm wide by 47 mm high. Its elongated ovate striking platform consists of a single flake scar which served as the platform for the removal of a large number of flakes around the entire edge of the core, producing the keeled form. One end carefully is worked to a chisel-like edge with a bit angle of 50–60° on a general edge angle of 30°. The opposite end is blunted by a series of hinge fractures. The specimen largely remains unwashed for future residue analysis, but it is possible to tell that flake-scar ridges and the "keel" are well rounded. No debitage of this material occurred in the site, and it would appear that the artifact must have been brought in from some distance away.

The fourth artifact from Zone IIa is a perforated schist bead (Figure 5.3), also found in the screen during excavation of unit 5. Approximately pentagonal in shape, measuring 13.5 by 11.6 by 1.7 mm, the bead is a thin, unmodified schist pebble with a rough conical hole drilled in each face, meeting more or less on center.

Zone IIa also yielded six black chert flakes from excavation units 1 to 3 m east of the fluted point. It is notable that no debitage occurred in the two units that produced the four formed artifacts.

While this assemblage is extremely small, it also is diverse, and three of the artifacts are worthy of comment. The fluted point is similar to surface finds from the Peace River area (Fladmark 1981), and the associated radiocarbon dates confirm that fluted-point users were in the Peace River area prior to 10,000 radiocarbon years ago. However, these specimens are isolated examples, and to make comparisons to them one must search some distance. To the north the nearest assemblages lie some 1,500 km away in Alaska and Yukon. There are no comparable assemblages to the west or east, and to the south, fluted points in dated contexts lie in the U.S., some 1,000 km away. The Charlie Lake specimen is most similar to ones reported by Gryba (1983:Figure 30) from Sibbald Creek in the foothills of Alberta. The Sibbald Creek site contains in situ Paleoindian material in a

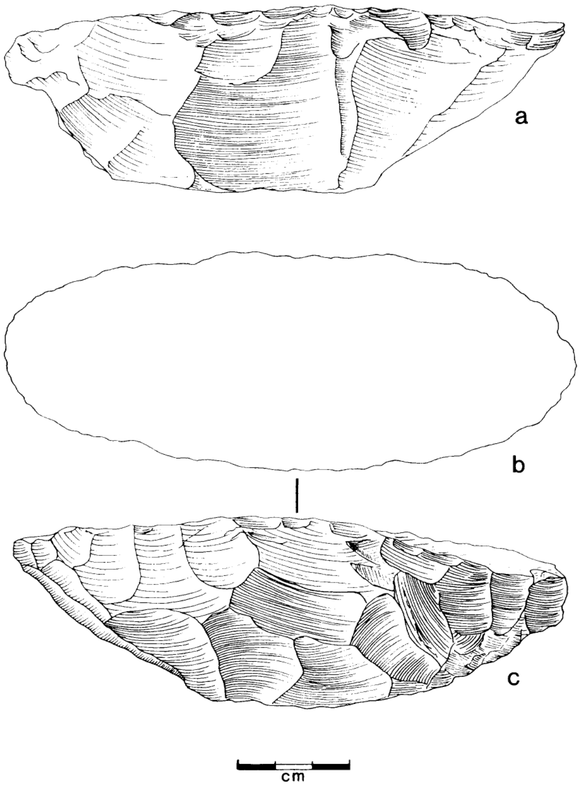


Figure 6. Core tool from Component 1.

shallow stratigraphic sequence with little visible stratigraphy. Although a radiocarbon date of 9570 ± 320 B.P. (GX-8808) was obtained from the lower sediments of the site, this was based on very small particles of wood charcoal scattered through the sediments, and the date cannot be considered as necessarily associated with the fluted points. Probably as a result of compressed stratigraphy, the fluted points at Sibbald Creek were found in association with late Paleoindian points. Furthermore, there appears to be a possibility that equipment failure may have affected the radiocarbon date (Gryba 1983:123). For these reasons we prefer to treat the fluted-point component at Sibbald Creek as undated. Charlie Lake and Sibbald points share certain features with some late Palaeoindian complexes from the northeast woodlands. Some fluted points from New England dated 10,000 to 10,500 B.P. exhibit multiple short basal thinning flakes, deep basal indentations, and often exhaustive resharpening (e.g., Gramly 1982:Plate 7f). These features distinguish the northern points from the classic fluted points of the central and southern plains and mountains of the U.S. Thus the Charlie Lake specimen fits with broadly distributed, though poorly dated, late northern fluted points. Although the point lies within the proposed "ice free corridor" it clearly is at least 1,000 years too late to have anything to do with peopling the New World south of the ice sheets, and in fact lends some credence to the idea that fluted points were introduced to the north from the south. However, the site is too small and too isolated to provide conclusive evidence for such a movement, and one should not forget that the lowest Charlie Lake sediments remain unexcavated.

The quartzite core tool has no precedents in western Canada of comparable age and no such artifacts have been reported in association with fluted points.

The stone bead is, to our knowledge, the first such artifact associated with a fluted-point assemblage.

Table 1. Zone IIa Faunal Remains Associated with Component 1 Artifacts (Units 4 and 5) and in Adjacent Units

Taxon	Units 4 and 5	Units 3, 6, 7
Large mammal		1
Small mammal	3	44
Lepus americanus (snowshoe hare)	2	16
Large *Lepus* (large hare)	2	2
Lagomorph		1
Spermophilus (ground squirrel)	2	120
Sciuridae		1
Ondatra zibethecus (muskrat)		1
Microtus (vole)		2
Microtine		2
Peromyscus (mouse)	1	7
Bison	7	1
Large ungulate	3	
Unidentified bird	4	5
Anas (surface duck)	1	
Small wader		2
Petrochelidon (cliff swallow)		16
Passerine		11
Fish	1	3
Total	26	235

FAUNA

Faunal remains are well preserved throughout the sequence at HbRf 39. In this paper only the fauna from Zone IIa are discussed (Table 1). These remains show considerable variation from one excavation unit to another in all stratigraphic zones, apparently reflecting subtle differences in depositional variables. For example, the greatest concentration of fauna for all zones is in units 1 and 3, which lie partly under an overhang of the "parapet." These units also are dominated by microfauna, probably deposited by owls roosting under the overhang. In this report two faunal assemblages are defined. The first assemblage is from units 4 and 5 which produced the artifacts of the fluted-point component and the earlier radiocarbon dates on bison bone. This assemblage is associated strongly with the human occupation and can be dated directly. The second assemblage occurs in units 3, 6, 7, and 9, which contain little or no artifactual material and radiocarbon dates slightly later than those in units 4 and 5, but which are thought, on stratigraphic grounds, to belong to Zone IIa.

The fauna from the two assemblages forms one of the few dated late Pleistocene/early Holocene assemblages in western Canada not dominated by large mammals. It is likely that most of the fauna results from noncultural events, probably deposition of owl pellets under the overhang in unit 3. The only specimens which can be associated clearly with human activity are the bison bones which exhibit cut marks, and it is notable that bison are common in the assemblage directly associated with the Component 1 artifacts.

The mammalian fauna contains a number of taxa which are not found in the area today. Speciation of *Spermophilus* is difficult, and cannot be undertaken on postcranial elements which form the bulk of the ground squirrel assemblage. On the basis of size and morphology, one can exclude Arctic (*S. parryi*), Thirteen-lined (*S. tridecemlineatus*), Golden-mantled (*S. lateralis*), and Franklin's (*S. franklinii*) ground squirrels. Comparison of mandibles and maxillae from HbRf 39 with modern Columbian (*S. columbianus*) and Richardson's (*S. richardsonii*) ground squirrels suggests that either species may be represented. No ground squirrels occur in the area today, with the nearest population being Columbian, about 100 km to the south in the Rockies. Modern Columbian ground squirrels occupy open alpine habitats (Banfield 1974:118), and the lack of any ground squirrels in the Peace River area today probably is the result of the modern forested environment. Ground squirrels are rare in

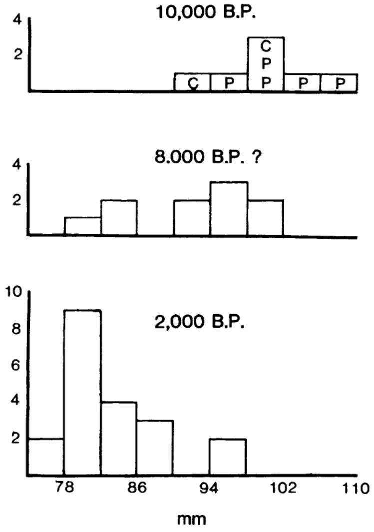


Figure 7. Breadth of trochlea (distal humerus) from Charlie Lake (C), Peace River terraces (P), Duffield (ca. 8000 B.P.), Muhlbach (ca. 2000 B.P.).

the site fauna after 10,000 B.P. and absent after 8000 B.P. While one cannot discount the possibility that these specimens may have burrowed into the site from a slightly higher level, the absence of burrows suggests they are contemporary with the rest of the Zone IIa fauna, as does the radiocarbon date (RIDDL 392) on a ground-squirrel femur.

Another important indicator of a more open habitat are the large *Lepus* specimens. Four lagomorph postcranial elements are much too large for *Lepus americanus* (Snowshoe hare), which dominates the fauna at HbRf 39 after about 10,000 B.P. Large lagomorphs are very difficult to speciate osteologically. However, assuming that an extant species is represented, these four bones must derive from either Arctic hare (*Lepus arcticus*) or from one of the southern species (e.g., *Lepus townsendii*, White-tailed jackrabbit). Although the former perhaps is more likely, either would indicate the presence of a much more open habitat.

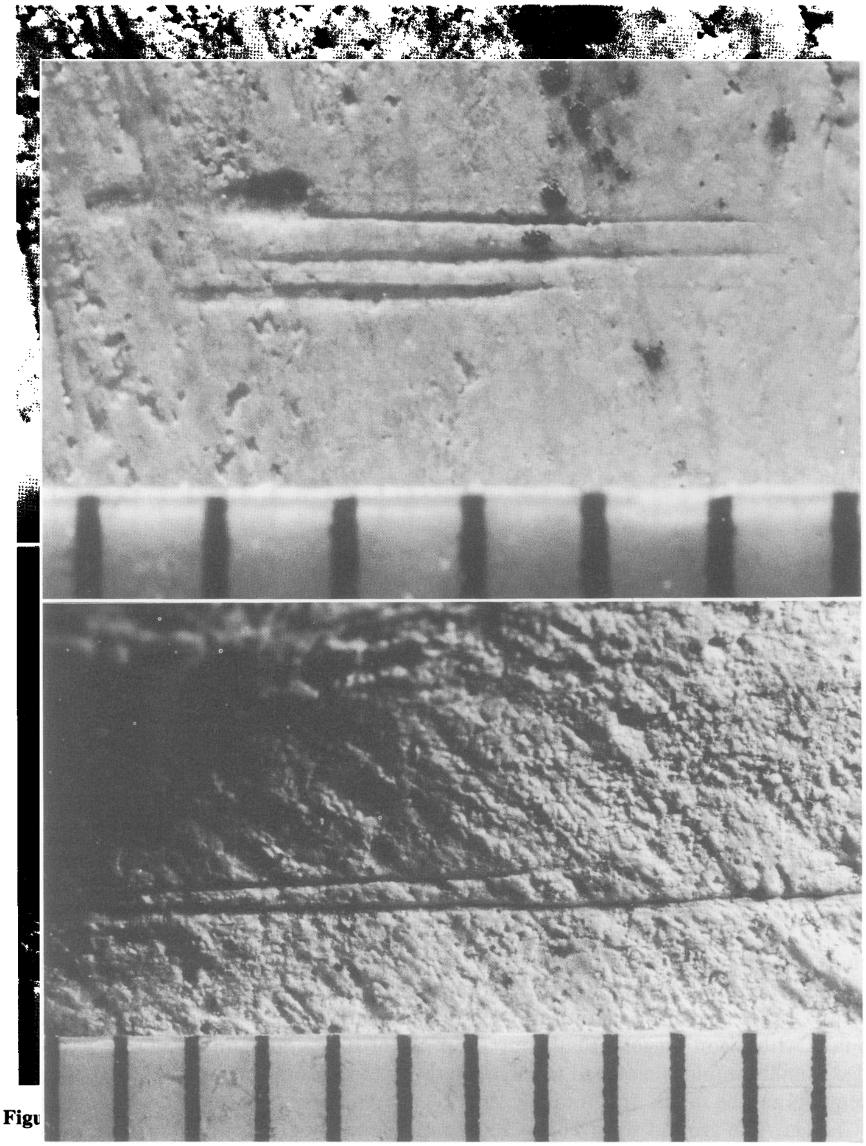
Although *Bison* occurred in the Peace River in historic times (Williams 1978), their presence at Charlie Lake and the absence of elk and moose also suggest more open conditions than prevail today. The bison cannot be speciated, but measurements of long bones show that they were of similar size to bison dated to about 9900 B.P. from the Peace River terraces in Alberta (Churcher and Wilson 1979) and are larger than mid-Holocene specimens from Duffield (Hillerud 1966) and the late Holocene Muhlbach site (Gruhn 1971), both in central Alberta (Figure 7).

All other mammalian species are represented in modern faunas from the area. However, one should note that the single muskrat tooth may be intrusive. Muskrat is very common in later zones at the site, and it is possible that this specimen (which is stained a very different color than the other specimens in Zone IIa) fell from the section during excavation of lower deposits. It should not be used as evidence for this species in the area in early Holocene times.

All avian species also are known from the area today, though the assemblage is somewhat unusual. *Petrochelidon* is almost certainly *P. pyrrhonata* (Cliff swallow) which build colonies of nests on cliff faces. Presumably such a colony existed at HbRf 39. Observations of modern colonies show that substantial "middens" may accumulate under such colonies, and these deposits include mud nests, droppings, and bones.

Other identified birds include a large duck (*Anas*) and a small wader, both suggesting nearby aquatic habitats. One fish bone can be identified as from a sucker (*Catostomus*).

Bison and "large ungulate" bones are the only specimens from Zone IIa with cut marks produced



Fig

by stone tools. Although positive identification of cut marks has been rendered less certain by recent studies (Behrensmeyer et al. 1986), we are reasonably confident that the specimens from Charlie Lake have been subject to human butchering. First, the cut marks occur as shallow, narrow, parallel striations, making rodent or carnivore activity an unlikely cause (Figure 8). Second, there are no rock types within the sediments of HbRf 39 capable of producing such striations except for flaked chert. Third, the cut marks occur on areas of bones where cut marks have been observed frequently on large ungulates from North American archaeological sites and from modern ethnographic studies. Cut marks occur at the following locations: epicondyles of humerus (two specimens), midshaft of rib, and above the semi-lunar notch of the ulna. Finally, some bones deliberately have been fractured

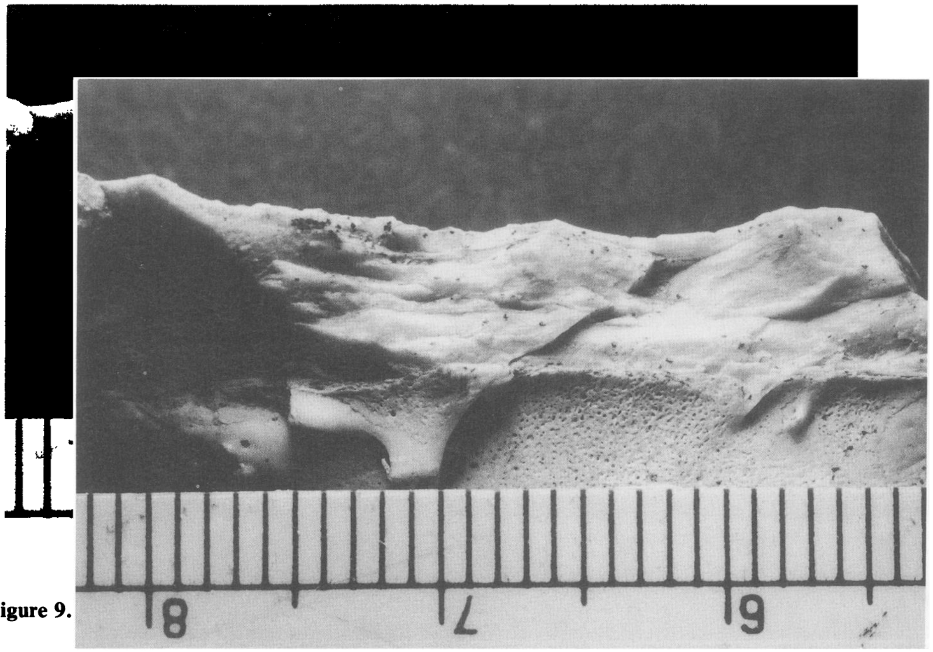


Figure 9.

for marrow, as demonstrated by the evidence for a point of impact and negative "flake scars" on the interior surface opposite the point of impact (Figure 9).

A number of the bones which exhibit cut marks also have been chewed extensively by large carnivores. While one cannot rule out the possibility that large carnivores dragged these bones to HbRf 39 from a human site located elsewhere, this is an unlikely explanation, given the presence of stone tools in association with the fauna.

PALEOENVIRONMENTAL IMPLICATIONS

Between ca. 10,500 and 10,000 B.P. the Charlie Lake area supported a varied fauna, including large and small mammals, birds, and fish. Two taxa—a large hare and a ground squirrel—suggest that forest was either absent or significantly less than occurs in the area today. The association of these two taxa with bison suggests that some form of northern grassland or tundra was present. A more varied faunal sample is required to establish the nature of the environment, but some preliminary statements can be made. It is unlikely that the environment resembled the modern tundra of northern Canada. The ground squirrel species represented is not *Spermophilus parryi* and neither bison nor cliff swallow are a component of the modern tundra fauna. While it obviously is dangerous to use negative evidence, one should note that no modern tundra species such as lemming or caribou are present.

There currently is some debate about the nature of late Pleistocene environments in northern North America (e.g., Guthrie 1985). The Charlie Lake faunal data support the view that environments quite close to major ice masses included abundant and diverse fauna, and there is nothing in this fauna to suggest environmental conditions approaching those of modern Arctic environments. Churcher and Wilson (1979) have described faunas from the lower terraces of the Peace River valley in Alberta, and these assemblages add a number of taxa to the late Pleistocene/early Holocene environment, including mammoth, a variety of equids, camel, elk, and musk-ox. Their suggestion that the environment resembled open prairie or woodland rather than closed forest (Churcher and Wilson 1979:75) is confirmed by the Charlie Lake specimens and by White's (1983) palynological analyses. The later stages of the ice-free corridor clearly were not inhospitable.

DISCUSSION AND CONCLUSIONS

The fluted-point component at Charlie Lake Cave exists in virtual isolation. The nearest dated assemblages containing fluted points are in Alaska (1,500 km to the northwest) (Clark and Clark 1983), Montana (1,200 km to the southeast) (Frison 1978), and Sibbald Creek (700 km to the southeast), if one accepts the Sibbald Creek date as a *terminus ante quem.* This isolation renders comparison with other areas somewhat fruitless. Charlie Lake Cave also provides the northernmost evidence for dietary and hunting practices associated with fluted points. The "big game hunting" adaptation at Charlie Lake parallels evidence from many sites to the south, which hardly is surprising in the light of the reconstructed late Pleistocene environment or subsequent adaptations in the area.

The morphology of the fluted-point specimen can be compared with specimens from Alberta and Alaska, and also with points found in the northeast region of North America, some of which also date in the 10,500 to 10,000 B.P. range. These late fluted points are quite distinct from the contemporary Folsom points being made to the south on the High Plains.

The function of the small lithic assemblage from Charlie Lake Cave is problematic. It is unlikely that a kill site is represented, as the artifact assemblage seems too diverse, and the bison remains suggest very selective transportation of elements from a kill site to this location. The simple bead is, as far as we are aware, the only such specimen recovered in association with a dated fluted-point assemblage. However, bone beads have been reported from some sites, and perforated soapstone pendants are thought to be associated with the Reagen site late fluted-point assemblage in Vermont (Funk 1978). The large, keeled core tool also has no precedent in other fluted-point assemblages. Later assemblages at the site suggest short occupation periods, probably during hunting excursions, as indicated by low artifact density and the predominance of projectile points and bifacial thinning flakes. Without a larger artifact sample it is difficult to make more concrete statements about activities which occurred at the site during the Paleoindian occupation of Component 1.

The site is of importance because it begins to fill a major gap in our knowledge of late Pleistocene/early Holocene adaptations in northern North America. It is only the second reliably dated fluted-point site in Canada, and the only such component which lies under a long stratigraphic sequence and which has an associated fauna. It suggests that the later stages of the ice-free corridor were characterized by environments which supported a varied fauna inhabiting the uplands of a largely open landscape which probably contained significant areas of proglacial lakes and wetlands.

Acknowledgments. We particularly thank Mr. and Mrs. John Cleeve for permission to conduct research on their property. This work was supported by grants from SSHRC to Fladmark and Driver. We thank Carol Fairhurst for undertaking the drawings and Ron Long for photographs. We thank Michael Wilson, Ruth Gruhn, Jean Hourston-Wright, and the Provincial Museum of Alberta for permission to measure bison bones. Dr. William Mathews visited the site and shared his views on stratigraphy and regional geomorphology. We are also grateful to the reviewers for their comments.

REFERENCES CITED

Banfield, A. W. F.
1974 *Mammals of Canada.* University of Toronto Press, Toronto.
Behrensmeyer, A. K., K. D. Gordon, and G. T. Yanagi
1986 Trampling as a Cause of Bone Surface Damage and Pseudo-Cutmarks. *Nature* 319:768–771.
Churcher, R. M., and M. Wilson
1979 Quaternary Mammals from Eastern Peace River District, Alberta. *Journal of Paleontology* 53:71–76.
Clark, D. W., and A. M. Clark
1983 Paleo-Indians and Fluted Points: Subarctic Alternatives. *Plains Anthropologist* 28:283–292.
Farly, A. L.
1979 *Atlas of British Columbia.* University of British Columbia Press, Vancouver.
Fladmark, K. R.
1981 Paleo-Indian Artifacts from the Peace River District. *B. C. Studies* 48:124–135.
Frison, G. C.
1978 *Prehistoric Hunters of the High Plains.* Academic Press, New York.

Funk, R. E.
1978 The Northeastern United States. In *Ancient North Americans,* edited by J. D. Jennings, pp. 303–372. W. H. Freeman, San Francisco.

Gramly, R. M.
1982 *The Vail Site: A Paleo-Indian Encampment in Maine.* Bulletin 30. Buffalo Society of Natural Sciences, Buffalo, New York.

Gruhn, R.
1971 Preliminary Report on the Muhlbach Site; A Besant Bison Trap in Central Alberta. *National Museum of Man Bulletin* 232:128–156.

Gryba, E. M.
1983 *Sibbald Creek: 11,000 Years of Human Use of the Alberta Foothills.* Occasional Paper 22. Archaeological Survey of Alberta, Edmonton.

Guthrie, R. D.
1985 Woolly Arguments Against the Mammoth Steppe—A New Look at the Palynological Data. *Quarterly Review of Archaeology* 6(3):9–16.

Hillerud, J. M.
1966 *The Duffield Site and Its Fossil Bison, Alberta, Canada.* Unpublished Master's thesis, Department of Geology, University of Nebraska, Lincoln.

MacDonald, G. F.
1968 *Debert: A Paleo-Indian Site in Central Nova Scotia.* Anthropology Paper 16. National Museum of Canada, Ottawa.

Mathews, W. H.
1978 *Quaternary Stratigraphy and Geomorphology of Charlie Lake (94A) Map Area, British Columbia.* Paper 76-20. Geological Survey of Canada, Ottawa.
1980 *Retreat of the Last Ice Sheets in Northeastern British Columbia and Adjacent Alberta.* Bulletin 331. Geological Survey of Canada, Ottawa.

White, J.
1983 *Late Quaternary Geochronology and Paleoecology of the Upper Peace River District, Canada.* Unpublished Ph.D. dissertation, Department of Archaeology, Simon Fraser University, Burnaby.

Williams, J. H.
1978 *Fort d'Epinette: A Description of Faunal Remains from an Early Fur Trade Site in Northern British Columbia.* Unpublished Master's thesis, Department of Archaeology, Simon Fraser University, Burnaby.

A 10,500 SEQUENCE OF BIRD REMAINS FROM THE SOUTHERN BOREAL FOREST REGION OF WESTERN CANADA

JONATHAN C. DRIVER

We kindly thank the publisher, Arctic Institute of North America, for permission to reproduce this work.

This article discusses the bird remains found at Tse'K'wa and their significant contributions to British Columbian ornithology. I had previously collaborated with Keith Hobson on a study of the archaeological evidence for birds in the Gulf of Georgia. Keith was at one time a technician and enthusiastic bird watcher in the Department of Archaeology at SFU, and produced the first radiocarbon dates on the early Tse'K'wa materials. After completing his PhD in biology at Saskatchewan in 1991 he embarked on a prestigious career as an ornithologist, working for universities and the federal government.

We wrote this paper to highlight some contributions of the Tse'K'wa animal bone collection to ornithology. Fossil birds are very rare in the interior of western Canada, so this paper established first fossil records in BC for quite a few species.

Passenger pigeons were present for much of the last 10,000 years in the Peace River region, suggesting that they were regular visitors prior to their mass extinction in the late nineteenth century. Quite a few species of migratory birds were present at the site from an early period, suggesting that migration routes were established soon after the glacial conditions came to an end.

A 10 500-Year Sequence of Bird Remains from the Southern Boreal Forest Region of Western Canada

JONATHAN C. DRIVER[1] and KEITH A. HOBSON[2]

(Received 4 March 1991; accepted in revised form 11 June 1991)

ABSTRACT. The prehistoric avian fauna from the Charlie Lake Cave site, Peace River District, British Columbia, spans the last 10 500 years and includes birds from eleven orders. Prior to about 10 000 B.P. the fauna is sparse and the most common species is Cliff Swallow (*Hirundo pyrrhonota*), which probably nested at the site. The avian fauna from 10 000 B.P. to the present is dominated by wetland associated birds (mainly grebes and ducks) of the same species found in the area today and is consistent with the establishment of boreal forest by 10 000 B.P. From about 8000 B.P. Passenger Pigeon (*Ectopistes migratorius*) occurs and appears to have been a regular component of the local fauna. The assemblages demonstrate rapid colonization of boreal environments by bird populations by 10 000 B.P. and probably indicate that the modern patterns of migration were established early in the Holocene.

Key words: British Columbia, fossil birds, Holocene, Passenger Pigeon

RÉSUMÉ. L'avifaune préhistorique du site de Charlie Lake Cave, dans le district de Peace River en Colombie-Britannique, couvre les 10 500 dernières années et comprend des oiseaux appartenant à onze ordres différents. Antérieurement à environ 10 000 BP, la faune est clairsemée et l'espèce la plus courante est l'hirondelle à front blanc (*Hirundo pyrrhonora*), qui nidifie probablement sur le site. L'avifaune couvrant de 10 000 BP au présent est dominée par des oiseaux associés aux terres humides (surtout des grèbes et des canards) appartenant aux mêmes espèces que l'on trouve actuellement dans la région, et cette prédominance correspond à l'établissement d'une forêt boréale d'ici 10 000 BP. À partir d'environ 8000 BP, la tourte (*Ectopistes migratorius*) fait son apparition et semble avoir été une composante régulière de la faune locale. Les assemblages indiquent une colonisation rapide des milieux boréaux par les populations d'oiseaux d'ici 10 000 BP et semblent indiquer que les schémas de migration actuels se sont établis au début de l'holocène.

Mots clés: Colombie-Britannique, oiseaux fossiles, holocène, tourte

Traduit pour le journal par Nésida Loyer.

INTRODUCTION

Well-preserved sub-fossil assemblages of bird bones are uncommon in Canada, mainly because assemblages of this type are usually recovered from caves and few cave sites have been excavated by paleontologists and archaeologists. This is especially true of sub-arctic and boreal regions. Open-air archaeological sites may sometimes produce large quantities of bird bone (e.g., Hobson and Driver, 1989), but most archaeological sites are dominated by species that were economically important to humans and rarely provide information about a wider range of species. Preservation of bone in open-air sites in boreal areas is usually quite poor, so there is very little evidence for the history and development of Holocene vertebrate communities in boreal regions. As a result, relatively little is known about prehistoric bird communities or the evolution of migratory routes to northern Canada and Alaska. Stratified deposits at the Charlie Lake Cave site within the boreal forest region of British Columbia span the last 10 500 radiocarbon years. The deposits contain a wide variety of vertebrate fossils, including birds. This paper describes the avian assemblage at this site and attempts to use these data in paleoenvironmental reconstruction.

THE CHARLIE LAKE CAVE SITE

The Charlie Lake Cave site is located a short distance from Charlie Lake, about 7 km up the Alaska Highway from Fort St. John, British Columbia (56°16′35″N, 120°56′15″W; Fig. 1). The site was excavated in 1983, and the setting and stratigraphy of the site have been described in detail elsewhere (Driver, 1988; Fladmark *et al.*, 1988). Although the site is named for a small cave in the sandstone escarpment that outcrops along the northeast side of Stoddart Creek, the cave itself contains only shallow deposits. Immediately in front of the cave is a deep gully that runs parallel to the escarpment containing the cave. The downslope side of this gully is formed by a large section of bedrock, which was probably detached from the bedrock escarpment in Late Pleistocene times, prior to 10 500 B.P.

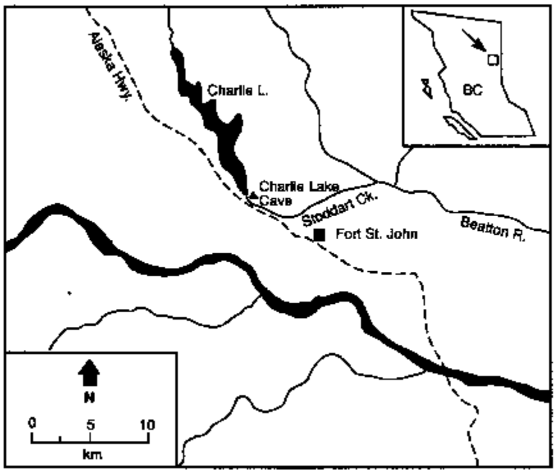


FIG. 1. Location of Charlie Lake Cave.

Since the retreat of Glacial Lake Peace from the site (probably shortly before 10 500 B.P.), the gully has been filling with sediments to a depth of more than 4 m. These sediments result from weathering of the sandstone bedrock and

---

[1] Department of Archaeology, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6
[2] Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada S7N 0W0

down-slope movement of sediments from the hillside above the escarpment. Radiocarbon dates and observations during excavation suggest that most of these sediments have been relatively undisturbed by subsequent biological and pedogenic forces. While sediments were being added to the gully, the site was visited occasionally by humans who left stone artifacts and bones there from as early as 10 500 B.P. (Fladmark *et al.*, 1988). It was also visited by a variety of predators that brought animal bones to the site and by animals that lived and died there, creating a well-preserved and well-dated faunal assemblage (Driver, 1988). The stratigraphic sequence has been divided into four major zones, some of which can be subdivided further into sub-zones (Table 1). More detailed descriptions of the stratigraphy and chronology of the site have been presented in Driver (1988) and Fladmark *et al.* (1988).

TABLE 1. Summary of stratigraphic zones and sub-zones and radiocarbon dates

Zone / sub-zone	Estimated time range	Radiocarbon dates B.P.
I	pre-10 500 B.P.	None
IIa	10 500 to 10 000 B.P.	10 770±120 (SFU 454) 10 450±150 (SFU 300) 10 380±160 (SFU 378) 10 100±210 (RIDDL 392)
IIa/IIb interface	10 000 B.P.	9990±150 (RIDDL 393)
IIb	10 000 to 9000 B.P.	9760±160 (SFU 355)
IIIa	9000 to 8100 B.P.	7800±800 (SFU 370)
IIIb	8100 to 7000 B.P.	8400±240 (SFU 357) 7100±350 (SFU 452)
IIIc	7000 to 6200 B.P.	None
IIId	6200 to 5500 B.P.	1130±240 (SFU 453)*
IIIe	5500 to 4300 B.P.	4800±640 (SFU 451) 4400±400 (SFU 385)
IV	4300 B.P. to present	6700±290 (SFU 356)* 4270±160 (SFU 382) 2900±400 (SFU 358) 1400±400 (SFU 379)

*These dates are inconsistent with the stratigraphy; see Driver (1988:1546).

AVIAN FAUNA

The 338 identified bird bones (Table 2) are a relatively minor component of the assemblage excavated from the site in 1983, which includes more than 3000 fish bones and more than 3000 mammal bones (Driver, 1988). The importance of bird bones in the various zones and sub-zones varies. In zone II, birds account for almost 19% of the identified specimens. In sub-zones IIIa, IIIb and IIIc the figure drops to about 8%, and in sub-zones IIId and IIIe and zone IV birds form only about 3% of the fauna.

Bird bones were initially sorted by family using the comparative collection in the Zooarchaeology Laboratory, Department of Archaeology, Simon Fraser University. All bird bones were then checked further using the collection at the Royal Ontario Museum, Toronto, the Zooarchaeological Identification Centre, Ottawa, and the Burke Memorial Museum, University of Washington, Seattle.

TABLE 2. Identified avian fauna by zone and sub-zone, Charlie Lake Cave site

Taxon	Zone/sub-zone							
	IV	IIIe	IIId	IIIc	IIIb	IIIa	IIb	IIa
Podiceps auritus				1	3	3	15	
Aechmophorus sp.	20			1	2	5	2	
Medium-sized grebes	2	2	1	2	9	3	4	
Phalacrocorax auritus	1							
Phalacrocorax sp.	2							
Cygnini	1							
Anserini	2							
Anatini	36	4	5		2		2	1
Anas crecca	13		2		1	9	1	
Anas platyrhynchos	1						1	
Aythyini	1	1						
Melanitta fusca	1							
Bucephela sp.	1							
Mergus sp.	1	1	1					
Lophodytes cucullatus	1							
Oxyura jamaicensis	2						1	
Falconiformes			1					
Tetraoninae	18	3	4		10	8	13	
Small Rail							2	
Fulica americana		1					10	
Calidris minutilla	1							
Calidris sp.						4		
Small wader	1							2
Larus sp.	2			1				
Ectopistes migratorius	5		1		2	1		
Strigiformes	3					1		
Asio flammeus							8	
Surnia ulula				5				
Ceryle alcyon		1						
Passeriformes	19	2	4		1	1	1	11
Hirundo pyrrhonota						1	3	16
Corvus corax					1			
Total	134	15	19	10	31	36	63	30

SYSTEMATIC DESCRIPTIONS

Avian remains are summarized below by order. Where possible we have included reference to the current status of species in the vicinity of Charlie Lake Cave. Unless stated otherwise, our analyses are based on information provided by Campbell *et al.* (1990).

Podicipediformes: With the exception of the earliest deposits (sub-zone IIa), grebes occurred throughout the sequence. Due to its greater size, *Aechmophorus* sp. was readily separated from other grebes. Although long considered as two colour phases of a single species, the Western Grebe (*A. occidentalis*) is now considered a separate species from Clark's Grebe (*A. clarkii*). There appear to be no osteological differences between the two species, which may have separated relatively recently. For this reason, an earlier identification of *A. occidentalis* for the large grebes (Driver, 1988) must be replaced by *Aechmophorus* sp. Approximately half of the remaining grebe bones were identifiable as Horned Grebe (*Podiceps auritus*). Presently Horned Grebes breed throughout this boreal ecozone. No breeding records exist for Western

Grebes here, but the area is coincident with the northernmost limit of inland occurrence of the species in British Columbia.

Pelecaniformes: Three cormorant bones were recovered from the most recent deposits (zone IV) and one of these was identified as Double-Crested Cormorant (*Phalacrocorax auritus*). The other bones were almost certainly of this species, since it is the only North American cormorant that regularly occurs inland. This species breeds on the southwest coast of Alaska (Godfrey, 1986). Northernmost breeding records in Canada are for northern Alberta at the southern edge of the boreal forest (Godfrey, 1986). In British Columbia nesting records occur only on the southwest coast, but the species has been recorded in the Charlie Lake region. Coastal records date to the last 5000 years (Hobson and Driver, 1989) and are coincident with the period of occurrence at Charlie Lake.

Anseriformes: A single swan bone was recovered from zone IV but could not be identified to species. Currently, both Tundra (*Cygnus columbianus*) and Trumpeter (*C. buccinator*) swans occur in this area. Tundra Swans use the Fort St. John region as a stopover site while migrating to and from Alaskan breeding grounds. Trumpeter Swans breed in the Peace lowlands and boreal forest but also use the Charlie Lake area as a stopover site en route to Alaska.

Two goose bones were identified in zone IV but could not be identified to genus or species. Duck bones were common in most zones, but species identification was difficult because of considerable overlap in bone size and morphology within this group. The most commonly identified species was the Green-winged Teal (*Anas crecca*), probably because its small size makes its bones distinctive. Currently this species breeds throughout the boreal and sub-arctic regions of Canada. A similar distribution is found for the Mallard (*Anas platyrhynchos*), for which two bones were identified. One Goldeneye (either *Bucephela clangula* or *B. islandica*) and one White-winged Scoter (*Melanitta fusca*) were found in zone IV. Both species of Goldeneye and the White-winged Scoter currently breed throughout northern British Columbia. Bones of Ruddy Duck (*Oxyura jamaicensis*) were found in zone IV and in sub-zone IIb. This species breeds in the Peace River area but also breeds locally farther north to the southern Northwest Territories. At least two mergansers were present in the upper zones. A large species (either *Mergus merganser* or *M. serrator*) was represented by three bones. Red-breasted Mergansers breed only in northwestern British Columbia but occur throughout the province. Common Mergansers have a more widespread breeding distribution in British Columbia and are known to nest in the Charlie Lake area. A single specimen of Hooded Merganser (*Lophodytes cucullatus*) was recovered from zone IV. This species is uncommon in the area today and typically breeds farther south in central British Columbia and southwestern Alberta.

Falconiformes: A single Falconiform bone was recovered in zone IIId but could not be identified to genus.

Galliformes: Grouse and ptarmigan (*Tetraoninae*) bones were a constant component of the fauna from sub-zone IIb onwards but identification to genus was not possible. Currently, ptarmigan (*Lagopus* spp.) occur mainly west of the Peace River region, but grouse are more common. Ruffed Grouse (*Bonasa umbellus*) occur primarily in forested areas of the region, whereas Sharp-tailed Grouse (*Tympanuchus phasianellus*) occur in more open areas of the Peace lowlands.

Gruiformes: Two small rail bones were recovered from sub-zone IIb. On the basis of size and morphology the bones are most similar to either Sora (*Porzana carolina*) or Virginia Rail (*Rallus limicola*). Today only the Sora is found in the Peace River region, and the Virginia Rail occurs only in the southern part of the province. However, this species does breed in northeast and central Alberta. Bones of the American Coot (*Fulica americana*) were a conspicuous component of sub-zone IIb. Coots breed at Charlie Lake today and range as far north as the southeast Yukon.

Charadriiformes: Three small gull bones were recovered. These were comparable to Franklin's Gull (*Larus pipixcan*) and Bonaparte's Gull (*L. philadelphia*), both of which can be found in the area today. A number of small wader bones were recovered. These include one specimen of Least Sandpiper (*Calidris minutilla*) and a number of other specimens assignable to *Calidris* sp. Many species of sandpiper pass through the Peace River region during their migrations to and from the northern breeding areas.

Columbiformes: It is believed that Passenger Pigeons (*Ectopistes migratorius*) occurred primarily in the eastern half of North America from central and southern Canada to Louisiana and Florida and wintered south of their breeding range (Goodwin, 1977:204). With the exception of the introduced Rock Dove (*Columba livia*), pigeons are currently absent from the Peace River area. Nine columbid bones were positively identified as Passenger Pigeon (Fig. 2). The earliest occurrence is in sub-zone IIIa, estimated to date from 9000 to 8100 B.P. (Table 1). This is the earliest fossil record for Passenger Pigeon in British Columbia, although specimens have been recorded from a number of Late Pleistocene locations in other areas of North America (Lundelius *et al.*, 1983).

Passenger Pigeons are currently regarded as having been casual and accidental in British Columbia (AOU, 1983), and Bent (1932:400) states that "Passenger Pigeon also have been recorded from British Columbia, but the evidence seems rather unsatisfactory." However, their occurrence in the faunal assemblages of four distinct stratigraphic zones suggests that they may have been migrating regularly to the area during the summer. A recent study of the Passenger Pigeon in the eastern woodlands of North America has shown that even in areas where the birds were known to be abundant during the 19th century, some prehistoric archaeological sites contain relatively few bones (Neumann, 1985). Neumann suggested that the immense populations of Passenger Pigeon recorded during the 19th century were largely the result of the alteration of the landscape through the introduction of European farming methods, which created a habitat highly favourable to Passenger Pigeons and which reduced the numbers of competitors for their major foods.

Prehistoric archaeological sites in the northeastern United States often exhibit relatively low percentages of Passenger Pigeon, even though the sites lie within the breeding area of the birds. Neumann (1985) ascribes these low percentages to the much smaller pigeon populations in the centuries prior to European incursions.

At Charlie Lake, Passenger Pigeons constitute about 3% of the total avian fauna. At the early 19th-century Fort d'Epinette, about 50 km southeast of Charlie Lake, Passenger Pigeon also accounted for 3% of the bird remains identified to at least the order (Williams, 1978). These values are higher than at some archaeological sites in the regions considered as prime Passenger Pigeon habitat in eastern North America. The occurrence of Passenger Pigeons at the only two sites in the Peace River District where fauna has been comprehensively

FIG. 2. Specimens of Passenger Pigeon. Top: two coracoids and a humerus from Charlie Lake Cave. Bottom: coracoid and humerus from late prehistoric sites in Ontario.

studied, coupled with their regular appearance in faunal assemblages from at least 8000 B.P., suggests that Passenger Pigeon was a relatively common summer visitor to the area.

There are similarly limited data from Alberta to support this conclusion. About 6% of the identified bird bones from the historic period site of Fort George in east-central Alberta were from Passenger Pigeon (McCorquodale, 1971; Smith and Kidd, 1971) and a single bone was identified from Fort White Earth, also in east-central Alberta (Hurlburt, 1977).

Strigiformes: A few large owl bones were identified, but genus could not be determined. An articulated foot of Short-eared Owl (*Asio flammeus*) was recovered from just above the interface between sub-zones IIa and IIb and probably dates shortly after 10 000 B.P. This species currently breeds throughout boreal and sub-arctic regions of Canada and Alaska. Bones of Northern Hawk-owl (*Surnia ulula*) were recovered from sub-zone IIIc, dating between about 7000 and 5000 B.P. Today this species is distributed throughout the boreal regions of North America.

Coraciiformes: A single bone of Belted Kingfisher (*Ceryle alcyon*) was recovered from sub-zone IIIe (5000 B.P.). This species breeds from western Alaska and throughout much of forested Canada.

Passeriformes: Bones of this very diverse order are difficult to identify to species, and the dearth of species represented is partly due to difficulties of identification. The most striking occurrence is the presence of numerous bones of Cliff Swallow (*Hirundo pyrrhonota*) in the lower deposits, mainly sub-zone IIa (10 500 to 10 000 B.P.). The rocky gully at the Charlie Lake Cave site would have provided a suitable nesting area for this species, which today nests a few metres above ground level in similar sandstone cliffs along Charlie Lake. Examination of deposits under modern Cliff Swallow communities shows that small middens build up, composed of droppings, decayed nests and dead birds. It is likely that the strong representation of Cliff Swallows in the earliest fauna records the presence of a colony of these birds, to our knowledge the oldest colony of this species recorded in Canada. Most of the other passerine bones from sub-zone IIa are probably from this species.

Other passerines recorded include a single bone of Common Raven (*Corvus corax*). Driver (1988) reported a specimen of Barn Swallow (*Hirundo rustica*), but re-examination of the specimen does not support the original identification and it has been included in the Passeriformes category.

TAPHONOMY AND PALEOECOLOGY

Generally, avian remains are considered poor paleoecological indicators because they are often difficult to identify to species and because birds may migrate long distances and are thus not restricted to local habitats. Furthermore, the presence of unexpected species at a particular locality can be ascribed to unusual short-term weather conditions, such as storms (e.g., Wilson, 1978). There are also more general problems with deducing past environments from vertebrate remains. Many of these have been summarized by Grayson (1981) and include problems of taphonomy, disturbance and quantification procedures. Grayson (1981) notes that one can either use presence/absence of a species or consider its relative frequency in an assemblage as an index of its importance.

Presence/absence is problematic because it gives equal weight to species represented by single bones and thousands of bones. Paleoecological reconstructions based on presence/absence are susceptible to errors introduced by mixing of assemblages by a variety of factors (e.g., redeposited fauna, rodent burrowing, etc.). On the other hand, the use of relative frequencies may exaggerate the importance of animals with bones that are easy to identify or animals that died on site and were left as complete skeletons. In this study we have relied mainly on presence/absence data because of the relatively small sample size and because we do not have a good understanding of the taphonomic history of most of the species identified.

All paleoecological studies using species as indicators of past environments must take into account the taphonomic history of the bones. For smaller mammals and birds it is particularly important to remember that a wide variety of predators may deposit bones and that the structure of the faunal assemblage may reflect as much on the type of predator as upon the local environment. Some of the bird bones at the Charlie Lake Cave site were probably introduced by avian and mammalian predators. The presence of sandstone cliffs in a forested setting would have been attractive to hawks and owls for nesting, roosting and feeding. The cave itself may have been an attractive den for carnivores. Avian predators are not well represented in the faunal assemblage, but this is not surprising as one would not necessarily expect owls and hawks to die at roosting sites, and one would expect bones of prey to outnumber bones of predators. Mammalian predators found at the site include virtually every modern carnivore in the Peace River district (Driver, 1988). Most of these date from the period of zone IV deposition, when the cave (a suitable denning site) would have been more accessible as the gully in front of it filled with sediment. Although mammalian predators are numerous, they were probably not responsible for introducing most of the bird bones. Many of the preserved bird bones are too large to have passed through a carnivore's digestive system, and they lack the heavy erosion caused by mammalian digestive processes. They are more similar in terms of size, breakage and erosion to the remains left by large owls (Kusmer, 1986). Moreover, some specimens were found as partially articulated units, suggesting deposition as pellets or as discarded, defleshed carcass portions.

Other bird bones were probably deposited as a result of natural deaths at the site. As was suggested above, Cave Swallows probably nested at the site, and the high frequency of this species in zone II is probably the result of natural deaths. Many of the bones are unbroken, which further supports this interpretation.

People were certainly contributing some bones to the faunal assemblages (Fladmark *et al.*, 1988), but there are problems assessing which bird species were humanly introduced. Ericson (1987) noted two criteria that definitely denote human involvement in the deposition of bird bones: modification of bones as a result of butchery, cooking, etc., or introduction of species not native to the region. No bird bones from the Charlie Lake Cave site exhibit evidence for butchery in the form of cut marks. Approximately 9.4% of all bird bones are burnt, which compares to 10% of the total fauna from the site. However, burning cannot be associated exlusively with human activity at this site. No bird bones exhibited the distinctive patterned burning associated with roasting (Vigne and Marinval-Vigne, 1983).

Ericson (1987) also discussed variation in the relative frequency of different areas of the bird skeleton as a possible indicator of human involvement in the accumulation of avian bones. Ericson studied natural and cultural accumulations of avian bones from predominantly coastal sites in northwestern Europe. Ericson's study showed that naturally deposited avian bones in coastal environments show over-representation of wing bones, while humanly accumulated domestic fowl faunas exhibit an under-representation of wing bones (Ericson, 1987:73). Unfortunately, Ericson's study is of limited value in evaluating avian assemblages in general. First, Ericson almost completely ignores widespread ethnographic data concerning the use of birds by humans for non-food purposes (e.g., decorative uses of feathers and talons). Second, Ericson assumes that domestic fowl provide a suitable model for the treatment of all birds used for food. This is an unwarranted assumption, especially as domestic fowl have heavily muscled legs, while in some wild birds the greatest amount of available meat is often associated with flight muscles of the wings and pectoral girdle. Livingston (1989) has suggested that element frequency may relate to the relative robustness of different areas of avian skeletons and has pointed out that the survivorship of anterior and posterior limbs may depend upon the locomotory adaptations of the taxa involved, so that relative frequencies of wing bones need not necessarily be a criterion of human or non-human accumulations.

In the absence of good criteria for distinguishing humanly accumulated bird bones from naturally accumulated bones, detailed discussion of element frequencies are not presented in this paper. However, note should be made of unusual element frequencies for owl bones, which suggest that they were humanly collected. Owls are represented by 17 specimens: a tarsometatarsus, 15 phalanges, and a premaxilla. This suggests deliberate selection of beaks and talons, a common pattern of human selection for raptor and owl body parts.

The Charlie Lake avian assemblages are dominated by species associated with freshwater environments. From zone IIb until the present there are fairly consistent assemblages of birds, which suggest the local presence of freshwater lakes and marshes. Grebes and ducks, as well as less common species, demonstrate the presence of open water from about 10 000 B.P. to the present. This fits well with the modern local environment, which includes a fairly large lake and associated wetlands.

Analysis of paleoenvironments in the area using geomorphology (Mathews, 1978, 1980), mammals (Churcher and Wilson, 1979; Driver, 1988) and palynology (MacDonald, 1987) provides further insight into environmental change. The final stages of deglaciation are poorly dated, but ice was absent from this part of the Peace River before 11 000 B.P. Large ice-dammed lakes dominated much of the lower-lying areas, and the site may have been covered by Glacial Lake Peace prior to 10 500 B.P. The vegetation of the region from 11 000 to 10 000 B.P. was an open grassland with patches of deciduous woodland (Churcher and Wilson, 1979; Driver, 1988; MacDonald, 1987). The avian fauna from sub-zone IIa is very sparse but is consistent with the environment reconstructed from the above data. The virtual absence of waterbirds, especially ducks, suggests that the glacial lakes may have been relatively unproductive environments and were not suitable for colonization by waterfowl.

By about 10 000 B.P. environments in the Peace River area underwent a major change as boreal forests colonized much of the landscape (MacDonald, 1987). Open habitats were replaced rapidly by boreal forest. This is reflected in the Charlie Lake mammal fauna (Driver, 1988). The bird remains after 10 000 B.P. essentially record the development of modern conditions. While the fauna is heavily biased towards waterbirds, it is consistent with modern avian faunas in the area today. It appears that once stable drainage systems and boreal forest were established in the Peace River District an essentially modern avifauna was present. Many of the species found in the Charlie Lake Cave site are migratory, which suggests that major migration patterns were established early in the Holocene. The presence of Passenger Pigeon from at least 8000 years ago demonstrates that this species was a regular component of the British Columbia bird community and that its range was not determined solely by the distribution of eastern deciduous forests.

ACKNOWLEDGEMENTS

Excavations at Charlie Lake Cave were funded by a SSHRCC grant to Knut Fladmark. Analysis of the fauna was funded by a SSHRCC grant to Driver. The following people kindly allowed access to comparative collections: Howard Savage (Toronto); Sievert

Rohwer, Terri Smith, Chris Wood (Seattle); Darlene Balkwill (Ottawa). Howard Savage also made a permanent loan of specimens of Passenger Pigeon to the Zooarchaeology Laboratory, SFU. Photographs and figures were prepared by the Instructional Media Centre, SFU. We thank an anonymous reviewer, W.A. Montevecchi and M.C. Wilson for their constructive and informative comments on the paper.

REFERENCES

AMERICAN ORNITHOLOGISTS' UNION (AOU). 1983. Check-list of North American birds. 6th edition. Lawrence, Kansas: American Ornithologists' Union.

BENT, A.C. 1932. Life histories of North American Gallinaceous birds: Orders Galliformes and Columbiformes. Washington. D.C.: Smithsonian Institution Bulletin 162.

CAMPBELL, R.W., DAWE, N.K., McTAGGART-COWAN, I., COOPER, J.M., KAISER, G.W., and McNALL, M.C.E. 1990. Birds of British Columbia. Victoria: Royal British Columbia Museum.

CHURCHER, C.S., and WILSON, M. 1979. Quaternary mammals from the Peace River District, Alberta. Journal of Paleontology 53:71-76.

DRIVER, J.C. 1988. Late Pleistocene and Holocene vertebrates and palaeoenvironments from Charlie Lake Cave, northeast British Columbia. Canadian Journal of Earth Sciences 25:1545-1553.

ERICSON, P.G.P. 1987. Interpretations of archaeological bird remains: a taphonomic approach. Journal of Archaeological Science 14:65-75.

FLADMARK, K.R., DRIVER, J.C., and ALEXANDER, D. 1988. The Paleoindian component at Charlie Lake Cave (HbRf 39), British Columbia. American Antiquity 53(2):371-384.

GODFREY, W.E. 1986. Birds of Canada. Ottawa: National Museum of Canada.

GOODWIN, D. 1977. Pigeons and doves of the world. Ithaca: Cornell University Press.

GRAYSON, D.K. 1981. A critical view of the use of archaeological vertebrates in paleoecological reconstructions. Journal of Ethnobiology 1:28-38.

HOBSON, K.A., and DRIVER, J.C. 1989. Archaeological evidence for use of Strait of Georgia by marine birds. In: Vermeer, K., and Butler, R.W., eds. The ecology and status of marine birds in the Strait of Georgia, British Columbia. Ottawa: Canadian Wildlife Service Special Publication. 168-173.

HURLBURT, I. 1977. Faunal remains from Fort White Earth, N.W.Co. (1810-1813). Edmonton: Provincial Museum of Alberta Human History Occasional Paper No. 1.

KUSMER, K.D. 1986. Microvertebrate taphonomy in archaeological sites: An examination of owl deposition and the taphonomy of small mammals from Sentinel Cave, Oregon. M.A. thesis, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia.

LIVINGSTON, S.D. 1989. The taphonomic interpretation of avian skeletal part frequencies. Journal of Archaeological Science 16:537-547.

LUNDELIUS, E.L., Jr., GRAHAM, R.W., ANDERSON, E., GUILDAY, J., HOLMAN, J.A., STEADMAN D.W., and WEBB, S.D. 1983. Terrestrial vertebrate faunas. In: Porter, S.C., ed. Late-Quaternary environments of the United States. Vol. 1, The Late Pleistocene. Minneapolis: University of Minnesota Press. 311-353.

MacDONALD, G.M. 1987. Postglacial development of the subalpine-boreal transition forest of western Canada. Journal of Ecology 75:303-320.

MATHEWS, W.H. 1978. Quaternary stratigraphy and geomorphology of Charlie Lake (94A) map area, British Columbia. Geological Survey of Canada Paper 76-20.

______ .1980. Retreat of the last ice sheets in northeastern British Columbia and adjacent Alberta. Geological Survey of Canada Bulletin 331.

McCORQUODALE. B.A. 1971. Identification of faunal remains from the Fort George site. In: Kidd, R.S. Fort George and the early fur trade in Alberta. Edmonton: Provincial Museum and Archives of Alberta Publication No. 2. 233-235.

NEUMANN, T.W. 1985. Human-wildlife competition and the Passenger Pigeon: Population growth from system destabilization. Human Ecology 13(4):389-410.

SMITH, H.C., and KIDD, R.S. 1971. A record of the Passenger Pigeon in Alberta. Canadian Field Naturalist 85(3):259.

VIGNE, J.-D., and MARINVAL-VIGNE, M.-C. 1983. Methode pour la mise en evidence de la consommation du petit Gibier. In: Clutton-Brock, J., and Grigson, C., eds. Animals and archaeology 1: Hunters and their prey. Oxford: British Archaeological Reports International Series 163. 239-242.

WILLIAMS, J.H. 1978. Fort d'Epinette: A description of faunal remains from an early fur trade site in northern British Columbia. M.A. thesis, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia.

WILSON, M. 1978. Cyclones, coconuts and chickens across the sea: Dispersal theory and cultural diffusion. In: Duke, P.G., Ebert, J., Langemann, G., and Buchner, A.P. Diffusion and migration: Their roles in cultural development. Calgary: University of Calgary Archaeological Association. 65-105.

THE PREHISTORY OF CHARLIE LAKE CAVE
&
THE SIGNIFICANCE OF THE FAUNA FROM CHARLIE LAKE CAVE

KNUT R. FLADMARK, JONATHAN C. DRIVER

This excerpt is reproduced with permission of the Publisher of 'Early Human Occupation in British Columbia' by Roy Carlson and Luke Dalla Bonna. © University of British Columbia 1996. All rights reserved by the publisher. .

These papers are excerpts from Early Human Occupation in British Columbia, an archaeological book published in 1996. In 1988 the annual meeting of the Canadian Archaeological Association was held in Whistler, B.C. As part of the meeting, Roy Carlson, a professor at SFU, organized a symposium on the early human presence in British Columbia. Knut Fladmark and I each gave a paper on our work at Tse'K'wa, based on the 1983 excavation season.

Although it was intended to publish the book quickly, there were various delays, and Fladmark and I went back to Tse'K'wa in 1990 and 1991 before the proceedings of the Whistler symposium were finally published in 1996. We updated our papers slightly based on the later excavations, but both of these papers really reflect our thinking prior to the full analysis of the material from 1990 and 1991.

Fladmark's paper is a good introduction to the location and geology of the site, and it provides an account of the cultural materials recovered in 1983.

Driver's paper summarizes the animal bones from the 1983 excavations, and devotes more time to considering how the wide variety of animals were brought to the site. I noted that the bison bone was found in locations with lower amounts of small mammals and birds and suggested that most of the smaller animals were brought to the site by non-human predators, such as owls.

2

THE PREHISTORY OF CHARLIE LAKE CAVE

Knut R. Fladmark

Surface finds of Paleoindian styles of projectile points, particularly Plano/Scottsbluff-like forms, have been made by farmers, amateur surface collectors, and archaeologists in several interior areas of British Columbia (e.g., Fladmark 1981). However, until 1983 none had been recovered from an excavated, dated context. Given the strategic location of this province, astride crucial portions of both proposed interior and coastal routes for early human populations moving south from Beringia (e.g., Fladmark 1983), the complete absence of any firmly dated Paleoindian occupations in British Columbia represented a troublesome gap in knowledge pertaining to the initial colonization of this continent. This situation began to change in 1983 with the excavation of the Charlie Lake Cave site in northeastern British Columbia, which yielded a small fluted point component at the base of a deep sedimentary and cultural sequence spanning about the last 10,500 years.

Charlie Lake Cave first came to my attention in the summer of 1974 in the course of directing initial heritage impact surveys of the Peace River Valley, and in 1983 I obtained Social Sciences and Humanities Research Council funding for a single short season of excavation at the site, assisted by Jon Driver and Diana Alexander as principle co-investigators. Further excavations took place at Charlie Lake Cave in 1990 and 1991. Analysis of this material is still in progress. Although more artifacts were recovered, the outline of the cultural sequence presented here has been modified in only one significant way. A microblade core was recovered from a context securely dated at about 9500 BP. The core is made on a roughly rectangular piece of tabular chert. It has a unifacially flaked keel and a poorly prepared striking platform. At least six microblades had been detached from one end of the core, but none was associated with this isolated find. The core bears a superficial resemblance to some early Holocene cores from Alaska. More details and comparisons will be provided in a later paper. Charlie Lake Cave is located about 9 km northwest of the modern city of Fort St. John in the Peace River district of northeastern British Columbia. The site is barely visible today to travellers on the Alaska Highway as a small south-facing sandstone abutment near the crest of a low wooded ridge forming the southeastern margin of Charlie Lake, about 6 km north of the Peace River itself. The ridge area is currently developed as a low-density residential subdivision and the site is on private property (Figures 1 and 2).

Charlie Lake Cave itself technically meets the requirements of a true small endogenic cave, rather than rockshelter, consisting of a single main chamber penetrating about 6 m into the hill, by a maximum of about 4.5 m wide. The one entrance to the cave is so low and narrow that an adult must stoop almost to hands-and-knees to enter (Figure 3), although near the back of the inner room even a relatively tall adult can safely stand upright (Figure 4). Two bedrock-floored secondary chambers also open off the back of the main room, but are too small to have ever been appropriate for human use. The cave is developed in a vertical sandstone escarpment which outcrops discontinuously along the northeast shore of Charlie Lake, belonging to the "Dunvegan Sandstone Formation" of Cretaceous age. Because Dunvegan Sandstone is known to occasionally contain "coal deposits," we were cautious about using unidentified carbonaceous materials from the excavations for radiocarbon dates. Consequently, all of the early dates on the site, as well as two of the later dates, were obtained on bison bone collagen.

Although the presence of the cave is a prominent local physical characteristic and the feature which first attracted my attention to this location, the cave itself turned out to be relatively sterile of aboriginal cultural deposits. Instead, the site accumulated and preserved its long stratigraphic sequence because of a unique alignment of bedrock features located outside the cave mouth which has retained thousands of years of archaeosedimentary aggradation.

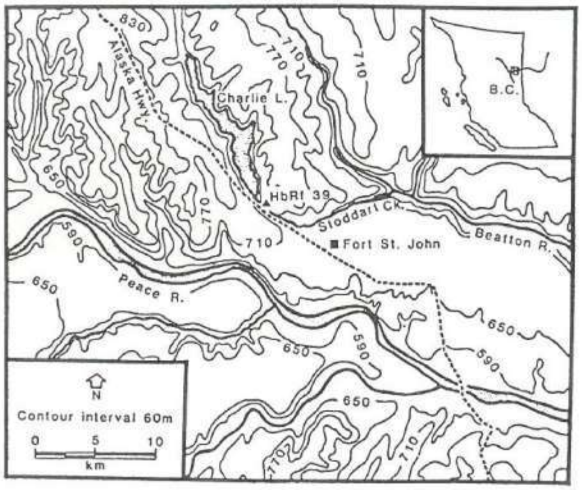


Figure 1. Location of HbRf 39.

The "parapet" is the name that we applied to a large independent block of sandstone which parallels the main escarpment in front of the cave, and which has acted as a natural abutment to entrap and retain sedimentary accumulations derived from the mouth of the cave and the overlying hillside (Figure 5). The parapet and other similar sandstone outcrops seen along the hillside are large blocks detached and tilted slightly away from the main bedrock escarpment, possibly as a result of Pleistocene glacial plucking or large scale cryoclastism. The inclination of the sandstone bedding planes in the parapet generally parallel those of the main escarpment, which rules out any significant angular displacement of the parapet block, such as from the collapse of an originally much larger rockshelter-style roof overhang (Figure 6).

Figure 2. Aerial view of site location, indicated by the arrow, looking northwest over the Alaska Highway and Charlie Lake.

Figure 3. View of main escarpment and cave mouth before excavation.

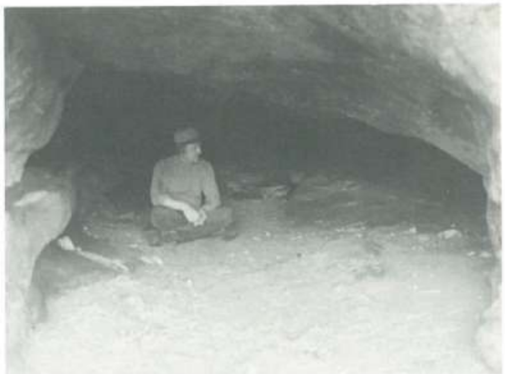


Figure 4. View into the main room of the cave. Small secondary chambers open to the right and left of Richard Gilbert.

Most of the deep bedrock crevice formed by the detachment of the parapet was probably rapidly infilled by mass-wastage and cryoclastic rubble, resulting in the coarse, resistant, and organically sterile sediments encountered in the lowest stratigraphic zone in our excavations. More than 10,000 years of gradual sedimentary accumulation in the crevice between the parapet block and the main bedrock escarpment containing the cave, created the important "platform" area, where our excavations were concentrated (Figures 5 and 6). In total, eight complete 1 by 1 m units and four partial units were excavated in the platform in 1983 to a maximum safely manageable depth, usually averaging 3 to 4 m below surface. We also placed two excavation units in the cave itself, but those proved shallow and unproductive, reaching consolidated bedrock within only 30 to 40 cm. Excavation was by trowelling, with all matrix dry-screened through 3 mm mesh.

The sedimentary sequence encountered in excavations in the platform area includes five main stratigraphic zones, labeled I to V from bottom to top, which were traceable across the entire excavation area with considerable confidence. Zone I, the basal stratigraphic unit, consists of a very resistant sandy sandstone rubble, ranging in particle-size from large boulders to clay, with a very low proportion of allochthonous or non-local rocks. It was penetrated to a maximum depth of only 40 cm in one unit in 1983 due to the difficulty of excavation, but appeared generally sterile of both faunal remains and any definite micro or macro cultural indicators. Zone I is currently interpreted as mainly coarse mass-wastage deposited during or shortly after the initial detachment of the parapet from the main bedrock escarpment. The 1990 and 1991 project at this site penetrated through Zone I sediments reaching consolidated bedrock about 1 to 1.5 m below the bottom of the 1983 excavations, encountering no lower cultural materials. In Figure 8, which is a view of the west wall of excavation unit 5, Richard Gilbert is sitting on Zone I sediments, while pointing to the lowest cultural component in overlying Zone IIa.

Zone II lay deeper than about 2.5 m below the surface in all excavation units, and consisted of a silty-sand, with numerous sandstone bedrock fragments. Near its base was a stratigraphic subunit designated Zone IIa, primarily consisting of apparently reworked tills and glaciolacustrine sediments probably originally deposited on the hillside above the cave and washed into the crevice, beginning about 11,000 BP (Figure 9). A few hundred years later the first humans utilized the crevice area for butchering bison, and perhaps other short-term functions. At this time it is conceivable that a late stage of Glacial Lake Peace still occupied the adjacent plateau surface (Mathews 1978, 1980). If that was the case, then what is now the Stoddart Creek valley in front of the cave site might have been an arm of that large pondage, and speculatively a strategic animal and human crossing and meeting point.

The lowest cultural level at Charlie Lake Cave was located in stratigraphic Zone IIa, which relatively clay and rubble-rich, proved highly resistant to trowelling and had to be broken up by short-handled picks; consequently most of the early cultural materials were found in the screen. The 1983 Component 1 assemblage consists of only four stone tools and five flakes, all found near

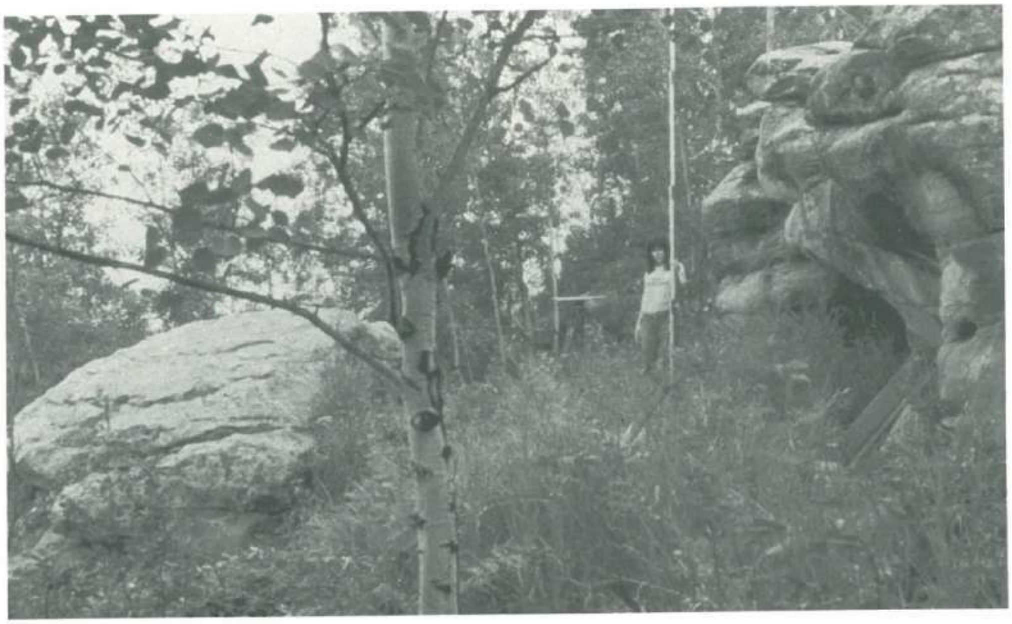


Figure 5. General view of platform area before excavation, looking northwest – the cave entrance is just to the right of Oslynn Benjamin holding the stadia rod, and the "parapet" is to the left.

the base of Zone IIa, close to the contact with Zone I. The most diagnostic artifact is a stubby, lanceolate, extensively resharpened point of black chert, weighing 6.67g and measuring 39.3 mm in length (Figure 10a). Its maximum width of 28.4 mm occurs approximately three-quarters of the distance back from the tip, while its maximum thickness of 5.6 mm is reached at the mid-point of the central axis. Hafting modification consists of a 6 mm deep V-shaped basal notch and multiple shallow basal thinning scars which terminate in hinge fractures 19 mm from the basal notch and 14 mm short of the tip on one face. Second and third generation thinning flakes overlap the first series, but carry only about 15 mm onto the point. Lateral edge-grinding of the point is slight, extending only about 13 mm up from the base on one side and 20 mm on the other, while the basal edge itself does not appear to have been ground. Overall, the point has a slightly asymmetrical form, caused by one relatively straight and one curved lateral edge, which suggests that it may have been ultimately modified or reworked to function as a knife in its last phase of use. Preserved blood residues of an unidentified animal, were located on the point by T. Loy, then of the British Columbia Provincial Museum.

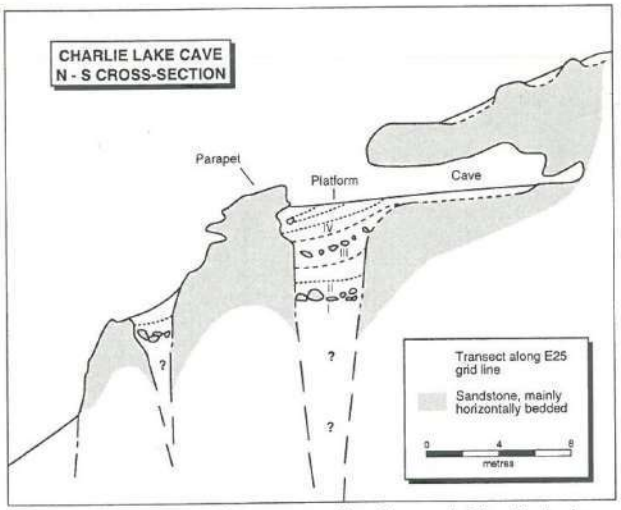


Figure 6. Generalized cross-section through Charlie Lake Cave and excavated "platform" sediments, Zones I to IV.

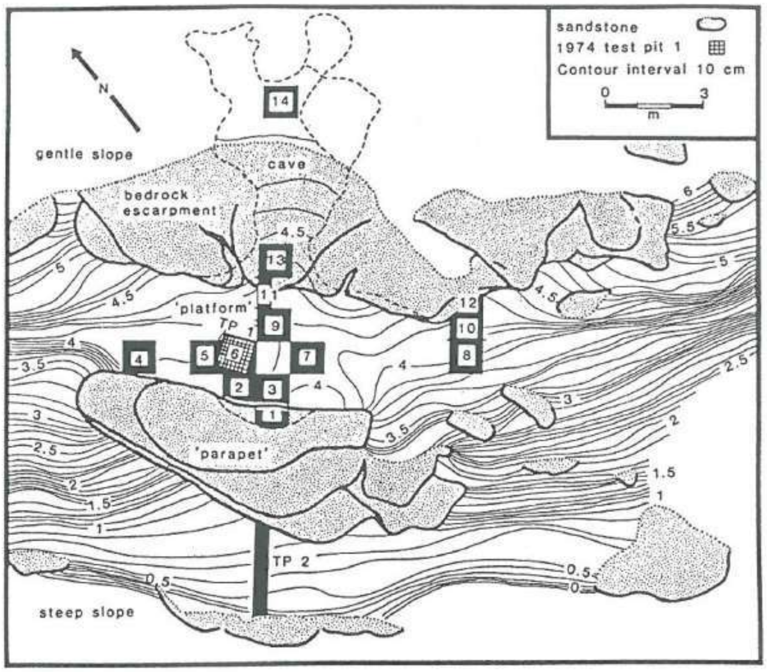


Figure 7. Local topography and location of 1983 excavation units at Charlie Lake Cave. Earlier test pit locations are indicated by "TP1."

The side-scraper or retouched flake was found in the same excavation unit and level as the point, and is a dark gray chert flake, roughly triangular in plan form, measuring 39.9 by 29.7 by 7.1 mm (Figure 10c). Both sides are formed by steep fracture edges, while the base of the triangle is retouched into a relatively straight unifacial bit with an edge-angle of about 50°. All secondary flake scars are fresh and unworn, although there is some microfracturing evident along one of the steep lateral edges.

The third flaked tool from Component 1, found approximately 2 m west of the point and scraper in the same stratigraphic zone, is a large "boat-shaped" core-tool of light yellow medium-grained quartzite, measuring 148.5 by 57.8 by 47.2 mm, and weighing 465.1 g (Figure 11). Its elongate ovate upper surface consists of a single unretouched flat flake scar, which served as the striking platform for the removal of a large series of secondary flakes around the entire rim, resulting in a streamlined, symmetrically rounded longitudinal plan and a sharply converging triangular "keeled" form in transverse cross-section.

One end of the core-tool is carefully unifacially retouched into an acute chisel-like bit, with a general edge-angle of 30° and a bit-angle of 50 to 60°, while the opposite extremity is blunted by a series of hinge fractures. This artifact has a well-worn feel, with most flake scar ridges and the ventral "keel" being smoothed and rounded, and it may have functioned as some kind of heavy duty adze-like chopping tool for butchering game or working bone and wood. No detritus or other specimens of yellow quartzite were found at the site and this piece must have been curated and brought in from some other place of origin. The core-tool is an unusual specimen, with few good parallels in other dated and published Paleoindian assemblages, to my knowledge. Four examples of similar quartzite core-tools were found in the later seasons of excavation.

The fourth artifact from Component 1 in 1983 was the most unexpected find. From the same excavation unit and level as the point and the scraper, came a single small, delicate, biconically perforated bead of soft, shiny gray-green schist (Figure 10b). Approximately pentagonal in shape, measuring 13.5 by 11.6 by 1.7 mm, the bead is basically just a thin unmodified schist pebble with a roughly conical hole drilled in each face, meeting more or less on centre. Although the faces of the bead are smooth, except for some tiny protuberant crystalline inclusions, they have not obviously been ground or polished, nor have the edges. However, the perforation is definitely artificial, and must have been drilled in from both sides and not punched or gouged. Such drilling need not have required any specialized technology in this relatively soft stone; indeed the fluted projectile point tip itself has proportions matching the taper of the bead's perforations. To my knowledge this is the first perforated stone bead positively associated with an excavated, dated, fluted point assemblage in North America, although bone beads have been reported from several Paleoindian sites. It is difficult to reconstruct the cultural activities which might readily account for an assemblage consisting of only one point, one scraper, five large core-tools, and one tiny bead, all unbroken, associated with butchered bison bones; particularly when two of those artifact types are rare or nonexistent in other published Paleoindian assemblages.

Besides the retouched stone tools and bead, the Zone IIa deposits also yielded several small black chert flakes, possibly reflecting small-scale bifacial thinning or retouching activities, in excavation units 1 to 3 m east of the fluted point and bead, plus a faunal assemblage dominated by bison bones.


Figure 8. View into excavation Unit 5, complete. Gilbert points to the location of the lowest cultural component. The rod is 4 m long. This is also the same N.21-22, E.22 section drawn in Figure 13.

Component 1 is directly associated with four radiocarbon dates on bone collagen, produced by both accelerator mass spectometry and normal analytical methods, of 10,100 ±210 (RIDDL 392); 10,380 ±160 (SFU 378); 10,450 ±150 (SFU 300), and 10,770 ±120 BP (SFU 454), or an average age of about 10,425 BP. Two of the dated bison bones exhibit scratches which could be interpreted as deliberate cut-marks and were from the same excavation unit and level as the point, scraper, and bead, while another dated bone was in close association with the quartzite core-tool (Figure 12). Two additional radiocarbon dates of 9990 ±150 (RIDDL 393) and 9760 ±160 (SFU 355) were also obtained from just above the stratigraphic interface between Zones IIa and IIb.

Zone IIb, overlying the earliest occupation, was characterized by continuous active weathering of the sandstone and deposition of its sedimentary products in the crevice. Unfortunately, Zone IIb itself yielded no modified artifacts and its associated Component 2 consists of only eighty-one black chert detrital flakes. Artifact descriptions for Components 2 to 11 are based on the 1983 excavations only.

In stratigraphic Zone III, which began deposition about 8500-9000 BP, organic matter began to become a visually significant component in the crevice fill, with thin richly humic beds interca-

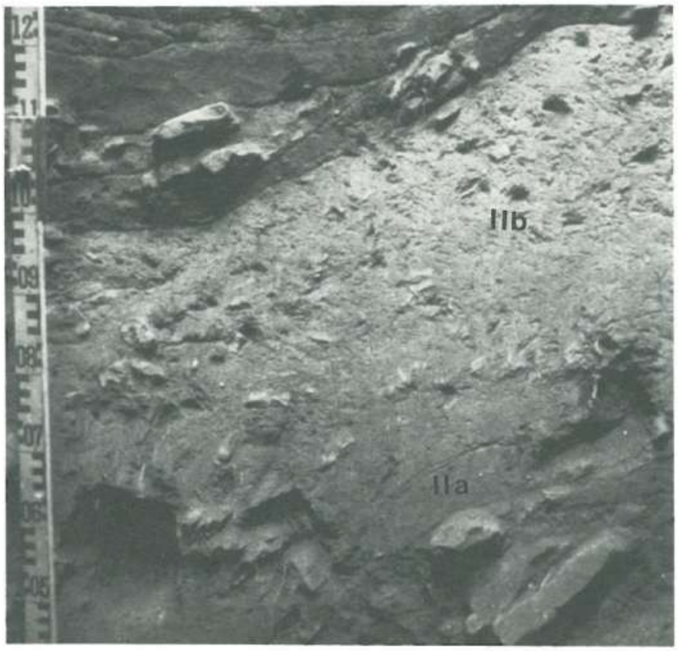


Figure 9. Close-up of Zone IIa and IIb sediments at the base of the N.21-22, E.22 section shown in Figures 8 and 13.

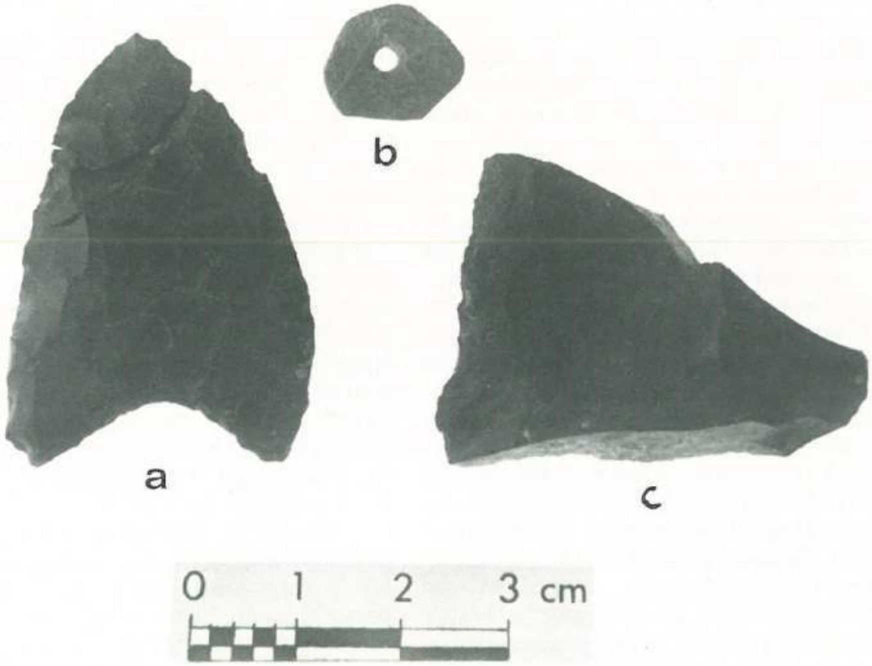


Figure 10. Photograph of three of the Component 1 artifacts: (a) fluted point, (b) bead, and (c) retouched flake.

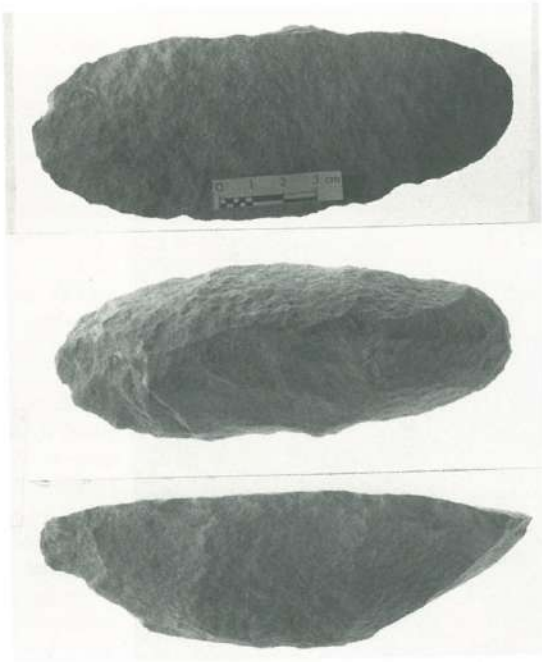


Figure 11. Photographs of three views of the large quartzite core-tool from Component 1.

lating with mineral strata at the toes of fans against the north side of the parapet. A major fall of large sandstone slabs near the base of Zone III associated with dates of 8400 ±240 (SFU 357) and 7800 ±800 (SFU 370) correlates with a hiatus in cultural occupation. A fragmentary human mandible, probably of an elderly female, and a small collection of detritus comprises Component 3, found immediately above the rock-fall and associated with an accelerator date of 7400 ±300 (RIDDL 10). That mandible was the only human physical remains found at the site.

Zone III is a complex stratigraphic unit consisting of multiple, thin, intricately interbedded alternating mineral and organic bands, grouped into stratigraphic subzones labeled a to e from bottom to top (Figure 13). The upper levels of Zone III are marked by distinctive reddish silty sands, and despite events such as the rock-fall, overall Zone III is characterized by a much finer mean particle size range than the levels underlying or overlying it. These sedimentary parameters probably reflect a relatively passive physical environment and increased rates of chemical weathering at this time. Indeed, deposition of Zone III between about 8500 and 4500 BP (±200 years), correlates well with the classic Hypsithermal climatic period.

In the upper parts of Zone III were found the small cultural assemblages of Components 3, 4, 5, and 6 including three medium-sized projectile points of generalized side-notched or corner-notched forms: one definite chert microblade fragment (the only microblade from the site), and two generalized leaf-shaped bifaces. A total of 159 flakes were also associated with these components.

Zone IV is a highly organic, dark pebbly sand, characteristic of the upper 1.0 to 1.3 m of sediments across the entire platform excavation area. Despite its obvious organic accumulation, which suggests that biotic factors had by this time overtaken rates of mineral sedimentation, Zone IV is characterized by a relatively coarse mean particle size, matched only by the much earlier Zone II sediments. Associated radiocarbon dates indicate that Zone IV was probably deposited between about 4200 and 1400 BP.

Component 7 in the lower part of Zone IV yielded two relatively large corner-notched points and twenty-seven flakes, followed in the middle part of that zone by two small stemmed points, one larger "Oxbow-like" point and 164 flakes in Component 8. Component 9 in the upper part of Zone IV yielded one relatively large expanding stem point and another 182 flakes.

Figure 12. Close-up view of presumed butchering marks on a bison long-bone fragment from stratigraphic Zone IIa. The longest cut-mark is about 1.5 cm.

Zone V at the top of the stratigraphic section consists of a thin buried pedogenic Ah horizon traceable across most of the platform excavation area, capped by about 30 to 40 cm of dark organic silty sand, containing both prehistoric and historic cultural materials. Artifacts found in Components 10 and 11 in this zone include three small side-notched points, the base of another small expanding stem point, sixty-eight flakes, and assorted recent historic materials. No radiocarbon dates are associated with this zone.

In total, ten later cultural components were found stratigraphically in sequence above Zone IIa and the earliest occupation, supported by a further twelve radiocarbon dates (Figure 13). These components generally consist of small assemblages of flaked stone tools, including occasional projectile points and retouched flakes, all roughly similar in overall content and degree of diversity to the earliest occupation.

The repeated pattern through time of relatively meagre anthropogenic sedimentary inputs, despite a small, constricted and focused area for human occupation and cultural imprinting, suggests that this site was never seriously utilized as a general purpose habitation area. It is probable that throughout its entire ca. 10,500 years of use by aboriginal people it mainly periodically functioned as a short-term campsite and work area, associated with local resource exploitation activities such as bison hunting.

As noted previously (Fladmark, Driver, and Alexander 1988:383), direct cultural relationships for the small Paleoindian assemblage from Charlie Lake Cave are difficult to pin down with certainty. The few other excavated fluted-point sites so far known in Canada date to the same 10,000 – 10,500 BP time period (e.g., Gryba 1983, MacDonald 1969). Like Charlie Lake Cave, their points tend to be relatively small, multiple, basally-thinned forms, unlike the extensively fluted points of the contemporary Folsom complex, or the larger styles of the 11,000 – 11,500 BP "classic" Clovis complex, both best defined in the central and western United States. Given the well-established age of the American Clovis complex, the Charlie Lake Cave Paleoindian assemblage is clearly 500 to 1000 years too late to have been left by any early "proto-Clovis pioneers" penetrating southwards from Beringia via the ice-free corridor. Of course, this picture could quickly change with the future dating of new fluted point sites in this area. However, on the basis of present information, the early assemblage from Charlie Lake Cave seems best interpreted as a late variation in a "fluted point continuum" with its earliest manifestations located south of the Wisconsinan glacial limits in what is now the United States. Thus, the oldest cultural component at Charlie Lake Cave site was probably left by Paleoindians filtering *northwards* into west-central Canada after the retreat of the Laurentide ice-front and the development of a productive environmental regime about 10,000 to 11,000 years ago. After that earliest occupation, the site seems to have continued to be used in much the same way, as a periodic hunting and processing camp for small groups of people, up until the historic period.

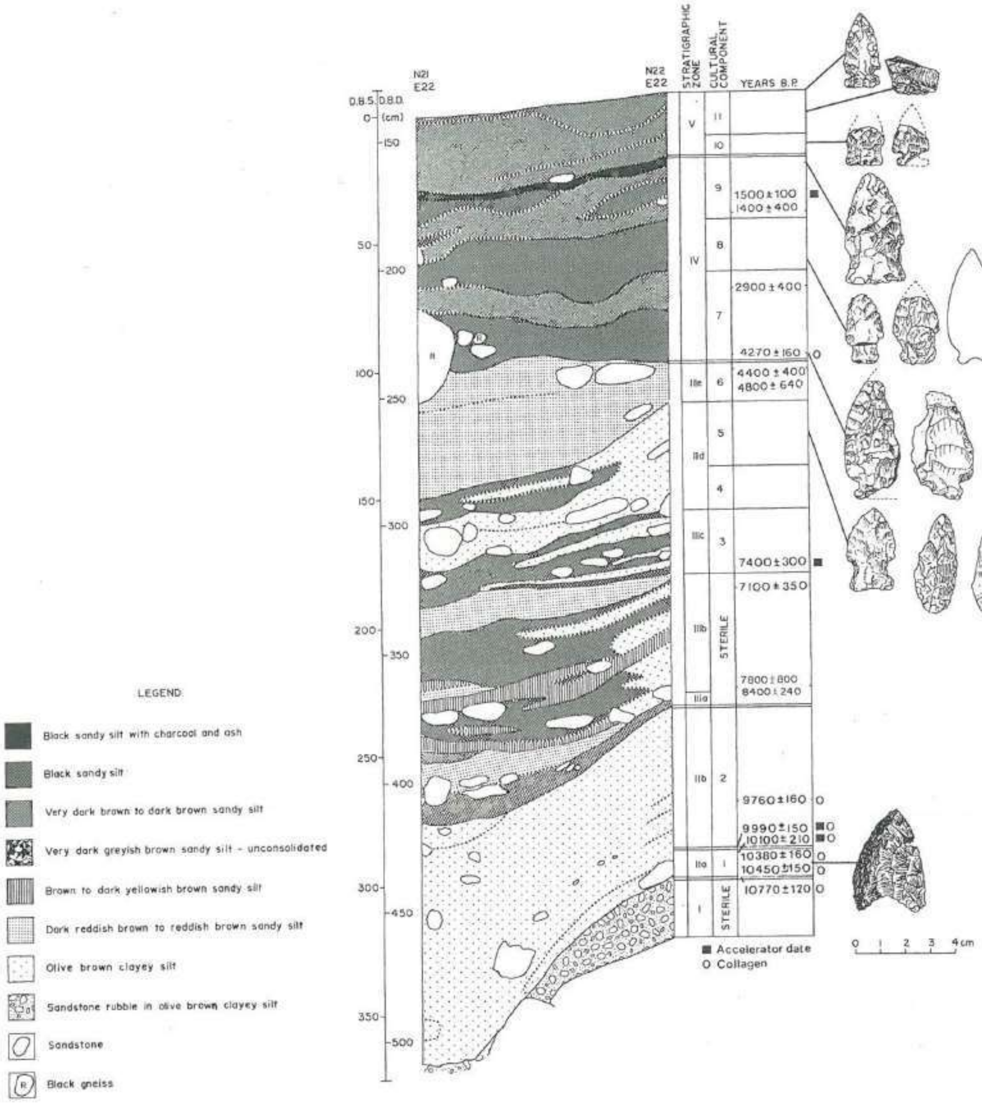


Figure 13. A typical vertical section north-south through the platform excavation area (N. 21-22, E. 22) showing the stratigraphic association of radiocarbon dates and projectile points from the 1983 excavations.

3

THE SIGNIFICANCE OF THE FAUNA FROM THE CHARLIE LAKE CAVE SITE

Jonathan C. Driver

The Charlie Lake Cave site, Peace River District, northeastern British Columbia, is the only excavated, dated site in Canada in which an association of fauna and a fluted point assemblage occurs. There are two major reasons for a detailed analysis of the fauna. First, because the fauna includes a variety of small vertebrates, it provides us with important information concerning animal populations in a newly deglaciated landscape. Second, it provides a glimpse of the subsistence activities of Paleoindians in the Peace River area. As this region was close to the retreating ice sheets, the fauna reflects subsistence strategies employed by Paleoindians as they colonized newly available land. These topics are discussed in more detail in this chapter than has been possible in previous, more descriptive, studies (Driver 1988, Fladmark, Driver, and Alexander 1988).

THE SITE

The Charlie Lake Cave site is located on the south-facing slope of a low sandstone escarpment which forms the north side of the Stoddart Creek valley, a few hundred metres downstream from Charlie Lake, British Columbia. Detailed description of the site is unnecessary in view of previous publications (Fladmark, this volume, Fladmark, Alexander and Driver 1984, Fladmark, Driver, and Alexander 1988). The faunal remains discussed in this chapter were recovered from a deep gully between a small sandstone cliff in the bedrock escarpment and a large block of sandstone (referred to as the "parapet") downslope from the cliff face. Charlie Lake Cave is located in the bedrock cliff, but contains shallow deposits with little time depth. Excavations penetrated the gully deposits to a depth of about 3.5 metres. Cultural and faunal material were found in all major strata except the lowest zone (Zone I), which consisted of large sandstone boulders in a silt/clay matrix.

Radiocarbon dates show that the earliest fauna was deposited between 10,700 BP and ca. 9000 BP in a silty clay with larger sandstone clasts. This depositional unit, Zone II, is divided into two subzones. Subzone IIa dates 10,700 to 10,000 BP, and contains the fluted point assemblage described elsewhere (Fladmark, this volume, Fladmark, Driver, and Alexander 1988). Subzone IIb dates 10,000 to 9000 BP and contains flakes but no other diagnostic cultural remains. The two subzones are separated on the basis of slight changes in sediments, but both were probably the result of re-deposition of glaciolacustrine sediments mixed with weathered bedrock and larger bedrock clasts.

At the time of the deposition of Zone II sediments, the gully would have been accessible from east and west ends. One should not think of fauna being deposited in a closed sediment trap, but rather that the downslope "parapet" allowed sediments moving down the hillside to accumulate behind it. Bones may have been incorporated in the sediments either by moving downslope and becoming trapped behind the rock or by being added to the accumulating pile of sediments by natural or cultural agencies which introduced bones from any direction.

THE FAUNA

The fauna from subzone IIa is fairly sparse when compared with the thousands of specimens recovered from later zones at the site (Driver 1988).

Identified specimens are recorded in Table 1. The mammal fauna is dominated numerically by ground squirrels (*Spermophilus* sp.), which do not occur in the area today, and which disappear completely from the faunal record shortly after the end of Zone II (ca. 9000 BP). It is not possible to identify the species of ground squirrel represented, but either Columbian (*S. columbianus*) or Richardson's ground squirrel (*S. richardsonii*) are present; other species can be excluded on the basis of size or dental morphology. Other important species include snowshoe hare (*Lepus americanus*), bison or large artiodactyl (all assumed to be *Bison* sp.), and a large lagomorph (*Lepus* sp.) which may be either arctic hare (*Lepus arcticus*) or a jackrabbit (e.g., *L. townsendii*). Neither of these large lagomorphs occurs in the region today and either species would be expected in an open, unforested environment. The single specimen of muskrat (*Ondatra zibethicus*) in this subzone is a tooth. The specimen is stained a much darker brown than other rodent teeth from these deposits, and is identical in colour to specimens from the upper part of the site. It is interpreted as a specimen which fell from the section during excavation, and should not be considered as part of the fauna. The avian fauna is dominated by cliff swallow (*Hirundo pyrrhonota*), and many of the unidentified passerine bones are probably also from this species. This early occurrence suggests that swallows readily extended their northern summer migration to follow the retreating ice sheets. A few fish bones were also found in the upper part of this subzone. None were identified, but specimens from subzone IIb have been identified as sucker (*Catostomus* sp.).

A more diverse fauna occurs in subzone IIb. This diversity need not result completely from a more diverse biota; it may be partly the result of an increased sample size. The mammalian fauna is dominated by snowshoe hare, setting the trend for the entire Holocene assemblage in which this species is consistently the most numerous (Driver 1988). Ground squirrels are a minor component of the fauna, and occur mainly in the lower part of the subzone. Microtines are better represented, and include *Microtus xanthognathus* (chestnut-cheeked vole), a relatively rare species, although still present in the region today. Small *Microtus* could not be identified to species because diagnostic teeth were missing, but either meadow vole (*M. pennsylvanicus*) or long-tailed vole (*M. longicaudus*) were present. Gapper's red-backed vole (*Clethrionomys gapperi*) was present and bison also occurs. In the avian fauna, cliff swallow no longer dominates. Aquatic birds are well represented, including grebes (*Aechmophorus* sp. and *Podiceps auritus*), a small number of surface feeding ducks, ruddy duck (*Oxyura jamaicensis*), coot (*Fulica americana*), and a rail. Upland birds include the *Tetraoninae* (grouse or ptarmigan) and a set of phalanges from short-eared owl (*Asio flammeus*).

ORIGIN OF THE FAUNA

The taphonomic history of the entire fauna is difficult to establish, mainly because many species are present in small numbers. Furthermore, the fauna as a whole consists predominantly of small mammals and birds, and recent taphonomic studies have concentrated much more on the larger mammals. Nevertheless, it is important to try to understand the origin of the fauna in view of the association with artifacts. If one were to propose that the entire faunal assemblage was the result of human hunting, then this site would provide a view of Paleoindian subsistence very different to the widely held hypothesis that the early occupants of North America were subsisting largely on big game.

Specimens which owe their presence at the site to human activity cannot be identified unequivocally. The most convincing case can be made for bison. A number of bison and unidentified large artiodactyl bones (assumed to be bison) display cut marks (Fladmark, Driver, and Alexander 1988) in locations consistent with human butchery (Table 2). Binford (1981) has noted that similarities in artiodactyl anatomy from species to species result in similar patterns of butchery in cultures separated widely in time and space. The location of cut marks on the specimens described in Table 2 can be reproduced in ethnographic and archaeological examples (e.g., Binford 1981, Frison 1973). Many bison and large artiodactyl bones display spiral fractures, some with a well-defined point of impact, which has also been cited as good evidence for smashing of bones by humans (Binford 1981).

However, one cannot be completely certain that the bison and large artiodactyl bones arrived at their ultimate location as a result of human activity. A number of specimens demonstrate good evidence for carnivore chewing (Table 2). Unfortunately, on no specimens do the carnivore marks and cut marks overlap, and one cannot determine positively whether humans or carnivores modified the bison bones first. However, if one assumes that the carnivores chewed the bones after they had

Table 1. Identified fauna, Zone II, Charlie Lake Cave, 1983 season.

Taxon	Subzone IIa	Subzone IIb
Pisces (fish)	4	14
Amphibia (frogs)		2
Aechmophorus sp. (large grebe)		2
Podiceps auritus (horned grebe)		15
Medium sized grebe		4
Anatini (surface feeding ducks)	1	2
Anas crecca (green-winged teal)		1
Anas platyrhynchos (mallard)		1
Oxyura jamaicensis (ruddy duck)		1
Tetraoninae (grouse or ptarmigan)		13
Rallidae (small rail)		2
Fulica americana (American coot)		10
Charadriiformes (small wader)	2	
Asio flammeus (short-eared owl)		8
Passeriformes	1	11
Hirundo pyrrhonota (cliff swallow)	16	3
Lepus americanus (snowshoe hare)	18	145
Lepus sp. (large hare/jackrabbit)	4	
Marmota sp.		1
Spermophilus sp. (ground squirrel)	122	24
Peromyscus sp. (deer mouse)	6	2
Clethrionomys gapperi (Gapper's red-backed vole)		2
Ondatra zibethicus (muskrat)	1	
Microtus sp. (vole)	2	3
Microtus xanthognathus (chestnut-cheeked vole)		2
Microtine	2	19
Canis sp. (wolf/dog)		1
Mustela nivalis (least weasel)		2
Mustelidae (weasel family)		1
Bison sp. (bison)	8	11
Large artiodactyl	3	6

been discarded by humans, then the sample of bones may be biased by either selective transportation of bones to the site by carnivores or selective destruction and removal of bones from the site by carnivores. One should certainly not assume that the large ungulate and bison bones are lying where they were discarded by hunters. Thus, although the evidence strongly favours the hunting of bison by Paleoindians, the assemblage is not simply the refuse left after a successful hunt. In this regard, it is interesting to note that a minimum of three bison are represented by only twenty-eight fragments. This suggests that either humans or carnivores were very selective in their choice of bones.

While analysis of surface damage to the bones of large mammals may provide evidence of their taphonomic history, this method reveals much less about the origin of smaller vertebrates. For example, a complete undamaged phalanx of a snowshoe hare could be the result of *in situ* death, discard by a human or animal predator, or downslope movement of bones originally deposited upslope by either of the first two processes. Broken bones may also result from human or animal predation or from mechanical effects during and after deposition, and no keys have been developed to distinguish such breakage patterns. Furthermore, modes of damage caused by particular predators vary widely. For example, humans may cook small vertebrates whole, strip the meat and cause minimal bone damage, or may pound bones into small fragments. In a review of the actions of great horned owls (*Bubo virginianus*), Kusmer (1986) noted that bones of prey such as duck or snowshoe hare might be discarded as picked skeletons or might be broken during consumption. It would be extremely difficult to distinguish these processes from those produced by humans. At the microscopic level, erosion of bones due to digestive processes may be detectable (e.g., Kusmer 1986), but insufficient studies have been undertaken to distinguish the effects of various predators, and the effect of human digestive processes on small bones is also unknown. As humans, mammalian carnivores, and owls may all discard bones before consumption of prey, absence of digestive erosion cannot be used to rule out any of these predators.

Element frequency is not very useful in analyzing even the most common small vertebrates at the site. Bones were recovered from 3 mm mesh during excavation, and it is likely that some specimens were missed as a result of this recovery procedure. For example, ground squirrel metapodials are infrequent, whereas those of snowshoe hare are common; this may well result from the smaller ground squirrel bones passing through the screen. For snowshoe hare one finds that the frequency of phalanges is correlated with size. Thus, first phalanges are more common than second phalanges and third phalanges are missing. Analysis of relative abundances of limb bones of ground squirrel (Table 3) demonstrates that frequency of elements deviates strongly from the pattern expected for complete skeletons, but the reasons for the over-abundance of forelimbs is difficult to determine. On the other hand, snowshoe hare conforms reasonably closely to the expected pattern (Table 4).

Observations during excavation suggest that some portions of small vertebrates were deposited as articulating units. For example, I observed articulated limbs or feet of ground squirrels and *Tetraoninae*. The articulating set of short-eared owl phalanges from Zone IIb were presumably deposited as a single unit. Such patterns may suggest rapid burial and relatively undisturbed sediments, but they do not identify the mode of death nor the means of transportation to the site. Overall, the small vertebrate fauna from Zone II suggests transportation to the site by either owls or raptors, rather than by mammalian carnivores. Carnivores would be expected to reduce bone to small fragments by chewing and ingestion; many of the bones of snowshoe hare and ground squirrel are either complete or more than half complete (Tables 4 and 5).

Unfortunately, one cannot completely rule out the possibility that some of the small vertebrates may have been brought to the site by humans. Analysis of damage to small vertebrate skeletons by humans has received little attention in the archaeological literature, and, as noted above, treatment of small vertebrates is likely to be variable. One feature that is missing from all small vertebrate specimens at Charlie Lake is a distinctive burning pattern which often characterizes small mammals eaten by humans (Dansie 1984, Vigne and Marinval-Vigne 1983). There was no evidence of any burning of small vertebrate bones in Zone II.

In order to attempt to resolve the problem of human use of small vertebrates, analysis of bone distribution was undertaken. The distribution of bones is plotted in Figure 1 in which data from both subzones is combined. It is notable that two units (units 3 and 9) frequently contain the greatest percentage of specimens of particular taxonomic categories. Thus, unit 3 contains the highest frequencies of ground squirrel, snowshoe hare, grebes, ducks and coot, and cliff swallow; unit 9 contains the highest frequencies of microtines and grouse. This cannot be accounted for by the depth of sediment. For example, the volume of Zone II deposits in unit 4 is 0.89 m^3 while in unit 3 Zone II deposits occupy 0.79 m^3. Yet unit 3 contains a much greater concentration of bones than unit 4. Similarly, the volume of Zone II sediments in unit 5 (where relatively little fauna was recovered) is 1.2 m^3, while unit 9 contains a relatively large number of bones in 0.43 m^3.

Although one could wish for a larger excavation area, it appears that most taxonomic groups occur most densely in the two units furthest from the east and west end of the gully and closest to the gully margins. I suggest that this is because most species were being deposited at the site by owls or raptors which roosted in or on the rocks bordering the gully. It is notable that the only specimens which were definitely hunted by humans (bison and large artiodactyl) have a somewhat different distribution. This taxonomic group is the only group which does not appear with the highest frequency in either unit 3 or unit 9; it is also the only group whose highest frequencies are in the three western units – 4, 5, and 6. These western units also produced the four artifacts from the fluted point assemblage of subzone IIa. The

Table 2. Bison and large artiodactyl bones, Zone II, Charlie Lake Cave, 1983 season.

Element	Portion	Carnivore damage	Cutmarks
Cranium	3 fragments		
Tooth	Premolar		
Vertebra	Fragment		
Sacrum	Anterior	Right side	
Pelvis	Fragment		
Rib	Midsection	Both ends	Medial side
Humerus	Distal + shaft	Proximal end	
Humerus	Distal	Epicondyles	Epicondyles
Humerus	Shaft fragment	One end	Epicondyles
Radius	Distal +shaft		
Radius	Shaft		
Ulna	Proximal	Proximal end	Olecranon
Carpal	Whole		
Metacarpus V	Proximal		
Metacarpus	Proximal		
Tibia	Proximal + shaft		
Tibia	Distal + shaft	Both ends	
Tibia	Shaft		
Metapodial	Shaft		
Phalanx 1	Whole		
Phalanx 2	Whole		
Phalanx 2	Whole		
Phalanx 2	Proximal		
Sesamoid	Whole		
Sesamoid	Whole		

projectile point, scraper, and bead were excavated from unit 5, and the core/scraper from unit 4. Unit 5 produced over 90 per cent of the flakes from the cultural assemblage of subzone IIb. Thus, there is clear evidence that human activities were associated with the western end of the gully, while the major deposition of smaller vertebrates occurred at the eastern end, notably at the gully margins, and without associated artifacts. This associational data strengthens the case that only bison and large artiodactyl bones were deposited as a result of human activity.

PALEOENVIRONMENTS

At the time of the initial deposition of subzone IIa sediments extensive glacial lakes may have filled many valleys in the region (Mathews 1978, 1980). The chronology of proglacial events is not particularly well dated, but by 10,200 BP at the latest the Clayhurst stage of Glacial Lake Peace, with shorelines at the elevation of the Charlie Lake Cave site, had drained. For much, if not all, of Zone II times the environments in this region would have been characterized by immature river systems, probably carrying much greater loads than modern rivers. Slopes would have been unstable as a result of glacial lake drainage.

The paleoenvironmental implications of the Zone II fauna have been discussed elsewhere (Driver 1988). One can argue convincingly that the change from subzone IIa to subzone IIb marks the transition from a largely open landscape to one in which coniferous forest was predominant. In IIa the presence of bison, a large lagomorph, ground squirrels, and cliff swallows are indicative of open conditions, while snowshoe hare indicate the presence of some forest. The virtual absence of waterfowl from subzone IIa seems to indicate that drainage regimes were not sufficiently stable to allow colonization by the plants and animals upon which waterfowl depend. In IIb there is a notable decline in ground squirrels and cliff swallow, and the large lagomorphs are absent. The increased frequency of snowshoe hare, together with the presence of chestnut-cheeked vole and Gapper's red-backed vole suggest that boreal forest dominated the environment. The increase in waterfowl demonstrates that a variety of productive aquatic habitats were established and that migratory species had extended their northern range.

Sediments from Zone II cannot be correlated across excavation units, except in so far as one can distinguish the two subzones. Lack of microstratigraphy, coupled with the sloping nature of the deposits means that subdivisions of subzones based on arbitrary excavation levels only have meaning within an individual excavation unit. Only excavation unit 3 contains sufficient fauna to warrant analysis of changing frequencies of species within subzones. Figure 2 plots the relative frequency of waterfowl, cliff swallow, snowshoe hare, and ground squirrel for ten arbitrary levels in layer 15 in unit 3. A date of 10,100 ±210 BP (RIDDL 393) was obtained on ground squirrel bone from 15-10. A date of 9990 ±150 BP (RIDDL 392) was obtained on bison bone from 15-6. The IIa/IIb boundary is between 15-6 and 15-7. 15-1 probably dates to about 9500 BP.

The most striking aspect of these data is the rapidity of the change in the fauna. This is particularly notable in the switch from ground squirrel as the most abundant small mammal in subzone IIa to snowshoe hare in IIb. Waterfowl also appear suddenly in the upper part of IIb. The suddenness of the change is also reflected in palynological studies from the region. MacDonald (1987) has analyzed lake bed cores from sites about 120 km northeast of Charlie Lake. At the base of the cores there is a zone dating 11,000 to 10,000 BP with high relative frequencies of sedges, grasses, and herbs, together with deciduous trees such as birch and aspen. At about 10,000 BP there is a rapid increase in conifer pollen (mainly spruce), which MacDonald interprets as the establishment of boreal forest.

Palynological and faunal evidence suggests that the open environment which followed deglaciation lasted no more than 1000 years. Paleoindian occupation took place within that interval. The establishment of boreal forest occurred quite rapidly, possibly over a period of a few hundred years. The new vegetation drastically altered the nature of the faunal community.

SUBSISTENCE

As discussed above, one can only make a convincing case for Paleoindian predation on bison at Charlie Lake Cave. In spite of the variety of other fauna, only bison is consistently associated with artifacts and only bison displays definite evidence of human procurement and processing. At Charlie Lake Cave we are seeing an isolated incident in Paleoindian life; perhaps a couple of days is represented. Whether or not this subsistence pattern represents a common event in the seasonal round cannot be determined. It has been argued that the big-game hunting aspect of Paleoindian subsistence has been over-emphasized and that in some areas of North America a wider range of smaller species was utilized (see, for example, Frison 1977, Johnson 1987). At Charlie Lake there is good evidence for large mammal hunting and the interpretation of Paleoindians as big-game hunters should not be overthrown, at least for this area of

Table 3. Ground squirrel limb bones, Zone II, Charlie Lake Cave, 1983 season.

Element	Complete element	>50% present	<50% present
Humerus	7		
Proximal humerus			1
Distal humerus		10	9
Radius	3		
Proximal radius		1	2
Distal radius		7	1
Ulna	2		
Proximal ulna		5	5
Distal ulna			2
Metacarpus	2		
Proximal femur		4	2
Tibia	2		
Proximal tibia		3	1
Distal tibia			2
Metatarsus	8		

Table 4. Snowshoe hare limb elements, Zone II, Charlie Lake Cave, 1983 season.

Element	Complete element	>50% present	<50% present
Proximal humerus			2
Distal humerus			3
Radius	1		
Distal ulna			1
Metacarpus	10		
Proximal metacarpus		1	3
Distal metacarpus		2	1
Proximal femur		1	
Distal femur			1
Proximal tibia			1
Distal tibia		1	3
Metatarsus	19		
Proximal metatarsus		4	4
Distal metatarsus		4	3
Phalanx 1	15		
Proximal phalanx 1		2	6
Distal phalanx 1			4
Phalanx 2	9		
Proximal phalanx 2			1

North America.

As discussed above, both faunal and palynological data are best interpreted as a grassland with scattered patches of woodland or forest during the 11,000 to 10,000 BP period. Evidence from Charlie Lake and from paleontological sites in other areas of the Peace River (Burns 1986, Churcher and Wilson 1979) suggests that the fauna available to hunters was dominated by large mammals, specifically bison. There is no evidence that either fish or waterfowl were available in sufficient abundance to constitute a major alternative resource.

Open landscapes dominated by large mammals and containing few vegetable resources suitable for human consumption are mainly confined to temperate and arctic areas of the northern hemisphere. Ethnographic data on hunter-gatherers in such environments show a strong reliance on large mammals, which were often hunted by communal techniques; in fact communal hunting of large mammals as a major subsistence strategy is largely confined to such conditions (Driver 1990). Recent examples of such strategies include bison hunters of the northern Plains, caribou hunters of the Canadian arctic, and caribou hunters of eastern Asia. Archaeological evidence from equivalent landscapes in the Late Pleistocene suggests similar adaptations (e.g., Klein 1973). It is entirely predictable, given what can be reconstructed of paleoenvironments in the Peace River area, that hunter-gatherers in such an environment would concentrate their efforts on big game, specifically on species which aggregated as herds for at least part of the year.

The Paleoindians at Charlie Lake were a northern extension of populations of bison-hunters who occupied the grasslands east of the Rockies during the Late Pleistocene and early Holocene. In much of that zone bison hunting remained the major subsistence method up to the ethnographic period. However, the rapid encroachment of boreal forest in the Peace River area after 10,000 BP must have necessitated a swift and complex readaptation to new resources with new distributions. By 9000 BP at the latest, and perhaps as early as 10,000 BP, grazing areas for bison had become substantially curtailed, and it seems very likely that bison populations would have declined drastically. Additionally, bison social organization may have changed in response to fragmentation of feeding areas and a reduction in the quality of forage.

While bison populations declined, other resources became more abundant. The increase in waterfowl has already been discussed. Other animals which become more common later in the Charlie Lake sequence include fish, beaver, muskrat, and snowshoe hare (Driver 1988), all typical species of the boreal forest today. The boreal forest adaptation of the ethnographically known Athabascan groups probably developed as early as 9000 BP in the Peace River region of British Columbia.

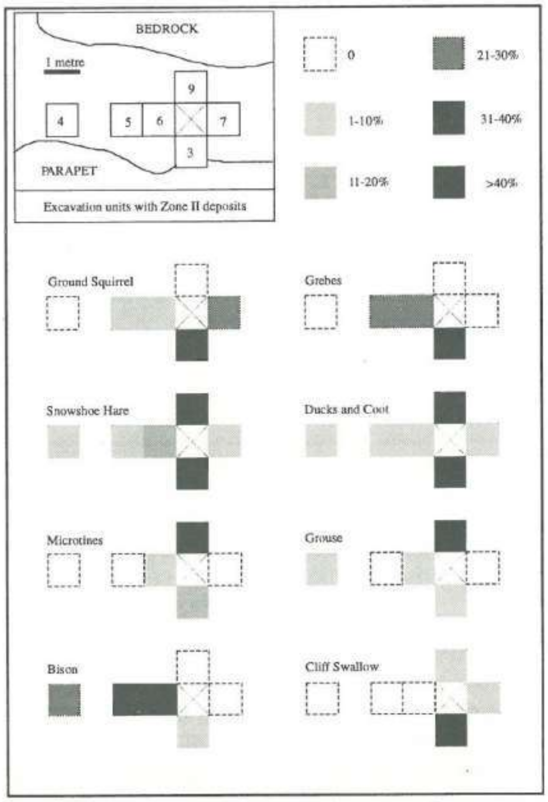


Figure 1. Distribution of selected taxonomic categories by excavation unit, Zone II, Charlie Lake Cave, 1983 season (shading indicates the percentage of specimens of a particular taxon that occur in each unit).

Acknowledgments

I am grateful to Knut Fladmark for the opportunity to study the fauna from this site, and for the provision of so much information on artifacts and stratigraphy. The many people who assisted in the identification of the fauna reported here have been acknowledged in previous publications. I thank Roy Carlson for the opportunity to participate in the symposium on early British Columbia. This research was funded by SSHRC grants to Knut Fladmark and the author. Further excavations were undertaken at Charlie Lake Cave in 1990 and 1991. The stratigraphy of Zone II has been revised to include more subzones, but the stratigraphic break described here as the IIa/IIb boundary is still unrecognised, and is still dated to about 10,000 BP. The beginning of Zone II probably dates about 10,500 BP. The end of Zone II now appears to date at about 9500 BP. More fauna were recovered in these excavations. Bison is still the only large mammal identified. Some species have been added to the microfauna and these will be reported elsewhere. The environmental reconstruction proposed here is still supported.

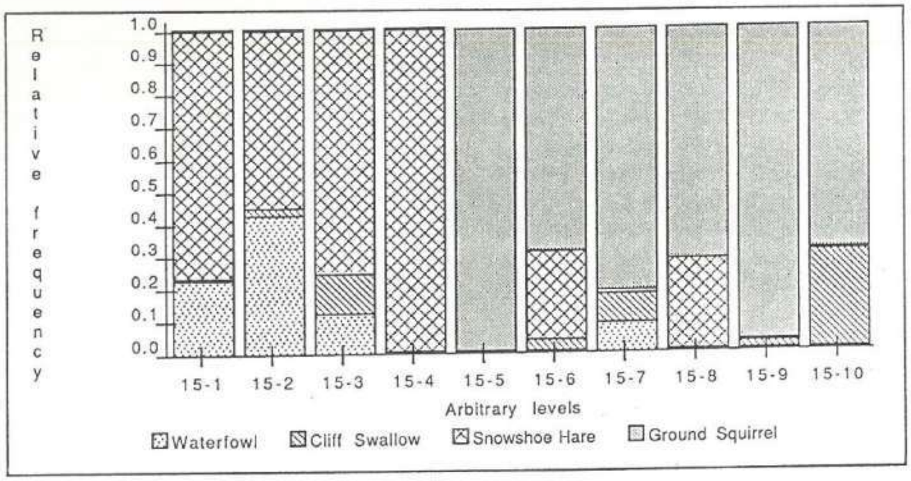


Figure 2. Relative frequency of selected taxonomic groups in arbitrary levels of layer 15, unit 3, Charlie Lake Cave, 1983 season.

STRATIGRAPHY, RADIOCARBON DATING AND CULTURE HISTORY OF CHARLIE LAKE CAVE, BRITISH COLUMBIA

JONATHAN C. DRIVER & 5 OTHERS

We kindly thank the publisher, Arctic Institute of North America, for permission to reproduce this work.

After we completed our excavations in 1991 we decided that we should focus on writing up what we had excavated, rather than undertake further excavations at the site. This paper was written to summarize our state of knowledge about the archaeological remains at the site. It focuses on describing the stone tools, the overall stratigraphy, and the dating. The stratigraphic summary replaced earlier work based on the 1983 excavations, and we were able to refine our dating of the site as a result of more radiocarbon dates. The different cultural periods were based mainly on the work done by Martin Handly for his M.A. thesis at Trent University.

The long list of authors reflects the need for a team approach to archaeological work, and include the project directors (Knut Fladmark and Jon Driver), stone tool analysis and development of the cultural sequence (Martin Handly), animal bone analysis (Randall Preston and Jon Driver), sediment analysis (Greg Sullivan and Knut Fladmark), and radiocarbon dating (Erle Nelson).

The most important aspect of the site is that it preserves a very rare record of humanly made artifacts dating from the end of the last ice age (at least 10,500 BC) to very recent times. The many layers at the site allow us to separate the different cultural periods. Good preservation of bone allowed us to submit radiocarbon dates that provide approximate ages for the various cultures that used the site.

The artifacts that exhibit the most change through time are projectile points – the sharp stone tips for spears, darts and arrows. In much of western Canada it is difficult to date archaeological sites, because many of them are found in shallow soils where radiocarbon dating is difficult for two reasons. First, animal bone is often not preserved due to the acidic nature of the soils. Second, although charcoal is often found, it cannot be reliably associated with human activity, because natural forest fires also produce charcoal. As a result, archaeologists look at the style of the projectile points to assign approximate ages. Tse'K'wa provides an opportunity to link artifacts of different styles to radiocarbon dates in a site with many distinct layers. So Tse'K'wa is a foundation for understanding the sequence of different cultures in the region.

The article also discusses the possible early presence of microblade technology. Microblades are the most efficient way of producing a cutting edge when the base technology is chipped stone. A small piece of high-quality raw material (known as the core) is shaped in such a way that numerous parallel-sided slivers of stone can be removed. These "microblades" can then be hafted in wood or antler to form knives or arrow barbs. The concept is rather like our utility knives that have replaceable blades. This technology allows people to carry small quantities of high quality stone with them, ensuring that they always have a sharp blade available. Not all archaeologists agree that the early microblade core from Tse'K'wa is part of this technology, because it doesn't conform to the classic methods of core manufacture. However, we argue that evidence for the removal of microblades is very obvious, and the lack of classic core preparation is because of the tabular nature of the raw material.

The paper also introduces some information about animal bones, including the raven burials, evidence for environmental change, and the presence of collared lemming. These topics were subsequently explored in more detail in other papers.

Stratigraphy, Radiocarbon Dating, and Culture History of Charlie Lake Cave, British Columbia

JONATHAN C. DRIVER,[1] MARTIN HANDLY,[2] KNUT R. FLADMARK,[1] D. ERLE NELSON,[1]
GREGG M. SULLIVAN[3] and RANDALL PRESTON[1]

(*Received 23 August 1995; accepted in revised form 27 April 1996*)

ABSTRACT. Three seasons of fieldwork at Charlie Lake Cave, British Columbia, have revealed a sequence of stratified deposits that spans the Late Pleistocene and entire Holocene. Analyses of sediments, radiocarbon dates, faunal remains, and artifacts show that the site was first occupied by people at about 10 500 B.P., when local environments were more open than today. By 9500 B.P., boreal forest had moved into the area, and human use of the site was minimal until about 7000 B.P., when a brief occupation of the site probably included a human burial. Use of the site intensified after about 4500 B.P., possibly because the cave became more accessible. The site was used both as a residential base camp and as a more temporary hunting station or lookout.

Key words: Paleoindian, Middle Prehistoric, Late Prehistoric, microblade, Holocene, late Pleistocene

RÉSUMÉ. Trois saisons de travaux sur le terrain à la grotte de Charlie Lake (Colombie-Britannique) ont révélé une séquence de dépôts stratifiés qui embrasse le pléistocène tardif et tout l'holocène. Des analyses de sédiments, des datations au radiocarbone, des restes fauniques et des artefacts montrent que l'occupation du site par des individus remonte à environ 10 500 BP, alors que le milieu local était plus ouvert qu'aujourd'hui. En 9500 BP, la forêt boréale avait colonisé la région et l'utilisation du site par les êtres humains a été minime jusqu'à environ 7000 BP, alors qu'une occupation brève du site a probablement inclus une inhumation. L'utilisation du site s'est intensifiée après environ 4500 BP, peut-être parce que la grotte est devenue plus accessible. Le site a été utilisé à la fois comme camp résidentiel de base et comme poste de chasse et de guet plus temporaire.

Mots clés: paléo-indien, époque préhistorique moyenne, époque préhistorique tardive, microlame, holocène, pléistocène tardif

Traduit pour la revue *Arctic* par Nésida Loyer.

INTRODUCTION

There are still areas of northern North America for which cultural sequences are based on only a few sites and rare radiocarbon dates. In these areas, it is important to establish better chronological control before beginning to tackle more complex archaeological research problems. Excavations at Charlie Lake Cave, spread intermittently over a period of nine years, have outlined the prehistory of northeastern British Columbia and of the southern boreal forest fringe of western Canada.

Charlie Lake Cave (HbRf-39) was recorded and tested in 1974 by K.R. Fladmark, who in 1983 directed a full excavation season at the site. Much of the information resulting from that season has been published (Driver, 1988, 1996; Driver and Hobson, 1992; Fladmark, 1996; Fladmark, et al., 1988). Most attention has been paid to two aspects of the site: the long cultural sequence, beginning with a Paleoindian component, and the well-preserved, diverse faunal assemblage, especially that associated with the Paleoindian artifacts.

In 1990 and 1991, J.C. Driver undertook further excavations to obtain larger samples of artifacts and fauna, again focusing special attention on the Paleoindian component. Material from these excavations has formed the topic of an M.A. thesis (Handly, 1993), and will provide the basis for further graduate student work.

SITE LOCATION AND FORMATION

The Charlie Lake Cave site consists of a number of microtopographic features associated with a cave. The cave is formed in a sandstone escarpment, which appears today as a small sandstone cliff about 2 m high. The cliff forms a prominent feature on a steep hillside about 25 m above the north side of Stoddart Creek, which drains Charlie Lake (Fig. 1). Between the floodplain of the creek and the top of the escarpment is a steep slope composed of sandstone boulders derived from the escarpment. These boulders are mantled by locally derived and redeposited glacial and glaciolacustrine sediments and colluvial deposits, on which a modern soil has formed. Above the escarpment the angle of slope declines, and the hillside merges into rolling topography formed by deposits of glacial till, overlain by glaciolacustrine sediments.

---

[1] Department of Archaeology, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada
[2] 653 Hendry St., Trail, British Columbia V1R 3J4, Canada
[3] General Delivery, Longmire, Washington 98397, U.S.A.

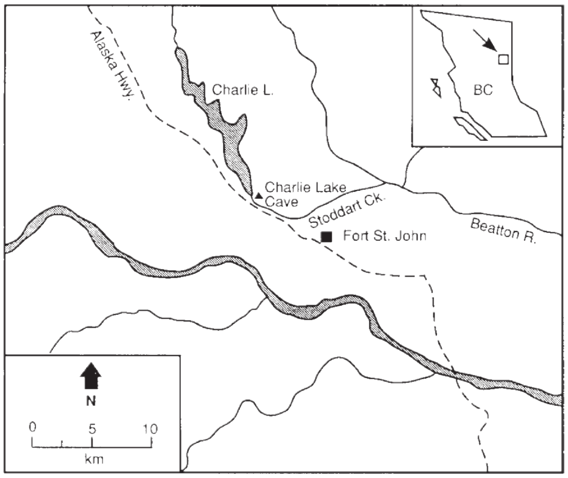


FIG. 1. Location of Charlie Lake Cave. Reprinted from Driver and Hobson (1992) with the permission of the Arctic Institute of North America.

At about 22 000 B.P., the Laurentide ice sheet made its final advance across northern Alberta into British Columbia, and covered the site location (Bobrowsky and Rutter, 1992). Dating for the glacial event around Fort St. John is poor, although it must have occurred after 22 000 B.P. and before 13 000 B.P. It is possible that subglacial water exploited joints and fissures in the sandstone bedrock, resulting in the initial formation of the cave (P. Bobrowsky, pers. comm. 1991). The retreat of Laurentide ice began before 13 000 B.P. (Bobrowsky and Rutter, 1992), but ice to the east impeded drainage, and proglacial lakes formed west of the ice margin. Mathews (1980) has demonstrated that a number of glacial lakes inundated the Fort St. John area. Shoreline elevations show that some of these lakes would have covered the Charlie Lake Cave site, and rythmites, which occur on the uplands to the north and east of the site, probably were deposited in one of these lakes. As lake levels went down, the location of the site was exposed. The remnant of a raised beach located on the hillside below the site probably belongs to the Clayhurst stage of Glacial Lake Peace (W. Mathews, pers. comm. 1983). It is not known when the lakes completely drained from the area around Fort St. John, but it probably happened before 10 500 B.P., because bison from gravels below the last stage of Lake Peace have been dated to this time (Apland and Harington, 1994).

Once the lake levels had dropped, the glaciolacustrine sediments covering the hillside began to erode, and re-exposed the sandstone escarpment. Possibly as a result of freeze and thaw processes operating on joints in the sandstone, a large section of the face of the escarpment was detached from the bedrock. This massive boulder (about 12 m long, 4 m wide, and 5 m high) moved about 3 m downslope, dropping vertically about 1 m. Surprisingly, the boulder did not topple over, but remained perched on the steep slope. Why this occurred is difficult to determine, but it may be that glacial or glaciolacustrine sediments on the downslope side prevented further movement. This massive rock, marked on Figure 2 as the "parapet," is split down the middle by the same line of weakness in which the cave was formed. The downslope movement of the parapet left a steep-sided gully between it and the bedrock face of the escarpment. The mouth of the cave, assuming that this feature had already been formed by subglacial erosion, would have been about 3 m above the base of the gully. Any sediments moving subsequently down the upper hillside and over the edge of the escarpment or out of the cave mouth would therefore have been trapped behind the parapet. As a result, the gully has filled with sediments for the past 10 500 years. The surface of these sediments is referred to as the "platform" (Fig. 2), because it is today a relatively flat area on a predominantly steep hillside. The floor of the cave retained little sediment for most of the site's history, and it was only when the deposits filling the gully reached the same height as the cave mouth (within the last 1000 years) that sediments could accumulate thinly within the cave itself.

An alternative interpretation of site formation is that the cave was formed only after the detachment of the "parapet" boulder from the escarpment. In this scenario, the cave would have been formed by subaerial weathering along a line of weakness in the sandstone, and the products of such weathering would have been deposited in the gully below the cave.

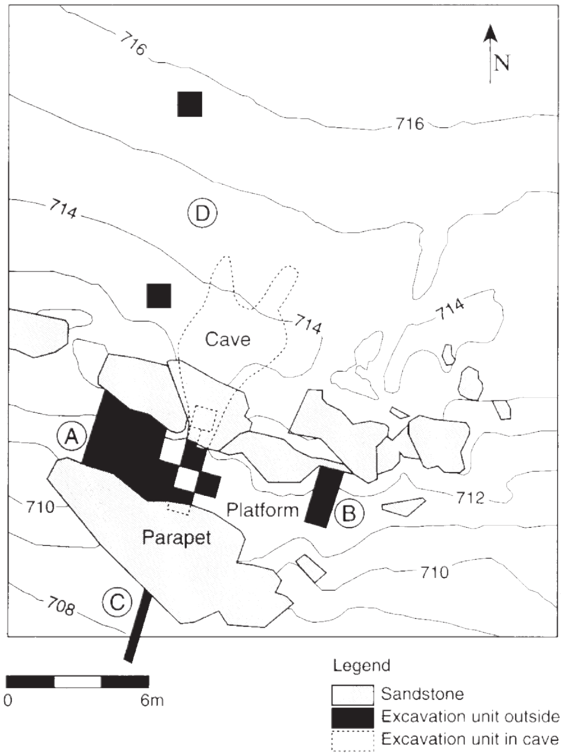


FIG. 2. Location of excavation areas, Charlie Lake Cave. The circled letters indicate excavation blocks. Elevations are in metres above sea level.

For archaeological purposes, the sediments within the gully are of more importance than the mechanism of gully formation, because they accumulated relatively rapidly (over 4 m in 10 500 years in some places). Most archaeological sites excavated in the boreal forest have very little sediment depth, and this lack of sediment has hampered preservation of cultural and environmental sequences. Although one would expect the cave to contain important cultural materials, test excavations have shown that relatively little cultural material has survived there, perhaps because of frequent use of the cave by twentieth-century children. Many people reported to us that they had dug in the cave as children, and a number claimed to have found stone artifacts there.

EXCAVATION HISTORY

Archaeological work at the site commenced with two test pits, totalling 1 by 1 m, excavated in 1974 (Fladmark, 1975). These pits did not succeed in penetrating very deep into the gully sediments, and a radiocarbon date suggested a relatively recent age for the cultural and faunal material recovered. Nine years later, a crew directed by Fladmark excavated a series of 1 by 1 m units, mainly in the platform area (Fladmark et al., 1988). These units established the considerable depth of sediments spanning the entire Holocene period, and defined the major parts of the cultural and stratigraphic sequence. These excavations also recovered the only Paleoindian projectile point from the site. In 1990 and 1991, a crew directed by Driver excavated a block of 1 by 1 m units in the area that had produced most of the Paleoindian artifacts. In the 1983, 1990 and 1991 seasons, test excavations were also made above and below the site, and geomorphological studies were conducted through a limited number of test units. Handly (1993) has organized the various excavation units into "blocks." Most of the analysis reported in this paper is based on studies undertaken on the largest set of contiguous units, known as "Block A," located on the platform in front of and to the west of the cave entrance (Fig. 2).

Excavation methods in the three main seasons were quite similar, and used the same standardized forms for recording. Distinctive stratigraphic units were identified by colour and texture and referred to as "layers." During excavation, thick layers were divided into arbitrary 10 cm "levels" contoured to the general slope of deposits.

Excavations were carried out mainly with trowels, and sediments were screened through 3 mm mesh. The lowest deposits were more difficult to excavate, and a variety of tools (including cold chisels, pry bars, dental picks, pick axes, geological picks, and power tools) were used to expose artifacts and bones. Very little damage was done to the artifacts and bones from the lowest deposits, although the first artifact found in the lowest component (the Paleoindian projectile point) was broken into three pieces. All materials are currently stored at the Department of Archaeology, Simon Fraser University (SFU).

STRATIGRAPHY AND RADIOCARBON DATING

Layers identified during excavation were grouped into stratigraphic units referred to as "zones," which have been labelled using Roman numerals. With the exception of Zone I, all other zones could be divided into "subzones," identified with lower-case letters. Zones were defined by sediment type, rate of sedimentation, and soil formation processes. Subzones reflect minor variations within zones. Initially, five zones were defined following the 1983 excavations. However, the most recent of these (Zone V) was distinguished only by the presence of historic artifacts, and has been combined with Zone IV, from which it is indistinguishable in colour and texture. The 1990 and 1991 excavations confirmed the presence of four stratigraphic zones. Because the open plan excavation methods allowed for finer stratigraphic resolution, some zones have been divided into more subzones than were originally defined in 1983. It has been possible to correlate the two stratigraphic systems in Block A, where 1983, 1990, and 1991 excavation units are contiguous. In publications that deal exclusively with the 1983 excavations, the 1983 system of zones and subzones has been used. In publications such as this, which deal with material from all seasons, the zonation based on the 1990 and 1991 excavations will be used. Figure 3 illustrates the west stratigraphic profile of the 1990 and 1991 excavations in Block A. Another profile, from the centre of Block A, has been published previously (Fladmark et al., 1988).

Granulometric analysis was conducted on the matrix fraction (particles smaller than 2 mm in diameter) of sediment samples collected in 1990 and 1991. On the basis of textural parameters of mean grain size and standard deviation (a measure of sorting), all layers were divided into two types, Groups 1 and 2. Group 1 deposits have a very small mean grain size (in the silt range), are poorly sorted, and are composed primarily of glaciolacustrine sediments washed into the gully from upslope. Group 2 sediments have a larger mean grain size (in the sand range), are better sorted than Group 1 deposits, and are composed primarily of sand particles weathered from the local sandstone, with varying amounts of silt and clay contributed from upslope. Group 2 deposits were subdivided into a finer Group 2A (greater amounts of clay and silt) and a coarser Group 2B. The different sediment types are independent of stratigraphic zonation, and reflect the mechanics of sediment formation.

Radiocarbon dates are presented in Table 1. The initial radiocarbon dating (SFU series) was done using the SFU Archaeology Department beta-counting laboratory on samples from the 1983 season. Problems were encountered immediately because the charcoal samples obtained during excavation were very small. These problems were compounded by the chemical fragility of the charcoal. Potential contaminants are normally removed from charcoal by washing with acid (HCl) and then with base (NaOH). However, the base wash removed much of these samples, rendering them even smaller and more difficult to date. This situation was the classic dilemma of all traditional radiocarbon labs: rigorous

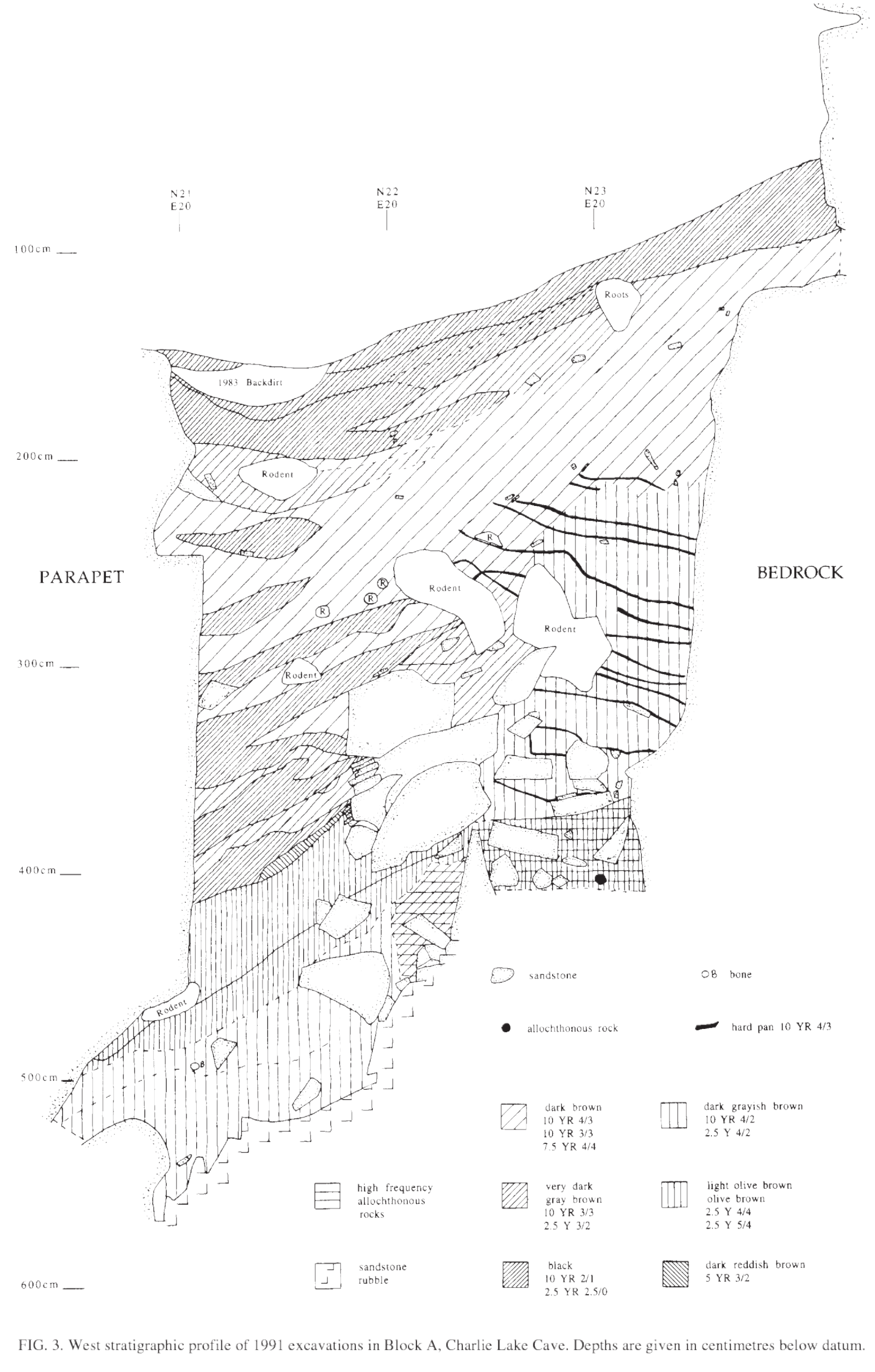


FIG. 3. West stratigraphic profile of 1991 excavations in Block A, Charlie Lake Cave. Depths are given in centimetres below datum.

TABLE 1. Radiocarbon measurements, Charlie Lake Cave.

Subzone	Component	Date[1]	Lab number[2]	Material
IIa	1	10500 ± 80[1]	CAMS 2129	Artiodactyl
IIb	1	10290 ± 100[1]	CAMS 2137	Raven
IIb	1	10380 ± 160	SFU 378	Bison
IIb	1	10450 ± 150	SFU 300	Bison
IIb	1	10560 ± 80[1]	CAMS 2134	Bison
IIb	1	10770 ± 120	SFU 454	Bison
IIc	2	9670 ± 150[1]	CAMS 2136	Bison
IIc	2	9760 ± 160	SFU 355	Bison
IIc	2	9990 ± 150	RIDDL 393	Bison
IIc	2	10100 ± 210	RIDDL 392	Sciurid
IIIa	3	9490 ± 140[1]	CAMS 2318	Raven
IIIb		7800 ± 800	SFU 370	Charcoal
IIIb		8400 ± 240	SFU 357	Charcoal
IIIe		7100 ± 350	SFU 452	Charcoal
IIIf	4	7400 ± 300	RIDDL 10	Charcoal
IIIg	5	1130 ± 240	SFU 453	Charcoal
IIIh	6	4400 ± 400	SFU 385	Charcoal
IIIh	6	4800 ± 640	SFU 451	Charcoal
IVa	7	2900 ± 400	SFU 358	Charcoal
IVa	7	4270 ± 160	SFU 382	Bison
IVa	7	4400 ± 80[1]	CAMS 3174	Artiodactyl
IVb	8	1400 ± 400	SFU 379	Charcoal
IVb	8	1550 ± 100	RIDDL 59	Charcoal
IVb	8	6700 ± 290	SFU 356	Charcoal

[1] previously unreported date

[2] RIDDL and CAMS dates are by accelerator mass spectrometry; SFU dates are traditional beta counting

treatment may leave little to measure, while insufficient treatment may produce erroneous results. In this case, as in many others, a balanced approach was attempted, and that is reflected in the large uncertainties associated with the SFU charcoal dates. These difficulties were exacerbated by the realization that two samples (SFU 356 and SFU 453) had probably been mixed up, either in the field or in the lab.

Shortly afterwards, accelerator mass spectrometry (AMS) measurement capabilities became available at SFU. This method removed the problems due to sample size, and a suite of AMS dates (the Radio Isotope Direct Detection Laboratory [RIDDL] series) was taken on further 1983 samples to test the traditional measurements. Later, these early AMS measurements were supplemented by further dates from another AMS lab (the Center for Accelerator Mass Spectrometry [CAMS] series) taken on materials excavated in 1990 and 1991.

A plot of radiocarbon age as a function of relative depth is presented in Figure 4. The depth of the radiocarbon sample is expressed as a percentage of the total depth of the quadrant of the excavation unit in which the date occurs. For example, a sample found 3 m deep in an excavation unit containing 4 m of deposit would be given a depth of 75%. This calculation has been used because the total depth of sediment varies across the site, and the stratigraphy dips quite steeply across the gully (see Fig. 3). With the exception of two measures (SFU 356 and 453), all others form an ordered progression, into which the two exceptions would fit if their sample numbers were switched. Unfortunately, we cannot retest this possible mistake, as both samples were entirely consumed in the traditional measurement process. Even so, we believe the AMS dates remove any substantial ambiguity, and that the data in hand provide a reliable chronological framework for the natural and human history of the site.

When the boulder that now forms the "parapet" moved downslope shortly before 10 500 B.P., it created Zone I, which consists of a layer of crushed in situ sandstone and a mass of overlying boulders. The crushed sandstone was presumably created by the weight of the boulder moving downslope. Smaller boulders seem to have broken away from the base of the parapet as it detached from the bedrock, and now form a confused jumble of rock, lying at a fairly steep angle in the bottom of the gully. Most of these smaller boulders are found on the north side of the gully. This may indicate that the boulder first detached and moved a short distance, and then moved again. Alternatively, the "parapet" may have moved only once, depositing large boulders near the point of detachment. Those boulders vary in size; the largest, about 1 m in height, stands vertically in the northwest corner of Block A. All boulders in Zone I are very resistant to mechanical fracturing, unlike most other sandstone boulders encountered higher in the excavation, which could be broken quite easily by cold chisel and hammer. The unweathered nature of the Zone I boulders suggests that they were not exposed to weathering before deposition (as would be expected if they had been formed during the detachment of the parapet and then protected from further weathering). Because of the difficulty in breaking up these rocks, they were removed only along a 1 m wide strip between the bedrock and the parapet.

Immediately after the initial movement of the "parapet" and the formation of the gully, sediments began to move downslope from the hillside above the site. These sediments formed a layer up to 1 m thick across the bottom of the gully; they are thickest to the south, where they comprise Zone II. Although no bedding structures were visible in these sediments, differences in texture and compactness were observed during excavation, allowing four subzones to be defined. The matrix of Zone II sediments belongs primarily to the Group 1 type, which suggests that rapid redeposition of glaciolacustrine sediments from upslope was the primary source of these deposits, rather than erosion of the local sandstone. These sediments were transported very rapidly into the gully at first, probably by mass wasting, and subsequently by slope wash until the sediments above the site became more stable. In the upper subzones of Zone II, the matrix becomes coarser (Group 2 sediments), indicating reduced input from upslope, slower overall rates of deposition, and a greater contribution from weathering of local sandstone. Zone II dates from about 10 500 to 9500 B.P. As can be seen from Table 1, there is a fairly good separation of radiocarbon dates from the lower part of Zone II (Subzones IIa and IIb) and the upper part of Zone II (Subzone IIc); the dividing line occurs at about 10 000 B.P. This division, also recognized in the 1983 excavations, corresponds to a shift in fauna, which suggests an environmental change (Driver, 1988). The lack of organic matter in Zone II supports the conclusion that deposition was too rapid and continuous to allow pedogenesis to occur.

Zones III and IV represent a shift toward the general depositional processes that occur at the site today. Zone III dates from about 9500 to 4500 B.P., and sand particles from in situ weathering of the local sandstone dominate the sediments. Transport of finer particles of glaciolacustrine deposits from upslope decreased during its deposition, and so did the sedimentation rate. In the lower subzones (IIIb–IIIe), Group 2B sediments dominate; these coarser sediments represent a reduction in slope wash. Later subzones are dominated by 2A sediments, which represent a renewed contribution of upslope sediments. This change might coincide with the "Hypsithermal," a period of decreased precipitation recognized in some paleoenvironmental reconstructions for the southern boreal forest (Lichti-Federovich, 1970). Slower rates of deposition allowed pedogenesis to occur at various times, and resulted in a greater organic matter content for Zone III. Horizons with higher proportions of organic material do not extend across the gully because of postdepositional leaching by groundwater percolating through sediments on the north side of the gully. This leaching also lowered the pH in more northern sediments, resulting in poorer survival of bone.

Zone IV differs from Zone III mainly in the decreased slope of deposits and the presence of pedogenic layers extending across the gully. Texture continues to be dominated by sand, but the amount of silt or clay particles contributed by slope wash seems to vary through the profile. Organic matter content is higher, and pedogenic horizons are thicker. This may be because more sunlight created denser vegetation as the deposits built higher in the gully and the slope of the sediments decreased. Organic material was also added by packrats, whose nests and droppings are common in more recent layers. Although there appears to be an increased sedimentation rate (Fig. 4), the lower bulk density of sediments due to greater amounts of organic matter may be responsible for this appearance.

The stratigraphic integrity of the site is suggested by the fairly good relationship between radiocarbon age and depth of sample. In 1990 and 1991, the open area excavation methods allowed for easy identification of rodent burrows. Generally, rodent holes were rare, narrow, and short. The only exception to this is a complex of tunnels containing woodchuck (*Marmota monax*) bones excavated from the northwest corner of the main excavation area in 1990. The size of this disturbance can be estimated from the rodent holes shown in Figure 3. The animals burrowed laterally into the deposits from the west, affecting about a square metre of deposits. In Zone II, numerous ground squirrel (*Spermophilus* sp.) bones have been found. AMS dating of one of these bones demonstrates its contemporaneity with the sediments in which it was found (Driver, 1988). There has been little disturbance by roots at the site, and there is no evidence that large tree roots or tree falls have disturbed the deposits.

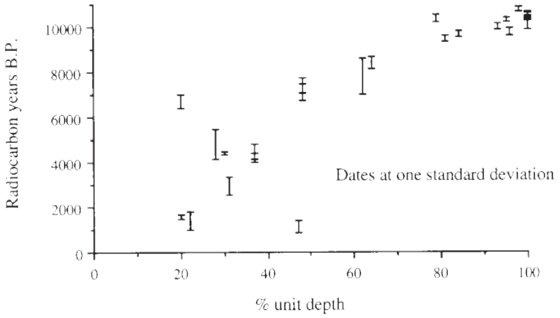


FIG. 4. Radiocarbon dates plotted against depth of sample.

In summary, sediments have been deposited at varying rates in the gully since 10 500 B.P. For the first 1000 years, deposition was relatively rapid, probably because glaciolacustrine deposits were being eroded rapidly after the recession of Glacial Lake Peace. After 9500 B.P., deposition rates slowed down, and soils formed in the gully. Pedogenesis was interrupted frequently by continual deposition, which buried old soils and formed new surfaces for further soil formation. The organic content of sediments has been affected by postdepositional leaching by groundwater on the northern side of the gully. Disturbance by rodent burrowing has been a factor in the formation of the deposits, but seems to have been minor and limited in extent.

CULTURAL COMPONENTS

We have defined ten cultural components, on the basis of stratigraphy rather than the nature of the artifacts. Generally, artifacts found within the deposits of a particular subzone have been defined as a component, and we have not attempted to either separate different occupations within a subzone or to lump occupations from different subzones. This strategy was chosen because most subzones contain relatively few artifacts, and few of these artifacts clearly display an intentional style in their formal properties. The majority of artifacts are chipped stone (mainly debitage), but there are a few ground stone and bone or antler pieces. This discussion emphasizes artifacts that can be compared stylistically with other assemblages, and is concerned mainly with culture history. A detailed lithic analysis has already been reported, and cultural components have been grouped into Early, Middle, and Late Prehistoric periods (Handly, 1993).

Early Prehistoric

Component 1 occurs mainly within subzone IIb, and dates to approximately 10 500 B.P. The calculation is based on an average of six dates (Table 1). This component is associated with butchered bison bone of an extinct species. In 1983, four formed artifacts were recovered (Fladmark et al., 1988). In 1991, more artifacts were added to the inventory. The complete basally thinned projectile point (Fig. 5a) shares features with similar points from surface sites in the Peace River and central and southern Alberta. No other dated sites in Canada contain this type of point. We exclude Sibbald Creek (EgPr-2) from consideration, because the dated charcoal from that site was not collected solely from the levels that produced basally thinned points (Gryba, 1983). From Montana, Davis and Greiser (1992) reported what appears to be a partially finished specimen with basal characteristics similar to those of the Charlie Lake specimen. This Montana artifact is associated with a date on scattered charcoal of 11 000 B.P., which is likely to be somewhat older than the date when the point was deposited. Frison (1991) described projectile points from the Goshen Complex that are basally thinned, but not fluted. These are dated around 11 000 B.P. at the Mill Iron site in Montana. Although the flaking pattern on the blade is different, the treatment of the base appears similar to that of the Charlie Lake specimen. We believe that the Charlie Lake point is probably derived from a late fluted point tradition, such as those seen in Montana. However, because of the scarcity of excavated specimens, the Charlie Lake point remains in unfortunate isolation as the only well-dated representative of the late fluted point tradition in western Canada.

Other artifacts have less information to provide on culture history but do suggest a limited range of activities for Component 1. Most notable is a series of large quartzite artifacts, which range from a barely retouched cobble to a biface and a well-made uniface (Fig. 6). Although Handly (1993) has classified these formally in a variety of ways—as cores, retouched flakes, bifaces, etc.—they have some common features that suggest a possible common function. They are relatively heavy and have strong, roughly shaped edges. They are all approximately 20 cm long. On many specimens, there is evidence for heavy use of the edges, such as battering and dulling. No debitage from the quartzite artifacts has been recovered, suggesting that they were made elsewhere, transported to the site, used, and discarded. We tentatively identify these as an assemblage associated with heavy butchering. That they were abandoned in the midst of broken bison bones suggests that they were connected in some way with butchering, although it is of course possible that the final association of bones and artifacts was the result of refuse disposal methods rather than a functional relationship.

Other chipped stone artifacts include some retouched flakes (Fig. 5b, c) and a small quantity of debitage (Table 2). The assemblage conforms to our expectations for kill-site assemblages, in that artifact diversity is low, debitage is rare, and the artifacts appear on morphological grounds to have functioned in hunting and butchering. The only exception to this is a small fragment of local schist which has been perforated biconically (Fig. 5e). This "bead" (Fladmark et al., 1988) was presumably for decorative purposes, although its rough outline suggests that it may never have been finished. The bison bones recovered in association with Component 1 are mainly lower leg bones, which might well have been left behind at a kill because of their relatively low meat yield.

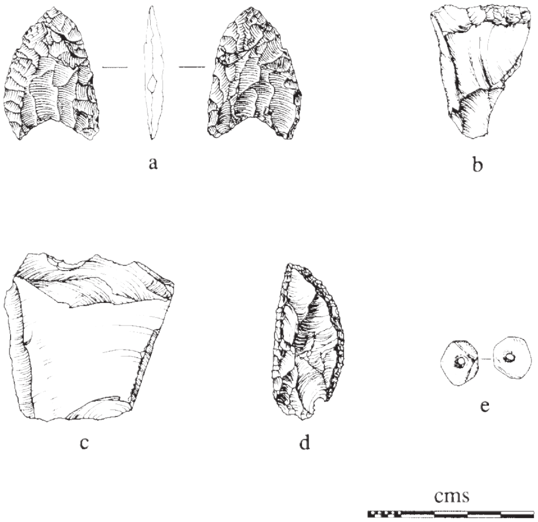


FIG. 5. Artifacts from Component 1 (a, b, c, e) and Component 2 (d).

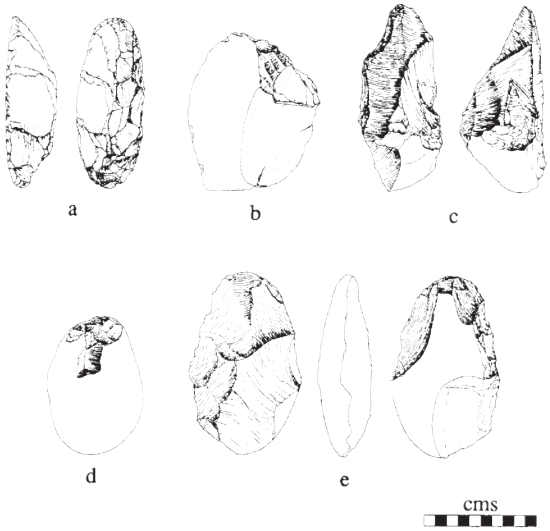


FIG. 6. Large quartzite artifacts, Components 1 and 2.

Associated with the bison bones and artifacts were numerous small rodent and bird bones. One notable find in 1991 was a large part of a raven (*Corvus corax*) skeleton (one of whose bones provides one of the later dates for Component 1). A small section of tracheal rings was also preserved, testifying to the extremely good preservation conditions of Zone II deposits. Articulated sets of bones, as well as the tracheal rings, show that the bird was deposited as a relatively complete carcass. Whether or not humans were involved in the death or deposition of the bird is difficult to say.

Component 1 shows that the first human inhabitants of the postglacial landscape were probably big-game hunters specializing in bison. As described elsewhere (Driver, 1988, 1996), this early landscape was open, with relatively little forest. The similarities to artifacts found elsewhere indicate that possibly people first entered this region from the southeast, as part of a bison-hunting population that expanded north and west as the glacial and lacustrine barriers disappeared.

Component 2 from Subzone IIc contains no distinctive artifact styles, and the total asssemblage is smaller and contains fewer stone tools than Component 1. It is associated with bison bone, and may represent a kill similar to that seen in Component 1. It dates to 9850 B.P. (average of four dates).

Component 3, in Subzone IIIa, dates to about 9500 B.P. and produced the most unexpected find of the 1991 excavation season. A microblade core was found in association with a considerable portion of another raven skeleton (Fig. 7) lying against the southern wall of the gully. The exact position and orientation of the microblade core are unknown, because the senior author was so intent on excavating the articulated bird skeleton that he ignored the microblade core until it was dislodged. However, it was lying near the feet of the raven. The raven skeleton consists of both legs and both wings, with bones from all four limbs lying in roughly anatomical position. Most of the vertebrae are missing, as are the sternum, ribs, pelvis, and head. Bones of the pectoral girdle (coracoid, scapula, and furculum) are present. It is possible that the missing bones were removed by scavengers, but this seems unlikely, because the rest of the skeleton was not scattered. A more plausible explanation is that the relatively fragile axial elements were destroyed by weathering or chemical activity. This interpretation is supported by the presence of weathered vertebrae, sternum fragments, and cranial fragments. The limb bones also show evidence of weathering and chemical erosion of their surfaces, and numerous postdepositional breaks have occurred on the long bones.

The microblade core (Fig. 8) presents some problems of interpretation. It is made from a small piece of tabular grey-blue chert. The two sides of the core (Fig. 8b, e) are formed by the natural bedding planes of the rock. The base (Fig. 8c) has been steeply and unifacially retouched, and may have been used as an endscraper. It is also possible that the retouch was to create a keel for the microblade core, as there is some crushing along the retouched edge, which might be a response to force applied when microblades were detached. The striking platform (Fig. 8a) is formed by what looks like a heat fracture, although there are traces of platform preparation scars at the end from which the microblades were struck, and there is some lateral crushing along one side of the platform, similar to platform damage observable on some Alaskan wedge-shaped cores. One end of the core is unmodified (Fig. 8f). The other end (Fig. 8d) displays traces of six microblade removals. The first three presumably ran the full depth of the core, to produce blades about 2 cm long. The last three all terminated halfway down the face of the core, and would have produced very small blades. Without further reshaping, the core would not have produced any more useful microblades, and it could be classified as exhausted.

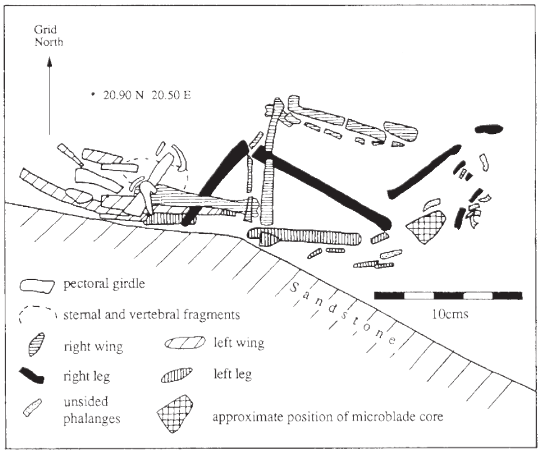


FIG. 7. Articulated raven skeleton and associated artifact, Component 3.

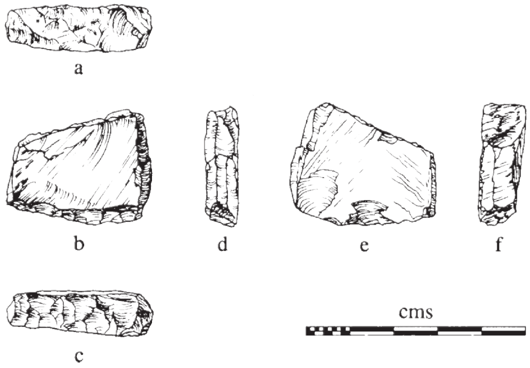


FIG. 8. Microblade core, Component 3.

In terms of overall size and shape, the core resembles the wedge-shaped cores of Alaska more than the conical or irregular microblade cores of later Holocene sites in northern British Columbia and Alberta. The Charlie Lake specimen is not a typical wedge-shaped core, because it lacks the sharp keel seen on most specimens. However, the platform preparation is similar, as is the removal of multiple microblades from a single face. Technologically, the Charlie Lake specimen is different from many Alaska specimens because it is not prepared bifacially. However, if one presumes that the bifacial preparation was normally undertaken to shape the core blank, this would not have been necessary with the tabular raw material from which the Charlie Lake core was made. Some Alaskan cores lack bifacial preparation as well.

A number of studies have shown that wedge-shaped cores occurred early in the Alaska sequence, even though they may have persisted until late Holocene times (Mobley, 1991). For example, Powers and Hoffecker (1989) showed that wedge-shaped microblade cores occurred in the Nenana Valley, Alaska, by about 10 500 B.P. Wedge-shaped cores have also been found nearer Charlie Lake Cave than the Alaska specimens, in Alberta. These include a recently reported specimen from Fort Vermilion, about 600 km downstream from Fort St. John on the Peace River (Pyszczyk, 1991), and a larger assemblage from the 4000 B.P. Bezya site in northeastern Alberta (LeBlanc and Ives, 1986). Microblades have also been found in southern Alberta at the High River site, in association with early Holocene Cody Complex artifacts (Sanger, 1968); the cores from that site recovered subsequent to Sanger's investigation remain unillustrated, but are reported as wedge-shaped (LeBlanc and Ives, 1986). Fedje et al. (1995: Fig. 11e) illustrated a broken biface, which may have been used as a microblade core, at the Vermilion Lakes site in Banff National Park, Alberta. This artifact is associated with radiocarbon dates of about 9900 B.P. Clark (1992) has reviewed the distribution of wedge-shaped cores outside of Alaska. The Charlie Lake and Vermilion Lakes examples appear to be the among the most southerly, and are the oldest examples known from Canada. Alaskan specimens are older and much more common.

Middle Prehistoric

Component 4, in Subzone IIIf, dates to about 7000 B.P. This component does not contain any temporally diagnostic tools, although Handly (1993) considers that a complete biface is similar to bifaces from the Taye Lake Phase in southwest Yukon (Workman, 1978). A piece of obsidian debitage has been sourced to Mt. Edziza, about 600 km northwest of the site. A fragmentary human mandible is also associated with this component. There is no evidence for deliberate burial, and we conjecture that it was displaced from a burial upslope, possibly in the cave.

Component 5 in Subzone IIIg has no acceptable associated radiocarbon dates, but must lie somewhere between 7000 and 5000 B.P. The projectile point recovered (Fig. 9a) has shallow side notches and basal thinning. Side-notched points were widespread in western North America at this time, and nothing about this specimen allows us to compare it specifically to any more restricted region. A similar specimen was recovered from the nearby Farrell Creek site, dated at about 4400 B.P. (Spurling, 1980: Fig. 34g). Outside of the Peace River area, similar specimens have been found in the Acasta Lake Phase in the central District of Mackenzie (Noble, 1971), in the Pointed Mountain Complex of the western District of Mackenzie (Millar, 1968; Morrison, 1987), and in the Taye Lake Phase of southern Yukon (Workman, 1978). Dates range from 7000 B.P. to 1600 B.P.

Component 6 in Subzone IIIh is well-dated to about 4500 B.P. As well as evidence for a range of lithic reduction activities, artifacts include a well-made side-notched projectile point (Fig. 9b) and a single microblade. A hearth was located to the west of the cave mouth. Sites in the region with similar projectile points include HbRb-17 (Spurling, 1980) and the Karpinsky site (Bryan and Conaty, 1975), although neither has produced radiocarbon dates associated with the projectile points. At Tezli, in north central British Columbia, a similar artifact was dated between 3300 and 3900 B.P. (Donahue, 1975).

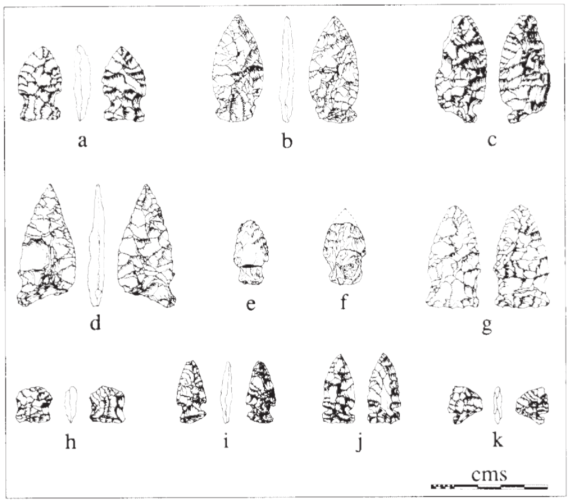


FIG. 9. Projectile points from Components 5 (a), 6 (b), 7 (c, d), 8 (e, f), 9, and 10 (g–k).

Component 7 in subzone IVa has three examples of side-notched, concave-based points (Fig. 9c, d), and a fragment of a small corner-notched point, dating to about 4300 B.P. The larger points have similarities to the Oxbow type of the northern plains and parkland region. Spurling and Ball (1981) suggested that these artifact types entered the Peace River area at a later date, proposing that a general decrease in the age of such artifacts is correlated with more northern latitudes. According to their data, Oxbow-like points in the Peace River should fall in the 3000 to 2500 B.P. range. The Charlie Lake Cave dates appear to refute this hypothesis.

Comparable specimens have been recovered from Farrell Creek (Spurling, 1980), the Karpinsky site (Bryan and Conaty, 1975), the Smoky site in north central Alberta (Brink and Dawe, 1986), and the Ski Hill site in northwestern Alberta (Thomson, 1973). However, all radiocarbon dates postdate 2000 B.P. Also, projectile points with a similar configuration are reported from the early part of the Shuswap horizon to the south and west of Charlie Lake Cave on the interior plateau of British Columbia, dating from about 4000 to 3000 B.P. (Richards and Rousseau, 1987).

In north central British Columbia, Donahue (1975) describes similar projectile points at Tezli dated around 1900 B.P. In northern British Columbia and southwest Yukon, similar projectile points have been found in Taye Lake Phase and Aishihik Phase sites (MacNeish, 1960; Workman, 1978). The early dates for Taye Lake Phase fit the Charlie Lake dates. In central District of Mackenzie, Noble (1971) defined an Oxbow complex dated 4500 to 3500 B.P., and the Fish Lake complex in western District of Mackenzie contains similar artifacts dated 3000 to 2500 B.P. (Millar, 1968).

Late Prehistoric

Component 8 in Subzone IVb probably dates to about 1500 B.P. It contains two small, apparently reworked projectile points with shallow side notches and convex bases (Fig. 9e, f). Two hearths and a cache of flakes were associated with Component 8. The projectile points can be compared with specimens from the Karpinsky site (Bryan and Conaty, 1975) dated at 1100 B.P. More distant comparisons include specimens from the Timber Point complex (2400 to 2700 B.P.) of the District of Mackenzie (Noble, 1971).

Components 9 and 10 occur in Subzone IVc and postdate 1500 B.P. Three point types have been recovered. Two large specimens with shallow side notches and flat bases (Fig. 9g, h) are similar to a specimen from Farrell Creek dated to 1600 B.P. (Spurling, 1980), and to another from the Ski Hill site (Thomson, 1973). These points are similar to Taltheilei Tradition specimens from 1900 to 300 B.P. (Noble, 1971). Similar specimens have also been found in northern British Columbia (MacNeish, 1960), in the western District of Mackenzie in the Mackenzie Complex (Millar, 1968), and in the Pointed Mountain Complex (Morrison, 1987).

Two small side-notched points (Fig. 9i, j) and one small corner-notched point (Fig. 9k) are similar to a range of arrowhead styles from many areas of northwestern North America dating to within the last 1000 years.

Much of the debitage from Component 9 occurred in an oval depression in front of the cave mouth. Not enough of this feature was excavated to determine if it was part of a structure. It was at least 3 m long, 2 m wide and about 30 cm deep.

DEBITAGE ANALYSIS

Handly (1993) provides a detailed study of the debitage from the site, which we summarize here. Chipped stone artifacts were divided into cores, unformed tools, formed tools, and debitage (Table 2). Debitage was analyzed using a combination of mass analysis (Ahler, 1989; Baumler and Downum, 1989) and individual flake analysis (Wilmsen, 1970; Rozen and Sullivan, 1989). Mass analysis is concerned with the overall size distribution of the debitage assemblage, while analysis of individual attributes examines variability within the assemblage. All debitage was described using the following attributes: raw material, size, weight, initiation face (striking platform) modification, interior surface lipping, eraillure scarring, exterior scar count, and cortex cover. Justification for these attributes is described elsewhere (Handly, 1993). Raw material selection may provide information about mobility across the landscape. The other attributes are expected to relate to the technology of stone tool production, specifically to the type of flaking being done and the stage of reduction reached during the preparation of stone tools.

TABLE 2. Summary of lithic data by component, Charlie Lake Cave.

Component	Debitage	Unformed	Formed	Cores	Total
1	8	8	1	2	19
2	28	3	0	1	32
3	160	1	0	1	162
4	68	8	1	2	79
5	121	11	4	7	143
6	96	9	2	1	108
7	33	6	5	2	46
8	216	17	8	1	242
9	361	6	6	1	374
10	132	4	6	0	142
Total	1223	73	33	18	1347

Analysis of raw material showed that virtually all chipped stone specimens were made on chert. Although various different types of chert were defined on the basis of colour and inclusions, the significance of these cannot be determined, as no lithic sources are known, apart from cobbles and pebbles in local gravels. In the Early Prehistoric assemblages, the most common raw material is a vitreous grey chert. In the Middle Prehistoric period, vitreous black chert is dominant. A vitreous mottled chert is most common in Late Prehistoric components.

Component 1 contains relatively little debitage. The small sample displays high cortical frequencies, unprepared platforms, and low exterior scar counts, indicating early-stage lithic reduction.

Component 2 debitage is characterized by small size, low cortical counts, low frequencies of interior surface lipping, and moderate values for exterior scar counts. A variety of reduction strategies may be represented, but the sample is too small to be certain.

The majority of debitage from Component 3 was recovered from an area of about one square meter. Debitage is small, with more than 90% of the sample weighing less than 0.1 g. This suggests late-stage lithic production, as do crushing, facetting, and grinding of platforms, higher frequencies of lipping, low frequency of eraillure scars, and high counts of exterior flake scars. The majority of debitage was probably produced during biface production or maintenance. The raw material types indicate that at least two bifaces were prepared. The presence of a microblade core and maintainable bifaces suggests high residential mobility, perhaps coincident with the development of boreal forest and a reduction in bison herds.

In Component 4 there is evidence for more early-stage reduction, including early-stage platform preparation, low frequencies of interior surface lipping, and moderate numbers of exterior flake scars. This pattern persists in Component 5, which also has the largest number of cores. Debitage is notable for a high frequency of cortical debitage, a variety of size ranges, platform preparation consistent with early-stage reduction, and moderate numbers of exterior flake scars.

In Component 6 there are spatially discrete areas of different types of debitage. Early-stage reduction occurred at the east and west ends of the excavated area, and a small patch of late-stage debitage was associated with a hearth between these areas.

No clear patterns can be seen in the small debitage sample from Component 7. Late-stage reduction is well represented in the debitage of Component 8, mainly to the southeast of a hearth in the centre of the excavation area. In this area, interior surface lipping and exterior flake scar counts suggest late-stage reduction or tool maintenance. The presence of broken conjoinable formed artifacts also supports this interpretation. On the northern side of the main excavation, a possible cache of chert flakes was recovered. These specimens are from the same raw material, have a high frequency of cortex, and are much larger than other debitage. They display no retouch, and no other pieces of this raw material were found in this component. Component 8 therefore includes both early- and late-stage reduction debitage.

In Component 9 the combination of small debitage size, late-stage platform preparation, interior surface lipping, and moderately high numbers of exterior flake scars suggests the manufacture and maintenance of tools in an oval depression in front of the cave entrance. Other debitage suggests that earlier stages of lithic artifact production also occurred. Both of these activities continue into Component 10.

FAUNAL REMAINS

In comparison with most sites in the region, faunal preservation is good at Charlie Lake Cave. This is particularly true for the fauna from Zone II, where relatively rapid deposition resulted in excellent preservation of quite fragile bones. The vast majority of specimens are from small mammals, birds and fish, and large mammals (bison, moose, elk) are quite rare. Many specimens probably reached the site as the result of natural processes.

Work on the large collection of fauna is in progress. Driver identified the entire collection from the 1983 excavations, focusing mainly on paleoenvironmental studies (Driver, 1988, 1996; Driver and Hobson, 1992). As the 1990 and 1991 collections appeared very similar to those reported earlier, a subsample of specimens from four excavation units has been selected for further study. Preliminary results show that the range of species identified from the 1990 and 1991 samples is very similar to that identified from the 1983 collection. The most obvious faunal change occurs at the Pleistocene-Holocene boundary, where the dominant small mammal changes from ground squirrel (*Spermophilus* sp.) to snowshoe hare (*Lepus americanus*). This change appears to mark the transition to a boreal forest from a predominantly open landscape established by pioneering plant species on the barren postglacial terrain. Since this change occurred (by about 9500 B.P.), the mammalian and avian faunas have remained fairly consistent though time.

Further evidence for the open landscape proposed for Zones IIa and IIb is the identification of a single specimen of collared lemming (*Dicrostonyx torquatus*) recovered from Zone IIb in 1991. This species is today confined to tundra, although during the late Pleistocene it lived south of the ice sheets (Lundelius et al., 1983).

RITUAL ACTIVITY

There is evidence from the earlier components that some ritual activities may have occurred at the site. The most obvious evidence is the presence of human remains in Component 4. The human mandible appears to have been burnt, but it is not calcined. The specimen might be the result of an incomplete cremation, but it seems more likely that it was dislodged from its original burial position, suffered some burning (either natural or cultural), and reached its final isolated position as a result of natural processes of erosion and deposition.

The two raven skeletons in Components 1 (c. 10 500 B.P.) and 3 (c. 9500 B.P.) also hint at ritual activity. The earlier skeleton is more disarticulated, possibly as a result of sediment movement after deposition. The bird was definitely deposited with some soft tissue, because the tracheal rings survived. As mentioned previously, the later bird was also deposited as an articulated specimen.

Ravens are of considerable significance in the ideology of First Nations in the Northwest, and are often associated with origin myths. In many Athapaskan stories, and in the stories of other cultures, Raven appears as a trickster and is often associated with hunting. Consequently, the discovery of two relatively complete raven skeletons inevitably leads to speculation about the role humans may have played in the deposition of the birds at the site. For the raven in Component 1, there is no evidence of human involvement in its death or deposition. There are no cut marks, no evidence that the bird was buried, and no clearly associated artifacts. On the other hand, there is neither evidence that the bird met its death by natural predation nor evidence of carnivore scavenging. There seems to be little to choose between a hypothesis of natural death and a hypothesis of human involvement. There is more evidence that the raven in Component 3 may have been deposited by people. First, there is a definite association, both spatial and stratigraphic, between the microblade core and the raven skeleton. Both occurred in a layer of limited extent which must represent a short period of sediment deposition against the parapet. There is no evidence of deliberate burial, but the configuration of the layer suggests that it was formed as sediments infilled a depression running parallel to the back wall of the parapet. Both the microblade core and the bird were deposited in that depression. The location of the microblade core close to the raven's feet also seems deliberate. While we cannot prove an association between the artifact and the bird, it seems unlikely that a complete bird skeleton and a very unusual artifact would become associated by chance.

of human attention in many times and places. We also interesting that Raven is often associated with the ing of the world, because the first human inhabitants of Lake Cave lived in a biotic environment that had ped only shortly before the people arrived at the site st have been changing rapidly. A modern Dene story Blondin (1990) relates how Raven found a cold land s uninhabited by people, but which contained a plen- pply of game. While we would not want to imply that ories contain "memories" of early postglacial times, it esting that ravens may have been of some special ance to the people who first moved into the new lands at the end of the Pleistocene.

CONCLUSIONS

paper has reviewed selected data from Charlie Lake mphasizing cultural chronology and the history of site on. Other studies will be the subject of further publi- . The temporal framework reported here is well sup- by a sequence of radiocarbon dates demonstrating the y of the stratified site. Few artifacts of any sort were t Charlie Lake Cave for any time period. Generally, cally distinctive artifacts are insufficient to allow one e confident statements about the sequence of tempo- agnostic artifacts or comparisons with archaeological ces from neighbouring regions. Following Handly , we have divided the Charlie Lake Cave sequence into Middle, and Late periods. The Early Period (10 500 to .P., Components 1 to 3) contains a basally thinned ile point similar to specimens known mainly from the south and east, and a microblade core which has ffinities to the north. Until larger number of artifacts overed from other dated contexts, we cannot relate this in any detail to cultural chronologies elsewhere. For e, other Paleoindian projectile point styles (e.g., Ag- in, Scottsbluff) are known from surface collections in ce River region, but are not represented at this particu-

lack of occupation at the site from about 9500 to 7000 obably does not indicate a regional abandonment or lation. Middle and Late Prehistoric occupations dif- om earlier uses of the site. The occupations were more , involved a greater range of activities, and resulted in tion of excavated features and denser deposits of bone ics. These have been interpreted as resulting from tial activities in Middle Prehistoric times and more

and the 1991 owners, Rory and Troy Henderson, kindly allo to disturb their property and attract numbers of visitors. In 1 Huhn family was renting the house at the site, and they we helpful in many ways. We are grateful to everyone who hel the excavations, but especially to two people. Dick Gilber only person who has participated in every excavation at the si was responsible for encouraging Fladmark to return to the 1983 and Driver in 1990. His hard work and friendsh appreciated. John Breffitt not only excavated in 1990, but als his expertise to make the site a safe place to work in the next s In Charlie Lake and Fort St. John we were welcomed and hel many people, including Donna Kyllo of the Fort St. John M and many people in the North Peace Historical Society; Finlay of Northern Lights College; Beth Todrick, who fou place to live; the Dixon family, who let us use their well wat everyone at the Charlie Lake store and post office. The first this paper has been improved by the critical comments o reviewers.

REFERENCES

AHLER, S.A. 1989. Mass analysis of flaking debris: Studyi forest rather than the tree. In: Henry, D.O., and Odell, G.H Alternative approaches to lithic analysis: Proceedings University of Tulsa Conference on Lithic Analysis. Oklahoma: University of Tulsa. 85–118.

APLAND, B., and HARINGTON, C.R. 1994. Pleistocene skeleton (*Bison bison* cf. *occidentalis*) from Clayhurst Cr British Columbia. Geographie Physique et Quate 48(2):213–223.

BAUMLER, M.F., and DOWNUM, C.E. 1989. Between mic macro: A study in the interpretation of small-sized debita Amick, D.S., and Maudlin, R.P., eds. Experiments in technology. International Series No. 528. Oxford: Archaeological Reports. 101–116.

BLONDIN, G. 1990. When the world was new. Yellow Outcrop.

BOBROWSKY, P.T., and RUTTER, N. 1992. The Quat geologic history of the Canadian Rocky Mountains. Geog Physique et Quaternaire 46(1):5–50.

BRINK, J., and DAWE, R.J. 1986. An introduction to the prel of the Grand Cache region, northern Alberta Rocky Mou In: Ronaghan, B., ed. Eastern slopes prehistory: Selected Occasional Paper No. 30. Edmonton: Archaeological Su Alberta. 161–246.

BRYAN, A.L., and CONATY, G. 1975. A prehistoric Atha campsite in northwestern Alberta. Western Canadian Jou

LATE PLEISTOCENE COLLARED LEMMING (DICROSTONYX TORQUATUS) FROM NORTHEASTERN BRITISH COLUMBIA

JONATHAN C. DRIVER

We kindly thank the publisher, Society of Vertebrate Paleontology, for permission to reproduce this work.

This short paper provides information on an unexpected and unusual find from the lower layers at the site. After the 1991 excavations were finished we began to work on identifying the animal bones that were recovered. Somewhat to our surprise we found a few specimens of the collared lemming, an animal that today only inhabits the high tundra of the arctic. This wasn't out of line with other species that indicated a cold and/or open unforested landscape during the earliest period of occupation – bison, ground squirrels and hares – but as collared lemming had not been found before in British Columbia it warranted a paper to itself.

The paper describes the specimens, noting that they were somewhat larger than modern lemmings, and then looks at the known distribution of lemmings at the end of the ice age. There are a number of specimens from fossil sites (mainly caves) well outside their modern distribution. This presumably suggests lemming populations were able to colonize cold, open landscapes around the expanding ice sheets, and had enough time to move south as the ice sheets expanded and in turn created new habitat that was suitable for lemmings.

As the climate changed and as forests moved in, lemmings were unable to survive and their populations dwindled and soon became extinct in the Peace River region.

NOTE

LATE PLEISTOCENE COLLARED LEMMING (*DICROSTONYX TORQUATUS*) FROM NORTHEASTERN BRITISH COLUMBIA, CANADA

JONATHAN C. DRIVER, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6

Charlie Lake Cave is a terminal Pleistocene/Holocene archaeological and paleontological site in northeastern British Columbia (Driver, 1988; Fladmark et al., 1988; Driver et al., 1996). Located in the Peace River District to the east of the Rocky Mountains (56°16′35″N, 120°56′15″W), the major feature of the site is a deep gully in front of a cave formed in a low sandstone escarpment. The gully runs parallel to the hillside, and has been filled with sediments moving down the hill since 10,500 B.P., resulting in up to 4.5 m thick deposits. The site is well stratified, and there is a strong correlation of radiocarbon age and depth, suggesting stratigraphic integrity. The site contains vertebrate assemblages deposited by natural agencies and human hunters, and there is also a long sequence of archaeological components at the site. The importance of the site was demonstrated by Fladmark's excavations in 1983 (Fladmark et al., 1988). Further excavations at the site were undertaken in 1990–1991, and remains of collared lemming (*Dicrostonyx torquatus*) were recovered during the second series of excavations. The specimens are described and their significance evaluated.

IDENTIFIED SPECIMENS

Two seasons of excavation (1983 and 1991) sampled the late Pleistocene deposits at Charlie Lake Cave. No *Dicrostonyx* specimens were identified from the 1983 fauna. Only a sample of the 1991 fauna has been studied in detail. This yielded two lower first molars. A subsequent search through unanalyzed material produced a largely complete mandible with a complete tooth row (Fig. 1). A left m1 (SFU HbRf-39 16398) and the right mandible (SFU HbRf-39 16957) were recovered from Layer 105 in stratigraphic subzone IIb, whose dating (discussed below) is the very late Pleistocene. As the isolated left m1 is less worn than the corresponding tooth in the right mandible, two individuals are represented. An isolated right m1 (SFU HbRf-39 15502) was found in the modern humus, but is almost certainly redeposited. Its colour is the same as rodent teeth from the lowest deposits at the site. Assuming that no mixing of samples occurred in the field or laboratory, the most likely explanation for this specimen is that it was excavated during the 1983 season, missed during screening, and incorporated into modern topsoil beside the 1983 excavations. In 1991, the excavation area was enlarged and the specimen was recovered from the humus layer in a new excavation unit. Field notes from 1991 mention that 1983 backdirt was found with the topsoil. This specimen is 0.4 mm longer than the other first molars, and represents a third individual. All specimens from Charlie Lake Cave are stored in the Museum of Archaeology and Ethnology, Simon Fraser University.

IDENTIFICATION

Dicrostonyx is usually identified from paleontological specimens on the basis of the distinctive features of the molars, including: re-entrant angles of equal depth on both lingual and buccal sides of the teeth; seven triangles and anterior and posterior loops on m1; re-entrant folds lacking cement (Banfield, 1974; Anderson, 1985). On the basis of these characters, the three Charlie Lake Cave specimens are identifiable to the genus *Dicrostonyx.*

Distinguishing between the two extant North American species of the genus, collared lemming (*D. torquatus*) and Ungava lemming (*D. hudsonius*), is more difficult, but the presence of an anterior internal loop on m3 identifies *D. torquatus* (Banfield, 1974). The Charlie Lake specimen exhibits this feature, which is most easily seen by counting the re-entrant angles on the lingual side of the tooth. In *D. torquatus* there are three angles (Fig. 1), whereas in *D. hudsonius* there are two.

Identification of the Charlie Lake specimen as *D. torquatus* is consistent with identifications of other paleontological specimens from western North America (Mead and Mead, 1989). It also fits the modern distribution of the two species, in which *D. hudsonius* is confined to the Ungava-Labrador peninsula in the eastern Arctic, while *D. torquatus* is found in tundra on the mainland and islands of North America and Eurasia (Banfield, 1974).

Morlan (1989) has shown that lemming teeth decreased in size from Pleistocene to Holocene times in the Yukon. The three lower first molars from Charlie Lake Cave have occlusal surface lengths of 3.7, 3.8 and 4.2 mm. These are within the range of measurements of 34 specimens from late Wisconsinan *Dicrostonyx* from Bluefish Cave 1, and are longer than any of the 30 modern specimens measured by Morlan. The relatively large size of the Charlie Lake Cave specimens is further evidence for a Pleistocene age.

CHRONOLOGY

After the formation of the deep gully at the site, glaciolacustrine sediments were washed down the hillside and into the gully. This process began shortly before 10,500 B.P. The sediments from the first period of this activity are collectively referred to as Zone II, which is divided into four subzones (IIa through IId) (Driver et al., 1996). Layer 105, from which the *Dicrostonyx* mandible and one molar were recovered, is the major layer in subzone IIb. Radiocarbon dates from this layer are 10,290 ± 100 B.P. (CAMS 2317) on a raven (*Corvus corax*) scapula, and 10,560 ± 80 B.P. (CAMS 2134) on a bison (*Bison* sp.) phalanx. Other radiocarbon dates from subzone IIb range from 10,770 ± 120 B.P. (SFU 454) to 10,380 ± 160 B.P. (SFU 378). Dates from subzone IIc are consistently later than IIb, which suggests good stratigraphic integrity at the site. Therefore, the lemming mandible is associated firmly with other faunal specimens from Zone IIb dated between 10,770 and 10,290 B.P. (Note that the definition and numbering of stratigraphic zones has been revised since earlier publications on the site. Consult Driver et al. [1996] for concordance with earlier reports).

ASSOCIATED FAUNA

Charlie Lake Cave faunas span the end of the late Pleistocene to the historic period (Driver, 1988; Driver and Hobson, 1992). Subzones IIa and IIb contain fewer taxa when compared with later periods, but this is probably due to the small number of specimens recovered. In addition to the lemming, the following taxa have been identified from IIa and IIb: duck (Anatinae), woodpecker (Picidae), raven (*Corvus corax*), cliff swallow (*Hirundo pyrrhonota*), a large hare (*Lepus* sp.), snowshoe hare (*L. americanus*), deer mouse (*Peromyscus* sp.), a marmot or woodchuck (*Marmota* sp.), ground squirrel (*Spermophilus* sp.), a wolf-sized canid (*Canis* sp.), and bison (*Bison* sp.). Relatively few identifications can be made to species. The large hare is much larger than snowshoe hare, and comparable to both arctic hare and jackrabbit. Ground squirrels could not be identified to species, but arctic ground squirrel (*S. parryii*) is not present. The canid is very similar to wolf (*C. lupus*), but human involvement at the site (Fladmark et al., 1988) means that domestic dog might have been present, and therefore the genus identification is preferred.

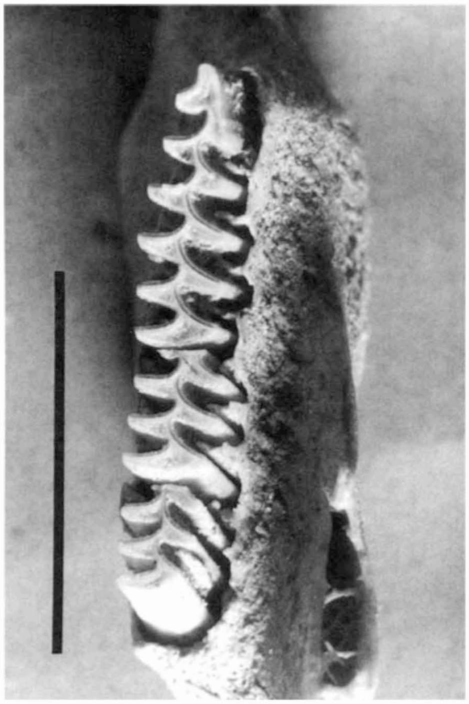


FIGURE 1. Right mandible, *Dicrostonyx torquatus,* Excavation Unit 29, Layer 105, Charlie Lake Cave (SFU HbRf-39 16957). Scale bar equals 5 mm.

DISCUSSION

Lemmings are relatively rare in late Wisconsinan faunas. A recent review notes only 24 North American Pleistocene sites containing lemmings, of which 17 contain *D. torquatus* (Mead and Mead, 1989). Specimens in association with radiocarbon dated faunas come from seven sites. Other sites are either dated by other means, or there is not a good association between the fossil lemmings and dated materials. Three sites (Eagle and January Caves, Alberta, and Old Crow, Yukon) are mid-Wisconsinan, with ages ranging from about 33,000 to 23,000 B.P. Two sites (Elkader, Iowa, and Moscow Fissure, Wisconsin) date between 17,000 and 20,000 B.P., and demonstrate that *D. torquatus* was able to expand east along the southern margin of the Laurentide ice sheet at the height of the last glaciation. Specimens dating to the last few millennia of the last glaciation have been found at sites in the west (Bell Cave, Wyoming, and Bluefish Caves, Yukon) with dates around 12,000 B.P. The stratigraphic position of collared lemming in relation to radiocarbon dates suggests a similar late Wisconsinan age for some other western sites (Bush Shelter, Little Box Elder Cave, and Little Canyon Creek Cave, all from Wyoming). The distribution of collared lemming south of the ice sheets suggests that maximum summer temperatures were lower than today (Graham, 1992).

The Charlie Lake Cave specimens are firmly dated to about 10,500 B.P. (average of six dates from subzones IIa and IIb), and are currently the youngest securely dated specimens outside of the modern range (Fig. 2). Charlie Lake Cave is roughly equidistant from Bell Cave to the south and Bluefish Cave to the north, both of which contain lemmings dated at about 12,000 B.P. Three hypotheses might explain the late presence at Charlie Lake Cave. First, there may have been a local population that survived in the area from mid-Wisconsinan through to the late Wisconsinan. Second, lemmings may have moved south from refugia in Yukon towards the end of the Pleistocene. Third, lemmings may have moved north from the central Rockies as biotic communities were re-established in Alberta and British Columbia at the end of the last glaciation. Of these hypotheses, the third is best supported by available data. There is no securely dated palynological or vertebrate fossil evidence for the existence of biotic communities in northeastern British Columbia and northwestern Alberta during the height of the last glaciation, so persistence of lemming through the glacial maximum is unlikely, although not impossible. Burns (1996) has presented a convincing case that most of western Alberta was uninhabitable during the height of the last glaciation, and that after deglaciation an open environment was established from about 11,600 to 10,300 B.P. This was created by pioneer species moving north from unglaciated regions to the south. Using palynological data, MacDonald and McLeod (1996) suggest a herb-shrub vegetation from about 12,000 to 10,000 B.P. from southern Alberta to Yukon, with spruce forests moving from the south into the Peace River region at about 10,000 B.P. Wilson (1996) has also suggested that fauna moved from south of the ice sheets into western Alberta and northeast British Columbia, basing his argument on the persistence of the southern species *Bison antiquus* until about 10,000 B.P. Apland and Harington (1994) suggest that *Bison occidentalis* moved south from unglaciated regions into the Peace River some time before before 10,500 B.P., supporting the hypothesis that the region was recolonized at the end of the Pleistocene, but raising the possibility that northern species were also involved. One of the oldest artifacts from Charlie Lake Cave also suggests initial migration of human populations from the south (Fladmark et al., 1988; Driver et al., 1996).

Lack of specific identification of many of the vertebrates associated with the Charlie Lake lemmings precludes a detailed comparison of species associations. The overall assemblage from pre-10,000 B.P. deposits has been interpreted as deriving from a relatively open landscape (Driver, 1988). Collared lemmings of definite or probable terminal Pleistocene age from sites to the south have been associated with southern species of ground squirrels, *Marmota,* snowshoe hare, and bison, as well as many other taxa that are not present at Charlie Lake Cave (Mead and Mead, 1989). Lemmings probably moved north in conjunction with other southern species that were adapted to open landscapes, and that found the pioneering associations of herbs and grasses an attractive habitat.

CONCLUSIONS

Collared lemming (*Dicrostonyx torquatus*) was present in northeastern British Columbia at 10,500 B.P. This is currently the latest known fossil record of this species outside its modern range. This species was a component of glacial faunas south of the Laurentide ice sheet from about 20,000 to at least 12,000 B.P. During deglaciation of western Alberta and northeastern British Columbia, southern flora and fauna moved north, creating a short-lived open environment along the east side of the Rockies. Collared lemming survived in this environment no

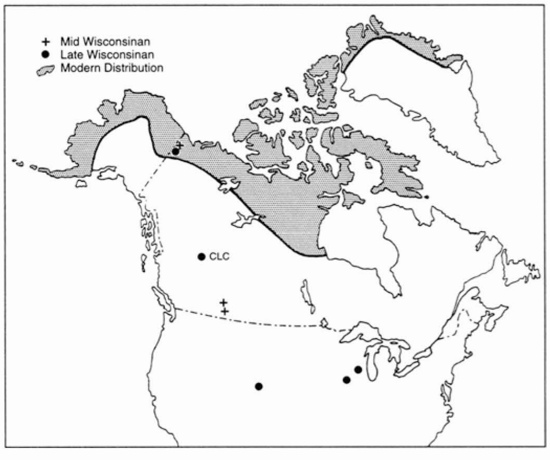


FIGURE 2. Modern distribution of *Dicrostonyx torquatus* and radiocarbon dated fossil specimens, including Charlie Lake Cave (CLC).

later than 10,000 B.P., when the appearance of spruce forests signalled the arrival of essentially modern vertebrate communities.

Acknowledgments—I am grateful to Randall Preston who identified the first lemming teeth from the site. Comments by two reviewers, C. R. Harington and R. E. Morlan, improved the paper. The research was funded by the Social Sciences and Humanities Research Council of Canada.

LITERATURE CITED

Anderson, S. 1985. Taxonomy and systematics; pp. 52–83 *in* R. H. Tamarin (ed.), Biology of New World *Microtus.* The American Society of Mammalogists Special Publication No. 8.

Apland, B., and C. R. Harington 1994. Pleistocene bison skeleton (*Bison bison* cf. *occidentalis*) from Clayhurst Crossing, British Columbia. Géographie Physique et Quaternaire 48:213–223.

Banfield, A. W. F. 1974. The Mammals of Canada. University of Toronto Press, Toronto.

Burns, J. A. 1996. Vertebrate paleontology and the alleged ice-free corridor: the meat of the matter. Quaternary International 32:107–112.

Driver, J. C. 1988. Late Pleistocene and Holocene vertebrates and palaeoenvironments from Charlie Lake Cave, northeast British Columbia. Canadian Journal of Earth Sciences 25:1545–1553.

———, and K. A. Hobson. 1992. A 10 500-year sequence of bird remains from the southern boreal forest region of western Canada. Arctic 45:105–110.

———, M. Handly, K. R. Fladmark, D. E. Nelson, G. M. Sullivan, and R. Preston. 1996. Stratigraphy, radiocarbon dating, and culture history of Charlie Lake Cave, British Columbia. Arctic 49:265–277.

Fladmark, K. R., J. C. Driver, and D. Alexander. 1988. The Paleoindian component at Charlie Lake Cave (HbRf-39), British Columbia. American Antiquity 53:371–384.

Graham, R. W. 1992. Late Pleistocene faunal changes as a guide to understanding effects of greenhouse warming on the mammalian fauna of North America; pp. 76–87 *in* R. L. Peters and T. E. Lovejoy (eds.), Global Warming and Biological Diversity. Yale University Press, New Haven.

MacDonald, G. M., and T. K. McLeod. 1996. The Holocene closing of the 'ice-free' corridor: a biogeographical perspective. Quaternary International 32:87–95.

Mead, E. M., and J. I. Mead. 1989. Quaternary zoogeography of the Nearctic *Dicrostonyx* lemmings. *Boreas* 18:323–332.

Morlan, R. E. 1989. Paleoecological implications of Late Pleistocene and Holocene microtine rodents from the Bluefish Caves, northern Yukon Territory. Canadian Journal of Earth Sciences 26:149–156.

Wilson, M. C. 1996. Late Quaternary vertebrates and the opening of the ice-free corridor, with special reference to the genus *Bison.* Quaternary International 32:97–105.

Received 5 January 1998; accepted 15 June 1998.

RAVEN SKELETONS FROM PALEOINDIAN CONTEXTS, CHARLIE LAKE CAVE, BRITISH COLUMBIA

JONATHAN C. DRIVER

We kindly thank the publisher, Society for American Archaeology, for permission to reproduce this work.

This paper emerged from a series of personal experiences I had while working at Tse'K'wa. Fairly late in the 1991 season I was excavating a layer dating to about 9000 BC that didn't appear to contain any humanly-made artifacts but, like many layers at the site, had a few animal bones scattered through it. As I was digging I uncovered two bird bones lying in an "articulated" position – in other words, they were in the same relationship to each other as they would be when the bird was alive. Leaving them in place, I began to dig carefully around them, and soon realized I was uncovering a complete bird skeleton. As I uncovered each bone I drew it onto a plan, numbered it and removed it, so by the end of the work I mapped an almost complete bird skeleton, with each bone numbered and bagged separately. The final part of the excavation was very delicate, as I uncovered and mapped the individual toe bones. In among the toe bones was a small rock, and as I removed it I realized that it was a rather unusual stone artifact known as a "microblade core". Made of very fine-grained stone, ancient people had carried it around so they could remove small, parallel sided flakes of stone, which could then be hafted in a variety of handles – rather like blades of utility knives that we use today. This technology is so distinctive that archaeologists make special note when it appears. The bird skeleton was lying in a small hollow, either natural or humanly made, so it appeared that someone had placed the dead bird in the hollow, with an artifact at its feet, and then covered it up so that it would not be disturbed.

As we excavated even deeper levels we uncovered a second bird skeleton, scattered across about a square metre. Although it was older by at least 1000 years, it was even better preserved. We also mapped the bones of this skeleton as they emerged, and confirmed that we had a second bird that seemed to have been buried as a complete individual.

During excavation seasons one is always concerned about getting as much done in the days available, so I didn't spend much time trying to identify these birds. I assumed that once I was able to study the bones they would turn out to be some kind of waterfowl because remains of ducks and grebes are quite common at Tse'K'wa. Once I got back to the university at the end of the summer one of the first things I did was to check on the identification, and I quickly realized we had uncovered two raven skeletons.

For anyone living in British Columbia the connection between ravens and First Nations people is well known. Bill Reid's massive cedar sculpture at the UBC Museum of Anthropology of Raven opening a clam shell is visited by tens of thousands of people every year, and his Jade Canoe, steered by Raven, is seen by millions at the Vancouver airport. Elementary school children all read stories about Raven the trickster.

This connection to BC's First Nations would be reason enough to get excited, but I had a personal connection to ravens and Tse'K'wa that caused shivers to run up my spine as I made the identification of the bird skeletons in the bone lab. When we had finished our excavations in 1991 I spent a morning at the site by myself, mainly down in the bottom of the deep excavation finalizing some of the drawings, checking measurements and just thinking about the site before we started backfilling on the following day. It had been very quiet in the excavation hole, too deep to hear traffic noise from the Alaska Highway, no comments from an excavation crew, no scraping of trowels on rock, and no rattling as sediments were shaken through the screens. My companions throughout that morning were a pair of ravens who hung around the site, talking to each other and, as I liked to think, talking to me as well. My experience with the ravens that morning filled my thoughts as soon as I had confirmed the identification of the bones.

I knew that there was a story to tell about the buried ravens, but it took me a while to sort it out, and quite a long time to get it accepted for publication. Like most scholars, archaeologists are most comfortable with the familiar. No one had found any evidence in North America for ritual behaviour this early, other than very rare human burials, and reviewers were reluctant to accept the interpretation that these two ravens were placed deliberately by people. I found this somewhat frustrating because the other region in which I work – the American Southwest – has thousands of examples dating from more recent times of "special" birds (mainly eagles, hawks, owls and parrots) found as complete skeletons. Often times these remains are in association with buildings identified as places of ceremonial or ritual activity for ancestral Native Americans. Tse'K'wa clearly would have a been a special place on the landscape, and both caves and ravens have all kinds of spiritual importance around the world. Why was it so difficult for other scholars to accept that the combination of complete skeletons, a special place, and culturally significant birds suggest that Tse'K'wa was a sacred location to the First Nations people who visited the site many years ago?

Eventually I was able to convince the editor of American Antiquity – arguably the best archaeology journal in North America – that there would never be agreement amongst reviewers. Some thought my manuscript was too speculative, and others thought it was worth publishing.

The published paper describes the location, configuration and age of the skeletons. It briefly describes the importance of ravens in cultures around the world. They are often seen as messengers, and are frequently connected to hunting. In some parts of North America Raven is both creator and trickster who has many human qualities.

I also noted that Tse'K'wa was likely a prominent feature of the landscape, not only because of the cave, but also because there was a very large vertical stone monolith in front of the cave that would have been much more visible than today. Caves are often entrances to the underworld, and the placing of spiritually important birds right in front of the cave mouth may suggest that they were seen as capable of communicating between the world of the living and the world of the spirits.

RAVEN SKELETONS FROM PALEOINDIAN CONTEXTS, CHARLIE LAKE CAVE, BRITISH COLUMBIA

Jonathan C. Driver

Two raven skeletons were excavated from Charlie Lake Cave, British Columbia, in association with Paleoindian occupations dated at about 10,500 and 9500 B.P. The distribution and condition of the bones, the association with artifacts, the configuration and location of the site, and data from ethnographic and historic sources contribute to the argument that the two ravens were deposited deliberately by people.

Dos esqueletos de cuervo (Corvus corax) se excavaron en Charlie Lake Cave, Columbia Británica, en asociación con ocupaciones paleoindias fechadas alrededor de 10.500 y 9.500 a.P. La distribución y condición de los huesos, la asociación con artefactos, la configuración y ubicación de sitio, y los datos de fuentes etnográficas e históricas contribuyen al argumento que los dos cuervos fueron de positados intencionalmente por seres humanos.

Ravens (*Corvus corax*) are significant mythological beings in many parts of Eurasia and North America. In 1991, two largely complete adult raven skeletons were excavated from Paleoindian components at Charlie Lake Cave in the Peace River District of northeastern British Columbia, Canada. The two specimens deserve reporting and discussion because they may provide data on Paleoindian ideology, a topic which has been ignored through lack of evidence. Attempts to interpret the significance of the two skeletons also exemplify the problems of using ethnographic data in archaeology and highlight the difficulty of demonstrating human intentionality in the deposition of unmodified objects.

Charlie Lake Cave

The location, formation, stratigraphy and cultural sequence at Charlie Lake Cave have been reported in detail elsewhere (Driver et al. 1996; Fladmark et al. 1988). In brief, the site is situated on a hillside above a creek which drains Charlie Lake (Figure 1). Part way down the hill, sandstone bedrock forms a low cliff in which there is a cave. A large boulder (referred to as the "parapet") stands vertically in front of the cave, with its longest axis parallel to the cliff. This creates a gully, roughly 12 m long and up to 7 m deep running across the hillside. The south side of the gully is formed by the north face of the "parapet" and the north side of the gully is formed by the bedrock cliff, with the cave a few meters above the base of the gully. At 10,500 B.P., the floor of the gully was steep, and was littered with boulders. Figure 2 provides a cross-section of the "parapet," gully, cave, and cliff. (The depth of the gully increases to the west, so this does not show the deepest part of the gully). Since about 10,500 B.P. sediments have been filling the gully, and these preserve a stratified sequence containing bones and lithics.

Although the site is located in the region of the hypothetical "ice-free corridor," it is unlikely that the corridor was capable of supporting life in late glacial times (Burns 1996; Driver 1998), and the site is too late to have anything to do with the initial peopling of the Americas. Component 1 (c. 10,500 B.P.) and Component 2 (c. 9850 B.P.), both contain flaked stone artifacts, relatively little debitage, and butchered bison bone. A fluted point tradition projectile point was recovered from Component 1. Component 3 (c. 9500 B.P.) includes a concentration of

---

Jonathan C. Driver ■ Department of Archaeology, Simon Fraser University, Burnaby BC V5A 1S6 Canada

American Antiquity, 64(2), 1999, pp. 289–298

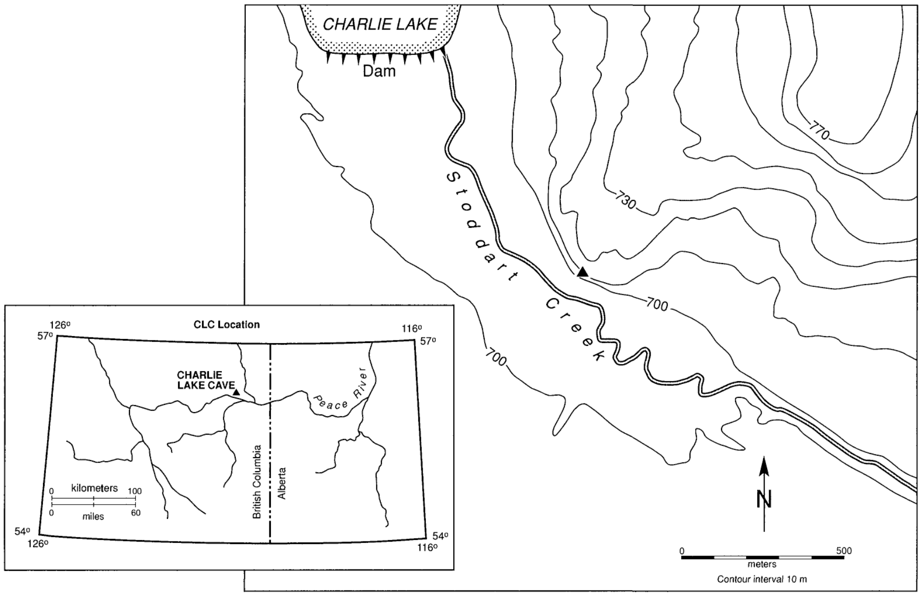


Figure 1. Location of Charlie Lake Cave (triangle) in relation to modern topography.

biface resharpening flakes and a microblade core. Raven skeletons were associated with Components 1 and 3.

The Importance of Ravens

Ravens are the largest of the passerine birds, found from arctic to temperate environments in Eurasia and North America. They are omnivorous, but appear to rely on scavenging carrion over much of their range. Ravens form permanent monogamous pairs, construct large nests, and drive their offspring out of their territory. Ravens are very vocal and may imitate calls of other animals (Angell 1978; Bent 1946; Heinrich 1989; Savage 1987; Wilmore 1979).Certain prominent raven behaviors are probably responsible for similar beliefs about them in Europe, Asia, and North America (see Table 1). Excluded from Table 1 is the well-known mythological role of Raven

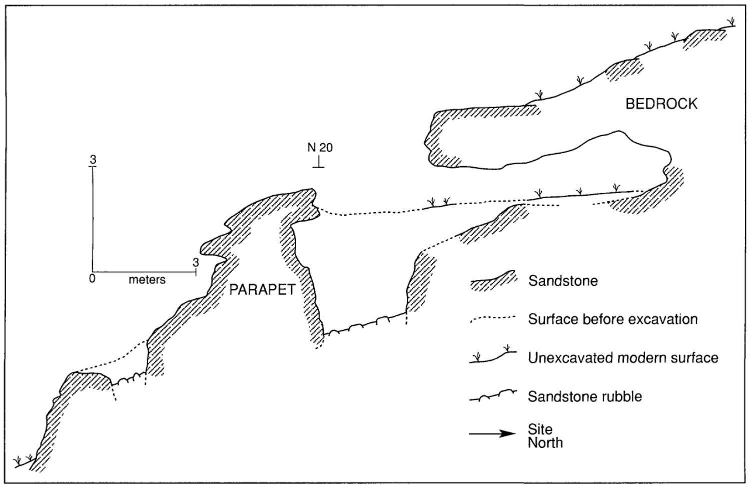


Figure 2. Cross-section of Charlie Lake Cave along the E25 grid line.

Table 1. Beliefs about ravens.

General and specific actions by ravens	Society	Reference
1. Ravens Find Animals		
a. Locate game animals for human hunters	Blackfoot	Grinnell 1962a
	Cheyenne	Grinnell 1962b
	Koyukon	Nelson 1973
	Dene	Blondin 1990
	Apache	Buskirk 1986
b. Invoked in song to call bison	Blackfoot	Wissler 1912
c. Drive caribou to hunters	Dene	de Laguna 1995
d. Help Elk find straying wife	Blackfoot	Wissler 1912
2. Ravens Scavenge		
a. Steal bait from traps	Nunamiut	Gubser 1965
	Koyukon	Nelson 1973
b. Scavenges Coyote's bison kill	Mandan	Beckwith 1937
c. Scavenge dead bison	Blackfoot	Wissler 1912
d. Hunters attract bears by imitating noises made by ravens while scavenging	Koyukon	Nelson 1973
e. Scavenge human dead on battlefields	Medieval Europe	Armstrong 1958, Rowland 1978
f. Hunters leave part of their kill for ravens	Dene	de Laguna 1995
	Medieval Europe	Cartmill 1993
3. Ravens Communicate with People		
a. Human placenta fed to ravens allows child to understand them	Kwakiutl	Goodchild 1991
b. Predict disasters and epidemics	Dene	Blondin 1990
c. Warn of storms at seas	Various, Alaska	Rooth 1971
d. Men wear raven skins to warn of enemies	Blackfoot	Grinnell 1962a
	Cheyenne	Grinnell 1962b
	Sioux	Brown 1992
e. Calls over camp tell of approaching people	Blackfoot	Grinnell 1962a
f. Tells man where son is hidden	Mandan	Beckwith 1937
g. Carried on ships, to be released and guide ship to shore	Europe	Armstrong 1958
h. Brings message during vision quest	Blackfoot	Wissler 1912
i. The sun's messenger in cult of Mithras	Roman	Armstrong 1958
j. Gather news for Odin	Norse	Armstrong 1958

as creator and trickster in northwestern North America and Siberia, because those accounts conceptualize Raven as a primordial figure whose identity (human versus avian) is ambiguous (Goodchild 1991).

In Table 1, beliefs about ravens have been arranged in three categories. Ravens' abilities to lead hunters to game are probably the result of misinterpretation of their associations with predators (including humans). Heinrich (1989) believes that ravens associate with large predators and humans to take advantage of scavenging opportunities. Mech (1970) states that ravens follow wolf packs and wait for them to make a kill; he also describes ravens flying ahead of wolves, waiting for them to catch up and then flying ahead again. This is very similar to ethnographic descriptions of ravens "leading" hunters to game.

Ravens scavenge the carcasses of large animals. Heinrich (1989) has described how unmated ravens recruit others to carcasses, to prevent territorial pairs from monopolizing the meat. Mech (1970) notes that ravens feed on kills immediately after wolves have finished, and that they congegate while a hunt is in progress. Scavenging ravens are symbolic of other events; in a Blackfoot song, the scavenging raven is a symbol of a successful hunt, while in medieval Europe the raven was associated with battles.

Ravens' frequent and varied calls have probably resulted in the widespread belief that they communicate with people, usually to bring news or foretell events.

North American archaeological data show that ravens were culturally significant in the past, especially in the northern Plains and their eastern margin, where the birds were commonly associated with bison (Mead 1986 : 73). Parmalee (1977) reports that ravens form up to 10 percent of bird bones from villages in South Dakota spanning the last 1,000 years, and

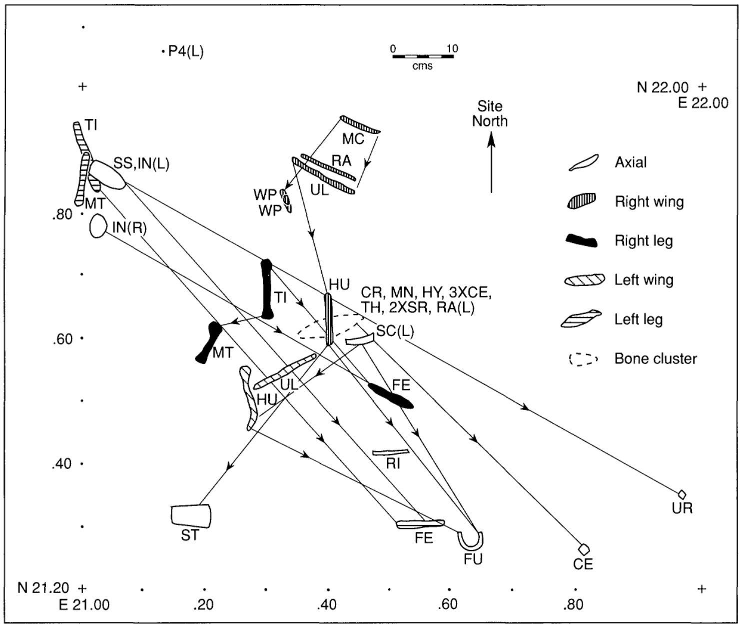


Figure 3. Skeleton of Raven I (based on field drawings). See Table 2 for key to abbreviations.

ravens occurred in about half the assemblages studied. Ubelaker and Wedel (1975) have shown that raven skins were included as grave goods in the same region. Late prehistoric or protohistoric burials with ravens are also known from Nebraska, Iowa and Wisconsin (Bray 1961; O'Shea et al. 1982; Wittry 1962). In recent times the Raven-Bearer society was present in Dakota, Hidatsa, and Blackfoot cultures (Lowie 1913), and raven skins were worn as emblems (Wissler 1913: Fig. 13). In all of the cases discussed above raven bones were associated with ritual items, but in no case was a complete raven skeleton present.

Raven I: Context and Taphonomy

Raven I was recovered as a dispersed skeleton from layer 105, one of a number of layers consisting mainly of glaciolacustrine sediments redeposited from their original position on the hillside above the site (Figure 3). Up to 1.5 m of sediments of this type accumulated along the deeper south side of the gully between about 10,500 and 9,500 B.P., with an accumulation of about one meter in the center of the gully where Raven I was found. Many slabs of local sandstone are present in these layers. The layers dip steeply south; this is illustrated by the fact that the northernmost specimen in Figure 3 is 60 cm vertically higher than the most southerly specimens.

Table 2. Minimum number of elements.

Element	Raven I	Raven II	Expected
Cranium (CR)	1	1	1
Mandible (MN)	1		1
Hyoid complex (HY)	1		1
Cervical (CE)	5	6	11
Thoracic (TH)	3	1	8
Synsacrum (SS)	1		1
Caudal (UR)	1		8
Furculum (FU)	1	1	1
Scapula (SC)	2	2	2
Coracoid (CO)		2	2
Sternum (ST)	1	1	1
Rib (RI)	1		18
Sternal rib (SR)	3		8
Innominate (IN)	2		2
Humerus (HU)	2	2	2
Ulna (UL)	2	2	2
Radius (RA)	2	2	2
Carpal		2	4
Carpometacarpus (MC)	2	2	2
Wing phalanx (WP)	2	3	8
Femur (FE)	2	2	2
Patella		1	2
Tibiotarsus (TI)	2	2	2
Fibula	1		2
Tarsometatarsus (MT)	2	2	2
Metatarsus I		2	2
Foot phalanges (P)	5	27	28

Note: Abbreviations in parentheses describe specimens in Figures 3 and 5.

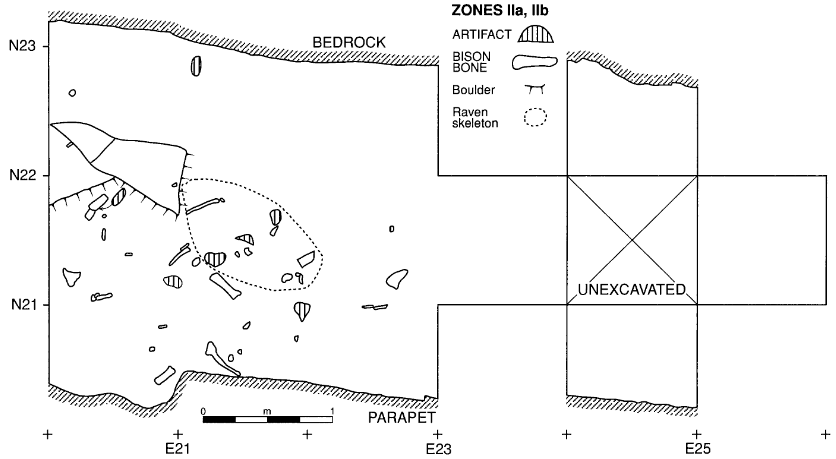


Figure 4. Location of Raven I in Component 1.

Table 2 presents data on the minimum number of elements (MNE) represented, including those recovered from the screens. In addition to the specimens positively identified as raven were some rib fragments and tracheal rings which are almost certainly from this specimen, but lacked sufficient diagnostic characteristics to be indentified positively. On Figure 3 (which shows only the position of elements recovered in situ) lines link skeletal elements which would articulate in a living bird. The direction of the arrow indicates hypothetical movement of specimens, assuming a downslope direction of movement. Specimens have tended to move from northwest to southeast, with some subsidiary movement in a northeast-southwest direction.

Raven I was probably deposited as a complete specimen. The presence of hyoid bones and tracheal rings shows that soft tissue was still in place, as do some articulations, such as the distal part of the right wing. It is likely that the bird was originally located either in the northwest corner of excavation unit 26 (where the left tibia and tarsometatarsus were found) or further to the northwest (upslope), possibly on or behind a large boulder shown in Figure 4. The bird was probably lying on its back with the head facing downhill (southeast). Evidence for this is the downslope location of cranium, mandible, vertebrae and pectoral girdle in relation to the upslope location of one hind leg, the synsacrum and the innominates. Because the right wing is upslope of the pectoral girdle and the left wing is downslope, this suggests a supine position. The sternum and furculum have moved a considerable distance from the trunk, and the coracoids have disappeared; these bones would be uppermost if the bird lay on its back, and would therefore be most susceptible to decay and disarticulation. Analysis of the stratigraphy shows that the bones which have moved the furthest were probably transported into a void underneath a pile of boulders on the steeply sloping gully floor. It seems likely that after the carcass was deposited there was a period of time which allowed some of the soft tissue to decompose; this was then followed by transportation of some bones downslope.

The virtual absence of foot phalanges may be related to preservation conditions. Bone is poorly preserved north of the N22 line because of groundwater percolation on the north side of the gully. If the bird was originally oriented as suggested above, then the feet would have been in an area of the site where preservation was poorer. The other missing elements are ribs and vertebrae. Although examples of these are preserved, numerous cervical vertebrae and ribs are missing. In the absence of any evidence for scavenging, it seems likely that weathering or diagenetic processes either destroyed these bones or rendered them so fragile that they did not survive the excavation and screening of the compacted sediments of layer 105.

A complicating factor not illustrated in Figure 3 is the presence of numerous sandstone slabs in the sediments which prevented downslope movement of some specimens. For example, the bone concentration in the center of the unit was behind a piece of sandstone, as were the lower left leg and pelvic girdle in the northwest.

There are a number of other hypotheses which might explain the distribution of the skeletal elements. Humans or animals may have disarticulated a bird carcass and scattered it across the unit. The lack of cut marks and carnivore tooth marks suggests that neither humans nor mammalian carnivores were involved in disarticulation. Ravens are sometimes killed by birds of prey which might disarticulate a carcass and leave portions lying in anatomical position. For example, Savage (1987:105) illustrates a raven killed by a goshawk, stripped of skin and muscle, and left as scattered portions of still articulated bones. However, it seems unlikely that such an event would leave the remains of the skeleton in such a logical anatomical order (e.g. left wing and right wing in their correct position in relation to the cranium and pelvic girdle). I therefore conclude that a relatively intact raven carcass was deposited at the site, and that downslope movement (when not prevented by rocks) dispersed once-articulated elements. Allowing for differences in the size of the birds, the distribution of Raven I is comparable to the distribution of rock dove skeletons which were allowed to disarticulate while protected from scavengers (Bickart 1984). In Bickart's experiment, gentle flooding moved bones within a protective cage.

To place Raven I in a wider context, Figure 4 shows the position of the skeleton in relation to artifacts and bison bones recovered from Component 1. Although only a small area of the site has been excavated, the raven is clearly associated with a locale containing relatively high frequencies of bison bones and artifacts, in contrast to the more eastern part of the excavated area which produced microfauna but no lithic artifacts or large mammal bones. Artifacts have been described in detail elsewhere, and include formed tools of chert and quartzite, and a small amount of debitage (Driver et al., 1996; Handly 1994).

In layer 105 of unit 26 the most common vertebrate taxon (other than the raven) is bison, with 12 fragments identified. Other associated taxa include large artiodactyl (probably also bison) (2), a canid (1), ground squirrel (1), squirrel family (1), microtine rodent (2), collared lemming (1), swallow (1), unidentified passerine bird (5), and unidentified (39). The semi-articulated, largely complete raven skeleton contrasts with the fragmentary and disarticulated condition of other taxa.

The preservation of individual elements of Raven I is remarkably good. This is illustrated not only by the presence of a wide range of elements (including such fragile specimens as tracheal rings) but also by the condition of the bone surface. All specimens appear fresh and unweathered, muscle attachments are very well defined, and there is no evidence of longitudinal cracking, which often characterizes the first weathering stages of bones (Lyman 1994).

Radiocarbon dating of the left scapula yielded an age of 10290 ± 100 B.P. (CAMS 2317; bone collagen; $\partial^{13}C = -18.7$). This finding is consistent with radiocarbon dates from this stratigraphic zone (Driver et al. 1996).

Raven II: Context and Taphonomy

Raven II was recovered from layer 92 in excavation unit 27, approximately 1.3 m south of Raven I. Following the deposition of Raven I in layer 105 there was continued redeposition of glaciolacustrine sediments into the gully. Dates from this period range from 10,100 to 9670 B.P. (Driver et al. 1996). At about 9500 B.P. the earliest visible soil horizon at the site developed on the surface of these redeposited sediments, and probably marks a period when rates of sediment deposition had slowed. Raven II was found in a small depression lying against the north face of the "parapet." The depression, about 20 cm wide, ran along the face of the "parapet" for about 2 meters, and was filled with a 15 cm thick lens of light, inorganic sandy silt which interrupts dark, more organic deposits below and above it. The depression is probably natural. Similar depressions can be observed at the base of vertical rockfaces in the area today. The inorganic fill of this depression seems to represent a period of rapid weathering of the north face of the "parapet."

The skeleton of Raven II lay parallel to the "parapet,"with its feet to the east. As can be seen from Figure 5, numerous articulations are preserved. The superimposition of the limbs (right wing over right leg over left leg over left wing) shows that the bird lay on its left side with its back to the "parapet."A microblade core was found in association with the phalanges and has been discussed elsewhere (Driver et al. 1996; Handly 1994).

There was little postdepositional movement of this specimen, but some skeletal elements are missing (Table 2). The cranium is represented by the occipital region, but little else survived and the

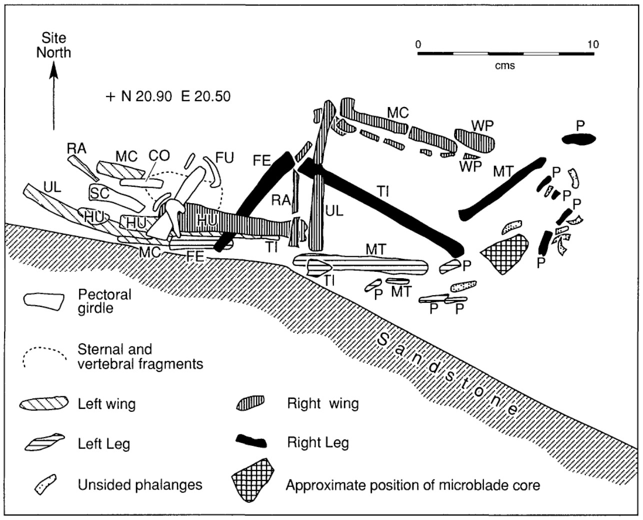


Figure 5. Skeleton of Raven II (based on field drawings). See Table 2 for key to abbreviations.

mandible is absent. The vertebral column, pelvis and ribcage are poorly represented, but the sternum and pectoral girdle are complete. Fore and hind limbs are virtually complete. The overall pattern of element preservation is similar to Raven I, but Raven II has better preservation of the digits. The preservation of individual elements in Raven II was not as good as Raven I. Many specimens were broken after deposition, with pieces lying in the correct relative position (for example, the right carpometacarpus in Figure 5 consists of eight fragments). This is probably the result of weakening of the bone as a result of mineral and collagen loss, followed by snapping of skeletal elements by sediment pressure. Bone surfaces were more weathered than Raven I, and lacked the "fresh" appearance of the earlier skeleton. Some specimens exhibit what appear to be narrow dissolution canals on the bone surface, possibly caused by roots or insects.

Raven II is associated with Component 3. In addition to the microblade core associated with the skeleton, Component 3 included a localized patch of biface retouch flakes where at least two bifaces were resharpened, and a piece of ochre in an adjacent excavation unit. Little other fauna was found in layer 92. The stratigraphic zone which includes this layer produced a diverse fauna typical of the southern boreal forest; no other articulated skeletons were found.

A radiocarbon date on the right scapula yielded a value of 9490 ± 140 B.P. (CAMS 2318; bone collagen; $\partial^{13}C = -19.4$), the only date from this component.

Origin of the Ravens

Both ravens were probably complete when deposited. Both might represent natural deaths. Alternatively, one or both of the birds may have been placed at the site by people. In view of the considerable importance of ravens in the ideology of Native Americans and First Nations in the United States and Canada, it is important to consider if people were involved.

The following data support the hypothesis of human involvement. Both ravens are associated with other items deposited by people. Raven I is associated with artifacts and butchered bison bone. A microblade core was found at the feet of Raven II.

Another possible reason for suspecting human involvement in the deposition of the ravens is the lack of scavenging. No scavenging damage can be detected on the bones, except for possible insect damage to Raven II, which might indicate special treatment of the birds and would explain why only ravens were found as complete skeletons. Such treatment could include deliberate burial in a natural depression in the case of Raven II and covering by rocks for Raven I. Experimental work suggests that unprotected bird carcasses will be removed very quickly from terrestrial environments by scavengers (Bickart 1984).

It is unlikely that Raven I was killed by a predator because the scattered bones retain anatomical relationships. It is very unlikely that Raven II died in that way because there is no evidence for scattering of its bones. The only plausible hypothesis which can compete with human placement of the carcasses is that one or both of the ravens died naturally at the site and became incorporated into sediments prior to scavenging. Ravens frequently nest on high cliffs, especially if tall trees are unavailable (Bent 1946). Although the Charlie Lake area may have been treeless 10,000 years ago (Driver 1988), the cliffs at Charlie Lake Cave would have been only a few meters high, and much higher cliffs (today with nesting ravens) can be found a few kilometers away on the shores of Charlie Lake. On the other hand, caves are uncommon in the region, and it is possible that the cave was sufficiently attractive to ravens to induce them to nest or shelter there. Ravens are known from late Pleistocene cave deposits; of 14 sites containing late Pleistocene ravens listed by Lundelius et al. (1983), 9 are cave sites.

Some other species were deposited as partially articulated skeletons during the first one thousand years of the site's history. Some of the bison bones were deposited by people as articulated portions of limbs. The articulated foot digits of a short-eared owl (*Asio flammeus*) were recovered from Component 2. Although not observed as articulated specimens in situ, some ground squirrel (*Spermophilus*) limbs were probably deposited as articulated units, based on specimens found in the screens. However, there is no evidence that any specimens, apart from ravens, were deposited as complete articulated skeletons.

Although it is relatively unlikely that two ravens would die at the site and become incorporated into sediments with no evidence of scavenging, it is not possible to exclude a natural origin for the two birds. In the following section I propose more circumstantial evidence to support the hypothesis of human origin.

Charlie Lake Cave as a Significant Location

Hunter-gatherers often imbue their landscape with cultural meaning. Probably the best-known examples of this are from Australia (Berndt 1976; Myers 1986), but ethnographies from many parts of the world demonstrate that significance was attached to certain features of the landscape. From North America there are examples of hunters leaving offerings at prominent rocks, including Blackfoot (Grinnell 1962a; Wissler 1912), Crow (Wildschut 1960) and Inuit (Birket-Smith 1959). Notable landscape features were named and integrated into culture histories by many North American hunter-gatherers, including Katzie (Jenness 1955), Sto:lo (Mohs 1987), Navajo (Luckert 1975), and various groups in interior Alaska (de Laguna 1995). In both Australia and North America, caves and prominent rocks were (and are) places of special or spiritual significance.

Situated at the end of a small promontory of high ground (Figure 1), at 10,500 B.P. Charlie Lake Cave would have overlooked either a shallow glacial lake or the recently drained lake bed. On the side of the hill there would have been a well-defined line formed by the sandstone cliffs in which the cave itself occurs. The cave would have been hidden from view by a prominent vertical rock (the "parapet") which would have stood as an isolated 7 m pillar. Thus, the end of the promontory was marked by a large rock and a cave. These features may have rendered this location sufficiently distinctive for it to be regarded as a "special" place, and I propose that the location was "memorialized" by Paleoindians through the deposition of ravens.

Discussion

Ravens were well known to Eurasian and North American peoples and the "human" characteristics of this large, conspicuous, vocal bird are probably responsible for similar beliefs about it in cultures separated widely in time and space. If ravens followed and scavenged large game animals in recent times, they probably did the same in the open landscapes of postglacial British Columbia. They would have been a visible and audible component of the environment, and would have attracted the attention of hunters.

It is not possible to state unequivocally that people are responsible for the death, deposition, and preservation of the raven skeletons at Charlie Lake Cave in the Paleoindian period. The argument in support of this position rests on the archaeological association, the lack of modification and disturbance of the skeletons, the presumed prominence of the site on the local landscape, and archaeological and ethnographic data concerning the importance of ravens in belief systems.

The skeletons from Charlie Lake Cave are not the remnants of bird skins of the type prepared by Plains Indians in late prehistoric times, because the skeletons are too complete. Nor are they the discarded remains of birds which have been skinned, because it would be difficult to prepare a skin without including bones of the lower wing and foot, and these elements are well represented at Charlie Lake. It is possible that only the beak was removed from these specimens, although in the case of Raven I only the upper beak (premaxilla) is missing. However, in both specimens the cranium is poorly preserved, and one cannot be sure that either part of the beak was deliberately removed. The skeletal remains present at Charlie Lake Cave must result from the deposition of complete birds or birds from which feathers had been plucked.

Both skeletons are well associated with humanly created and modified objects, and this strengthens the hypothesis of human involvement in their deposition. We should not be surprised to find possibly sacred materials in association with more mundane material. "Ritual" deposits are a regular feature of domestic sites throughout the world. The recently discovered decorated bison cranium from a Folsom kill was associated with the bone bed (Bement 1997).

Alternative hypotheses for a natural death can be developed. In these hypotheses the association with artifacts must be considered coincidental, and is the result of people and animals using the same place at slightly different times.

At present we do not have sufficient evidence to distinguish between human ritual deposition and natural death and burial. The data point to a potential relationship between Paleoindians, ravens and prominent features on the landscape. It is only by looking for similar associations on other sites that patterns may emerge to suggest an outline of Paleoindian ritual behavior. There is a lack of information about this aspect of Paleoindian life. Bement (1997) has reviewed evidence for Paleoindian ritual. Apart from the occasional burial, he lists the presence of ochre at a number of sites, the Cooper site painted bison cranium, a possible shaman pole posthole at Jones-Miller, and a bone-filled feature at Lake Theo. To this could be added possible cremations in the northeast (Deller and Ellis 1984). In view of the large number of artifacts associated with the Anzick burials (Bonnichsen and Lahren 1974), it is possible that Paleoindian artifact caches may also result from ritual activity. The Charlie Lake Cave ravens join this list as another example of possible ritual activity for which we must now seek further examples through careful excavation and mapping.

Acknowledgments. This research was funded by the Social Sciences and Humanities Research Council of Canada. The discovery and mapping of both skeletons in situ was the result of careful excavation by the 1991 Charlie Lake field crew, of whom I particularly thank Martin Handly and Gregg Sullivan for their work on the specimens reported here. Brian Hayden and Barbara Winter made useful comments on an earlier draft of this paper. I thank the editor of *American Antiquity* and numerous reviewers for helping me make the text more concise.

References Cited

Angell, T.
1978 *Ravens, Crows, Magpies and Jays*. University of Washington Press, Seattle.
Armstrong, E.A.
1958 *The Folklore of Birds*. Collins, London.
Beckwith, M.W.
1937 *Mandan-Hidatsa Myths and Ceremonies*. American Folklore Society, New York.
Bement, L.C.
1997 The Cooper Site: A Stratified Folsom Bison Kill in Oklahoma. In *Southern Plains Bison Procurement and Utiliation from Paleoindian to Historic*, edited by L.C. Bement and K.J. Buehler, pp. 85–99. Memoir 29. Plains Anthropologist.
Bent, A.C.
1946 *Life Histories of North American Jays, Crows and Titmice*. Bulletin 191. Smithsonian Institution, Washington, D.C.
Berndt, R.M.
1976 Territoriality and the Problem of Demarcating Social Space. In *Tribes and Boundaries in Australia*, edited by N. Peterson, pp. 133–161. Australian Institute of Aboriginal Studies, Canberra.
Bickart, K.J.
1984 A Field Experiment in Avian Taphonomy. *Journal of Vertebrate Paleontology* 4(4):525–535.
Birket-Smith, K.
1959 *The Eskimos*. Methuen, London.
Blondin, G.
1990 *When the World Was New: Tales of the Sahtu Dene*. Outcrop, Yellowknife.
Bonnichsen, R., and L. Lahren
1974 Bone Foreshafts from a Clovis Burial in Southwestern Montana. *Science* 186:147–150.
Bray, R.T.
1961 The Flynn Cemetery: an Orr Focus Oneota Burial Site in Allamakee County, Iowa. *Journal of the Iowa Archeological Society* 10(4): 15–25.
Brown, J.E.
1992 *Animals of the Soul*. Element, Rockport.
Burns, J.A.
1996 Vertebrate Paleontology and the Alleged Ice-Free Corridor: the Meat of the Matter. *Quaternary International* 32: 107–112.
Buskirk, W.
1986 *The Western Apache*. University of Oklahoma Press, Norman.
Cartmill, M.
1993 *A View to a Death in the Morning*. Harvard University Press, Cambridge.
de Laguna, F.
1995 *Tales from the Dena*. University of Washington Press, Seattle.

Deller, D.B., and C.J. Ellis
1984 Crowfield: A Preliminary Report on a Probable Paleo-Indian Cremation in Southwestern Ontario. *Archaeology of Eastern North America* 12:41–71.

Driver, J.C.
1988 Late Pleistocene and Holocene Vertebrates and Palaeoenvironments from Charlie Lake Cave, Northeast British Columbia. *Canadian Journal of Earth Sciences* 25: 1545–1553.
1998 Human Adaptation at the Pleistocene/Holocene Boundary in Western Canada, 11,000 to 9000 BP. *Quaternary International* 49/50: 141–150.

Driver, J.C., M. Handly, K.R. Fladmark, D.E.Nelson, G.M. Sullivan and R. Preston
1996 Stratigraphy, Radiocarbon Dating, and Culture History of Charlie Lake Cave, British Columbia. *Arctic* 49(3): 265–277.

Fladmark, K.R., J.C. Driver, and D. Alexander
1988 The Palaeoindian Component at Charlie Lake Cave (HbRf 39), British Columbia. *American Antiquity* 53: 371–384.

Goodchild, P.
1991 *Raven Tales.* Chicago Review Press, Chicago.

Grinnell, G.B.
1962a *Blackfoot Lodge Tales.* University of Nebraska Press, Lincoln.
1962b *The Cheyenne Indians*, vol. 2. Cooper Square, New York.

Gubser, N.J.
1965 *The Nunamiut Eskimos.* Yale University Press, New Haven.

Handly, M.J.
1994 Lithic Assemblage Variability at Charlie Lake Cave (HbRf-39): A Stratified Rockshelter in Northeastern British Columbia. Unpublished M.A. thesis, Department of Anthropology, Trent University, Peterborough, Ontario.

Heinrich, B.
1989 *Ravens in Winter.* Summit Books, New York.

Jenness, D.
1955 *The Faith of a Coast Salish Indian.* Memoir 3, Anthropology in British Columbia. British Columbia Provincial Museum, Victoria.

Lowie, R.H.
1913 *Societies of the Crow, Hidatsa and Mandan Indians.* Anthropological Papers Vol. XI, Pt. III. American Museum of Natural History, New York.

Luckert, K.W.
1975 *The Navajo Hunter Tradition.* University of Arizona Press, Tucson.

Lundelius, E.L., R.W. Graham, E. Anderson, J. Guilday, J.A. Holman, D.W. Steadman, and D.S. Webb
1983 Terrestrial Vertebrate Faunas. In *Late-Quaternary Environments of the United States,* volume 1, the Late Pleistocene, edited by S.C. Porter, pp.311–352. University of Minnesota Press, Minneapolis.

Lyman, R.L.
1994 *Vertebrate Taphonomy.* Cambridge University Press, Cambridge.

Mead, J.R.
1986 *Hunting and Trading on the Great Plains, 1859–1875.* University of Oklahoma Press, Norman.

Mech, D.
1970 *The Wolf.* Natural History Press, Garden City, New York.

Mohs, G.
1987 Spiritual Sites, Ethnic Significance and Native Spirituality: The Heritage and Heritage Sites of the Stó:lo Indians of British Columbia. Unpublished M.A. thesis, Department of Archaeology, Simon Fraser University, Burnaby, British Columbia.

Myers, F.R.
1986 *Pintupi Country, Pintupi Self.* Australian Institute of Aboriginal Studies, Canberra.

Nelson, R.K.
1973 *Hunters of the Northern Forest.* University of Chicago Press, Chicago.

O'Shea, J.M., G.D. Schrimper, and J.K. Ludwickson
1982 Ivory-billed Woodpeckers at the Big Village of the Omaha. *Plains Anthropologist* 27:245–248.

Parmalee, P.W.
1977 The Avifauna from Prehistoric Arikara Sites in South Dakota. *Plains Anthropologist* 22:189–222.

Rooth, A.B.
1971 *The Alaska Expedition 1966. Myths, Customs and Beliefs among the Athabascan Indians and Eskimos of Northern Alaska.* CWK Gleerup, Lund.

Rowland, B.
1978 *Birds with Human Souls.* University of Tennessee Press, Knoxville.

Savage, C.
1987 *Bird Brains: The Intelligence of Crows, Ravens, Magpies and Jays.* Sierra Club Books, San Francisco.

Ubelaker, D.H., and W.R. Wedel
1975 Bird Bones, Burials and Bundles in Plains Archaeology. *American Antiquity* 40:444–452.

Wildschut, W.
1960 *Crow Indian Medicine Bundles.* Museum of the American Indian, New York.

Wilmore, S.B.
1979 *Crows, Jays, Ravens and Their Relatives.* TFH Publications, Neptune, New Jersey.

Wissler, C.
1912 *Ceremonial Bundles of the Blackfoot Indians.* Anthropological Papers Vol. VII, Pt. 2. American Museum of Natural History, New York.
1913 *Societies and Dance Associations of the Blackfoot Indians.* Anthropological Papers Vol. XI, Pt. IV. American Museum of Natural History, New York.

Wittry, W.L.
1962 A Raven Headdress from Sauk County, Wisconsin. *Wisconsin Archeologist* 43(4): 87–94.

Received July 14, 1997; accepted August 25, 1998; revised September 29, 1998.

STRATIFIED FAUNAS FROM CHARLIE LAKE CAVE AND THE PEOPLING OF THE WESTERN INTERIOR OF CANADA

JONATHAN C. DRIVER

We kindly thank the publisher, Archaeopress, for permission to reproduce this work.

This article discusses the correlations between environmental change and human activity and the significance of Tse'K'wa to such research. In 1995 I attended an international conference in Berlin that looked at the archaeology of the transition period from the last ice age (the Pleistocene) to the modern period (the Holocene). I gave a paper summarizing archaeological data from western Canada for the period 11,000 BC to 9000 BC. At that conference it was suggested that we needed to have a second meeting that looked at changes in environment and hunting during this period of global environmental change. I therefore volunteered to organize a set of presentations within a conference on animal bone archaeology (zooarchaeology) that was held in Victoria, British Columbia, in 1998.

The paper that I presented included a discussion about when habitats would have been suitable for human habitation after deglaciation, but in view of the small number of sites and the differing intensities of archaeological fieldwork I did not feel confident in suggesting (as I now believe) that colonization of the interior of western Canada took place from south to north.

The rest of the paper focused on Tse'K'wa because it was (and is still) the only archaeological site in the interior of western Canada where evidence for environmental change can be correlated with evidence for human activities. The animal bone data from Tse'K'wa clearly show a rapidly changing environment as the ice was ending and new habitats were being established. Building on the results of the 1983 excavations, adding data from the 1990 and 1991 excavations allowed a more detailed picture of the changing environments. For example, one diagram in the paper shows how quickly the local small mammals change from ground squirrels to snowshoe hare. It was also apparent that animals that live in or near water became more prevalent once the forested environments were established.

STRATIFIED FAUNAS FROM CHARLIE LAKE CAVE AND THE PEOPLING OF THE WESTERN INTERIOR OF CANADA

Jonathan C. Driver
Department of Archaeology, Simon Fraser University, Burnaby, BC V5A 1S6, Canada

Introduction

At the end of the Pleistocene in many parts of the world there were significant and rapid environmental changes. For people in those regions, environmental change could have had three effects. First, some locations became uninhabitable, as was the case in many coastal regions inundated by rising sea levels. Second, in order to maintain populations in areas which did not become uninhabitable, new subsistence strategies were required; changing patterns of foraging, new settlement systems, or the domestication of plants and animals are examples of these strategies. Third, areas which had previously been uninhabitable or inaccesible were open for colonization. This paper deals with the latter topic by considering the evidence for early post-glacial environments in western Canada and the use of animal resources during the early post-glacial period.

Much of the discussion about early human cultures in the Americas has concerned the timing of the initial colonization, and especially the route and chronology for movement of people from northeast Asia through Alaska and western Canada and south into unglaciated territory from the Canada/U.S.A. border to the southern tip of South America. Even if one argues for a relatively late entry of people to the Americas (for example, seeing the Clovis culture at about 11,500 B.P. as the earliest manifestation of human presence), it is certain that people lived both north and south of the Laurentide and Cordilleran ice sheets which covered most of what is now Canada. The melting of these ice sheets therefore opened up an area of more than 10 million square kilometres for colonization in the early post-glacial period.

Data from western Canada summarized for the meeting of the INQUA Working Group on the Archaeology of the Pleistocene-Holocene Transition in Berlin (Driver 1998a) have not changed significantly in the past few years. At 12,000 BP most of western Canada was covered by ice or glacial lakes, with coastal refugia providing a possible route for late Pleistocene entry to land south of the ice sheets, if that had not already occurred prior to the last extensive glaciation. By 11,500 BP plant and animal fossils show the re-establishment of biotic communities in southern Alberta, and by 10, 000 BP most of western Canada south of 60° N was probably inhabitable. Unfortunately, the archaeological record prior to 10,000 BP is very sparse, and becomes even sparser when sites with faunal assemblages are considered. Only two published archaeological sites (Vermilion Lakes and Charlie Lake Cave) pre-date 10,000 BP and contain faunal assemblages with hundreds of specimens. In this paper I examine the fauna from Charlie Lake Cave with a view to assessing the adaptation of the first people to move into the recently deglaciated western interior of Canada.

Chronology and environmental setting

This paper is concerned with interior western Canada, which can be defined broadly as land lying east of the Rockies and west of the Canadian Shield. Because the western edge of this area was deglaciated first, attention is focused on the "western corridor" - a roughly 300 km wide strip of land to the east of the Rockies. Today this area is characterized by three major ecological zones - grassland, parkland and boreal forest - which succeed each other from south to north. The Rockies are mainly forested. First Nations who occupied these zones had conspicuously different adaptations. Bison (*Bison bison*) was the most important resource for inhabitants of grassland, whereas a variety of ungulates, especially moose (*Alces alces*) and caribou (*Rangifer tarandus*), fish, and waterfowl formed a more diverse subsistence base in the boreal forest. Plants were consumed in all areas, but were not dietary staples.

The radiocarbon chronology for deglaciation and the re-establishment of inhabitable biotic environments in western Canada remains contentious for two reasons:

1. Considering the size of the region, there are relatively few radiocarbon dates and a dearth of early archaeological, palynological and paleontological sites.
2. Before the development of AMS dating, bulk samples of sediments were sometimes used for dating, especially of pollen cores. Such samples are often contaminated by organics eroded from more ancient deposits, resulting in erroneously old radiocarbon dates. In addition, some aquatic plants obtain ancient carbon from dissolved bicarbonates, and these also provide dates which are too early (Beaudoin 1993: MacDonald et al. 1987, 1991; Wilson 1993).

If one is cautious about accepting radiocarbon dates on bulk organics derived from lake bed sediments, then the earliest post-glacial vegetation east of the Rockies probably appeared around 11,500 BP (MacDonald and McLeod 1996). Mandryk (1996) has pointed out that vegetation may have developed on stagnant ice. If such vegetation did exist, it may pre-date the formation of modern lakes and bogs which now hold the oldest palynological records. However, as will be seen, the evidence from vertebrate fossils shows no large mammals in most of the western corridor before 11,500 BP, so if there was a vegetation cover over stagnant ice it probably could not support human populations.

Palynological data show that deglaciated landforms were typically colonized by a vegetation cover which has no modern analogues (Lichti-Federovich 1970; MacDonald 1987; MacDonald and McLeod 1996; White and Mathewes 1986). The vegetation consisted mainly of grasses, sedges, herbs and shrubs. *Populus* sp. (probably aspen) is the most common tree represented, and may have been more common than suggested by pollen frequencies due to poor preservation of its pollen. The vegetation seems to have consisted of a mix of species which could colonize poor soils relatively rapidly. It may have resembled a combination of steppe/grassland, parkland and wet tundra. Pollen deposition rates are similar to those found on modern grassland margins (MacDonald and McLeod 1996). Except for areas which remain as grassland today, much of the western corridor was subsequently colonized by coniferous taxa, notably spruce, at about 10,000 BP. The development of this early boreal forest effectively marks the end of the early post-glacial vegetation.

Vertebrate fossils from the region provide a less detailed picture of the environments and environmental change, but do provide evidence for the absence of inhabitable landscapes during late glacial times. Burns (1996) has shown that dated vertebrates are either older than about 20,000 BP (i.e. they pre-date the last glaciation) or younger than 12,000 BP (i.e. they post-date the last glaciation). The absence of vertebrates dating between about 20,000 and 12,000 BP strongly suggests that western Canada could not support large mammals during the last glaciation, and that human occupation is also unlikely. Further evidence for the lack of inhabitable environments in the interior of western Canada comes from the species composition in early post-glacial times. With the exception of the most southerly areas, early post-glacial faunas are dominated by *Bison*. Typical North American late glacial species from south of the ice sheets, such as mammoth, horse and camel have not been found over most of the region in early post-glacial deposits, suggesting that large fauna did not colonize the area until after most of the late Pleistocene extinctions had taken effect. Given the common appearance of *Bison* (Wilson 1996), it would be remarkable if other taxa had somehow been missed by paleontologists, especially as they have been recovered from earlier deposits. Furthermore, early post-glacial bison in interior western Canada are most similar to specimens further south, and are different from specimens living north of the ice sheets (Wilson 1996).

Thus a cautious interpretation of the early post-glacial environmental sequence would see a relatively late deglaciation (c. 12,000 BP), followed by about 2000 radiocarbon years of open landscapes. During this time animal species moved into the western corridor from the south, with *Bison* (a survivor of late Pleistocene extinctions) the dominant large animal. Over much of the interior of western Canada the open landscapes were replaced by spruce-dominated boreal forest at about 10,000 BP.

Human history

I have reviewed western Canadian archaeological data elsewhere (Driver 1998a), and there has been little significant change since that review. Using a recently established database of Canadian radiocarbon dates (Morlan 1999) one can examine large scale patterns in dated sites (Figure 10.1). Canadian archaeological sites are given "Borden numbers" (combinations of letters and digits) according to their geographic location (Borden 1952). I have selected for analysis five "Borden blocks", running roughly northwest along the east foothills of the Rockies and adjacent plains. This area has yielded the greatest number of pre-9000 BP sites in western Canada. Each Borden block is identified by two letters (e.g. EP), and each encompasses two degrees of latitude and four degrees of longitude, except DP whose lower half is truncated by the Canada/U.S.A. border.

Figure 10.1 plots the number of sites dated to 1000 radiocarbon year intervals for five Borden blocks running south to north. A site was only included in a 1000 year interval once - i.e. multiple dates or multiple components from the same millenium and the same site were ignored. However, sites with dates from different 1000 year intervals were counted separately for each millenium. The small number of dated sites in all periods in the more northern Borden blocks is probably the result of low-intensity archaeological fieldwork, coupled with low sedimentation rates and poor preservation. For example, most of the dates for the HR block are from Charlie Lake Cave, discussed below. The relatively sharp increase in site numbers from 11,000 to 9000 BP is probably the result of (a) increasing prehistoric populations, and (b) increasingly stable land surfaces following a great deal of early post-glacial landscape remodelling. The earliest post-glacial landscapes were often either eroded or buried deeply (Ryder 1971), which means that it is difficult to find early sites, especially as accessible limestone caves are rare. Most of the radiocarbon dated pre-9000 BP sites listed in a previous study (Driver 1998a: Table 1) are buried by at least a metre of sediment, and some are much more deeply buried. Most were discovered either when excavating below a later prehistoric component or as a result of development activity.

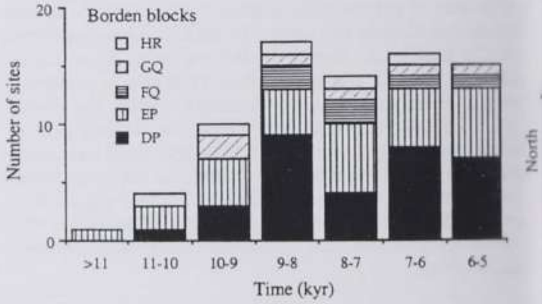


Figure 10.1. Number of dated archaeological sites or components per 1000 radiocarbon year intervals by Borden blocks.

As the major modern environmental patterns were established in western Canada by 9000 BP, one can see from Figure 10.1 that very few sites are available for analysis of the Pleistocene-Holocene transition. Most of the sites from the early period either lack fauna, or bones occur in small numbers. It is therefore impossible to detect temporal or spatial patterns in animal distribution. The remainder of this paper focuses on one site - Charlie Lake Cave - where stratified, dated faunal assemblages are associated with human occupations.

Charlie Lake Cave

Chronology

Charlie Lake Cave is located just north of the Peace River valley, about 160 km east of the continental divide at 56°16'35"N, 120°56'15"W, 730 m asl. The site, its stratigraphy and archaeological sequence have been described elsewhere (Fladmark et al. 1988; Driver et al. 1996, and references therein). The major features of the site are as follows.

1. Most materials have been recovered from roughly 4m of sediment which fills a gully in front of the cave entrance.
2. The sequence of deposits dates from about 10,500 BP to the present.
3. Archaeological components are found intermittently through the sequence, but there is a notable gap from about 9500 to 7000 BP with no human use of the site.
4. Faunal remains are found throughout the sequence, regardless of presence or absence of people.

Most of the deposits consist of a mixture of glacial lake silts redeposited from the hillside above the site and weathered sandstone from the local bedrock. Palaeosols have formed on these sediments from time to time, and a combination of granulometry and palaeosol formation has been used to subdivide the stratigraphy into zones and subzones. This paper uses the most recent stratigraphic nomenclature (see Driver et al. 1996). When looking at the Pleistocene/Holocene boundary we are concerned mainly with Zone II, which represents rapid redeposition of glacial lake sediments, and the lower part of Zone III in which sedimentation rates slowed, more weathered sandstone occurs, and the first palaeosols appear.

Zone II has been subdivided into four subzones. Subzones IIa and IIb are the earliest deposits which contain bones and artifacts, and six radiocarbon dates average 10,500 ± 40 BP. Subzones IIc and IId are very similar. Four radiocarbon dates, all from IIc, average 9850 ± 80 BP. Subzone IIIa is dated by a single date of 9490 ± 140 BP. Two dates from subzone IIIb average 8350 ± 230 BP. All subzones except IIIb contain stone artifacts. Details of artifacts and dates can be found in Handly (1993) and Driver et al. (1996). The sequence of radiocarbon dates agrees well with the stratigraphic sequence (Figure 10.2), and the rapid sedimentation in Zone II (up to one metre of sediment in 1000 radiocarbon years) has probably reduced the chance of mixed assemblages.

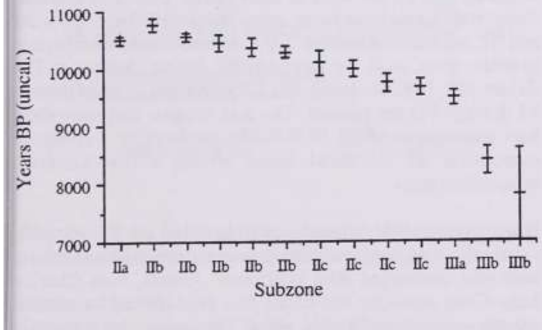


Figure 10.2. Radiocarbon dates from Zone II and lower Zone III, Charlie Lake Cave. Dates are organized by decreasing age within subzones.

Archaeology

Artifacts have been described in detail elsewhere (Handly 1993; Driver et al. 1996). With the exception of a drilled stone bead, all artifacts are of flaked local stone, mainly cherts with some quartzite. The array of tool forms is consistent with hunting and processing of animals. Few artifacts have sufficient distinctive formal qualities to allow comparison with dated sites elsewhere, and there are very few dated sites within 500 km. A spear point from the lowest cultural component (subzone IIb) is related to fluted point complexes to the south. A microblade core from subzone IIIa has some similarities to wedge-shaped cores from Alaska, but is technologically different. Debitage suggests little on-site production of artifacts; instead, artifact maintenance is represented by small resharpening flakes, and discarded formed artifacts are relatively common. This, together with the absence of hearths or charcoal, suggests relatively short-term use of the site in early post-glacial times. This contrasts with later (post-5000 BP) occupations, where there is evidence for artifact manufacture and hearth features.

Identified taxa and palaeoenvironments

Table 1 lists mammalian and avian specimens which have been identified to genus or species, as well as occasional family level identifications (e.g. Rallidae) where the family level identification provides useful palaeoenvironmental evidence. Taxa are grouped by their likely habitat preferences; "catholic" taxa are today associated with a wide variety of habitats.

The earliest fauna, from Subzones IIa and IIb, is different from all later faunas in a number of ways. It contains taxa which prefer open habitats and which are no longer found in the Peace River region. The most notable species is *Dicrostonyx torquatus* (collared lemming), which had a wider late Pleistocene distribution, but is now found only on tundra (Driver 1998b). Ground squirrels (*Spermophilus*), bison and a large hare are also associated. Forest mammals are notably absent, with the exception of snowshoe hare (*Lepus americanus*), which is represented by only a few specimens. Equally notable is the absence of waterfowl and aquatic mammals, suggesting that stable, productive, aquatic environments had not been established near the site.

Table 10.1. Identified fauna from Charlie Lake Cave. See text for details of inclusion of taxa.

TAXON	IIa,IIb	IIc,IId	IIIa	IIIb
Open habitat mammals				
Lepus sp.	*	*		
Large hare				
Dicrostonyx torquatus	*			
Collared lemming				
Spermophilus sp.	**	*	*	
Ground squirrel				
Bison sp.	*	*	*	*
Bison				
Aquatic birds				
Aechmophorus sp.		*	*	*
Western or Clark's Grebe				

Podiceps auritus		*	*	
Horned grebe				
Anas platyrhynchos		*		
Mallard				
Anas sp.		*		*
Teal				
Bucephela albeola				*
Bufflehead				
Oxyura jamaicensis		*		*
Ruddy duck				
Fulica americana		*	*	
Coot				
Rallidae		*		
Virginia or Sora rail				
Aquatic mammals				
Ondatra zibethicus			*	*
Muskrat				
Castor canadensis			*	*
Beaver				
Forest birds				
Surnia ulula				*
Hawk owl				
Picidae	*			
Woodpecker				
Ectopistes migratorius			*	
Passenger Pigeon				
Forest mammals				
Lepus americanus	*	**	**	**
Snowshoe hare				
Microtus xanthognathus		*	*	
Chestnut-cheeked vole				
Clethrionomys gapperi		*	*	*
Gapper's red-backed vole				
Marmota monax				*
Woodchuck				
Catholic birds				
Tetraonidae		*	*	*
Grouse				
Asio flammeus		*		
Short-eared owl				
Corvus corax	*	*		
Raven				
Hirundo pyrrhonota	*	*	*	
Cliff swallow				
Catholic mammals				
Peromyscus sp.	*	*	*	*
Deer mouse				
Neotoma sp.				*
Packrat				
Eutamias sp.			*	*
Chipmunk				
Canis sp.		*		
Wolf-size canid				
Mustela nivalis			*	
Least weasel				
Mephitis mephitis			*	*
Striped skunk				

* = present ** = common (NISP > 100)

Beginning in subzones IIc and IId, there is an increase in the number of taxa associated with aquatic environments and with the boreal forest. Snowshoe hare becomes common, and voles commonly associated with damp forest habitats occur. By the end of subzone IIIa the last of the ground squirrels disappear, and bison is the only grassland-adapted taxon present. Bison today occupy boreal forest in relatively low population densities; they probably persisted in the Peace River region as a result of the "Peace River grasslands" - areas of grassland and parkland within the southern boreal forest, mainly to the east of Charlie Lake Cave (White and Mathewes 1986: Figure 1). Thus by 9000 BP the fauna represented at Charlie Lake Cave is essentially modern, at least in terms of taxa represented.

The transition from relatively open to forested environments can be examined in more detail at Charlie Lake Cave because the relatively rapid sedimentation rates allow good separation of assemblages. The dominant small mammals of Zone II assemblages are ground squirrels and snowshoe hare. Figure 10.3 plots the relative frequency of these two taxa in three excavation units which are relatively deep and well dated. Units 26 and 28 are next to each other. Unit 3 is a metre away from them. Unit 3 was excavated in 1983 and units 26 and 28 were excavated in 1991, and different numbering systems were used for stratigraphic layers. Subzones IIb (layers 105, 104), IIc (layer 98), IId (layer 93) and IIIa (layers 82 through 91) are present. The data suggest that snowshoe hare appeared at about 10,000 BP, and became a common component of the local fauna within a few hundred radiocarbon years.

If we assume that ground squirrels were associated with relatively open, treeless environments, and that snowshoe hare was associated with coniferous forests, then Charlie Lake Cave provides one of the few post-glacial vertebrate records in western Canada which documents the transition from open to forested conditions. Nearby pollen records also document this transition. Of particular interest are dates and pollen zones from Lone Fox Lake to the northeast (MacDonald 1987) and Boone Lake to the southeast (White and Mathewes 1986). Dates for the local appearance of spruce at Boone Lake are about 10,700 BP. At Charlie Lake Cave and Lone Fox Lake this is a time of open vegetation.

Spruce forest was local around Lone Fox Lake by 9800 BP, which is consistent with the dates for the disappearance of ground squirrels and dominance of snowshoe hare at Charlie Lake Cave. As radiocarbon dates for the appearance of spruce are based on bulk sediment samples from Boone Lake, it is possible that the dates are somewhat older due to the "old carbon" effect. Alternatively, the more southern Boone Lake area may have been colonized by spruce earlier, with a subsequent lag in spruce migration north caused by a short cool period, possibly relating to the Younger Dryas. Possible evidence for a western interior cool episode was suggested for pollen data from the Vermilion Lakes site (Fedje et al. 1995: 102) and has been reported for the northwest coast (Mathewes 1994). Given the problems associated with radiocarbon dating at this time period, potential contamination of lake bed samples, problems of comparing plant and bone dates, and the variable sensitivity of vertebrates and plants to environmental change, there is remarkably good concordance between environmental reconstructions based on local pollen sequences and the Charlie Lake Cave vertebrates.

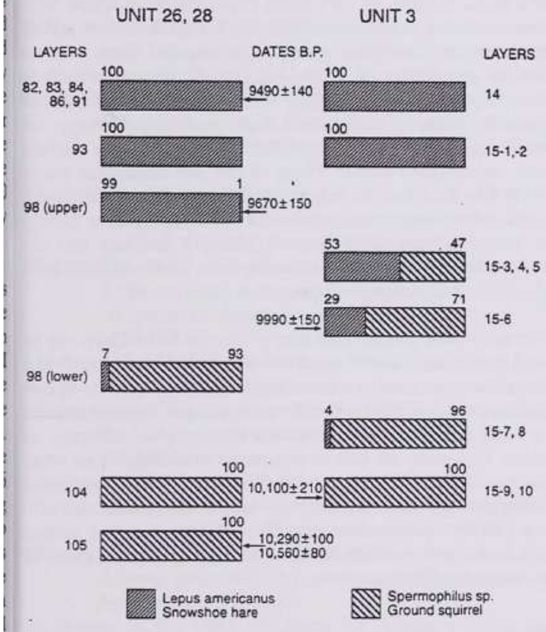


Figure 10.3. Relative frequency (%NISP) of ground squirrels and snowshoe hare for three excavation units.

Human adaptation

Taphonomic analysis of Charlie Lake Cave faunas is not yet complete, but it is clear that separating culturally deposited from naturally deposited specimens will be extremely difficult. Deposition of a wide variety of vertebrates occurred during times when the site was not visited by people, and one cannot assume that any taxon owes its presence on the site to human activity. Cutmarks are very rare. Burning is not present on any of the pre-9000 BP specimens, but is common in mid- and late-Holocene assemblages. For the early post-glacial assemblages discussed in this paper only bison displays evidence of cutmarks and spiral fractures with impact points (Fladmark et al. 1988). As discussed elsewhere (Driver 1998a), large game animals are typically associated with late Pleistocene and early Holocene archaeological sites in the western interior of Canada, and hunting of large game is a logical adaptation to the early post-glacial open environments. Bison is the most frequently found large mammal, but at Vermilion Lakes bighorn sheep was dominant and caribou was probably present (Fedje et al. 1995).

The early post-glacial hunter-gatherers in this region probably migrated from the south, taking advantage of newly created habitats. Kelly and Todd (1988) proposed a model for Paleoindian colonization of North America. Their predictions can be tested against the data from Charlie Lake Cave where the bison bones at the bottom of the Charlie Lake Cave deposits may well have been hunted by the first generation of people to inhabit the region in post-glacial times.

Prediction 1. Hunting should be important. Kelly and Todd argue for a primary role for hunting because it involves a set of techniques which can be transferred readily from one region to another, and because animals are available throughout the year. In more northern areas this does not apply solely to Paleoindians - hunting was of importance throughout prehistory. Bison hunting at Charlie Lake Cave is well represented, but other subsistence activities did not replace big game hunting in much of the western interior.

Prediction 2. There should be evidence for high mobility, especially in times of rapid environmental change. With only one site, this is difficult to assess. However, the lack of hearths and the discard of potentially useful artifacts (especially larger quartzite chopping tools) suggests mobility was important.

Prediction 3. Sites should be used repeatedly, but for short periods. It is difficult to assess how many times Charlie Lake Cave was visited during early post-glacial times. The excavated portion of the site which reaches the lowest components (about 12 square metres) has produced just over 100 bison bone fragments, 17 stone artifacts or cores, and less than 200 pieces of debitage (most of which derives from a couple of instances of biface resharpening). The most conservative evaluation of dates would have this deposition occurring over 500 radiocarbon years. This seems to be a series of minimal events, even if only two or three occupations occurred, and the site conforms to the prediction.

Prediction 4. Unique landscape features should be relatively unused. As Charlie Lake Cave is the only dated early post-glacial site for hundreds of kilometres in any direction, this is difficult to assess. It is clearly a unique landscape feature, but that was what attracted archaeologists there in the first place ! I disagree with this prediction. I suspect that hunter-gatherers moving into a new landscape were attracted to unique features for both practical and metaphysical reasons. Unique features help one navigate in new terrain, but are also important in the development of cognitive and spiritual maps. I have argued elsewhere that Charlie Lake Cave was 'memorialised' by its early occupants, and that deliberate burial of ravens took place there (Driver 1999).

Prediction 5. Technology should be easily transportable. As noted above, larger artifacts were discarded at the site, so transportability was probably a concern.

Prediction 6. There should be no long-term storage of food. Although the bison bones are frequently broken (presumably for marrow extraction), there is no evidence for intensive smashing of long bone epiphyses or diaphyses. Furthermore, in a relatively small assemblage of bison specimens there are a number which were not broken, including a humerus (subsequently chewed by carnivores), tibia, radius, and numerous phalanges. This contrasts with later prehistoric sites where bone smashing and boiling was common, presumably to produce fat for use in pemmican production (Brink et al. 1986; Reeves 1990). The absence of hearths also suggests minimal on-site processing. Bison bones left at the site in an unprocessed state include long bone ends which Brink (1997) ranks highly in terms of percentage of fat content. The six highest ranked long bone ends are proximal tibia, proximal humerus, proximal femur, proximal radius/ulna, distal femur and distal radius/ulna. There are no femora at the site, but a count of the minimum number of long bone ends shows that nine out of eighteen specimens are in the high-ranked bones defined above. It seems unlikely that high fat bones were being removed for processing off-site.

Discussion and conclusions

There is currently no evidence to suggest that people lived in most of what is now the western interior of Canada at any time prior to about 11,000 BP. The absence of archaeological evidence may be due to the reconfiguration of landscapes caused by the processes of deglaciation. However, palynology and vertebrate paleontology support the conclusion that this region could not support human populations until the re-establishment of vegetation (perhaps as early as 12,000 BP) and the immigration of animal populations (possibly not until 11,500 BP in the Calgary area, 11,000 BP near Edmonton, and 10,500 BP in the Peace River). The lack of late Pleistocene megafauna in post-glacial deposits suggests that most of the region was colonized by animal populations after the late Pleistocene extinctions of about 11,000 BP.

The first humans to enter the region depended on hunting, although they presumably would have gathered berries at the appropriate season. The environment they colonized was open, with areas of herbaceous brush and stands of decisuous trees. Evidence from Vermilion Lakes and Charlie Lake Cave shows that they hunted bison, with the addition of bighorn sheep and caribou closer to the mountains. By 10,000 BP much of the open landscape had been taken over by coniferous forests dominated by spruce. The only archaeological site which records this transition in any detail is Charlie Lake Cave. Vertebrates show a brief period (c. 10,500 to 10,000 BP) when animals adapted to open environments flourished, apparently at a time when aquatic habitats had yet to become sufficiently productive to attract waterfowl, beaver and muskrat. By about 10,000 BP forest species appeared, and a wide range of aquatic birds and mammals was also present.

Early human inhabitants of Charlie Lake Cave hunted bison, and may have continued to use the site for this purpose after spruce forests had begun to develop. The site was either part of a bison kill site, or very close to the kill area. Bison were butchered and bone marrow was extracted. However, not all bones were smashed to obtain marrow, and there was no further processing of bones for grease. This approach to animal exploitation, coupled with a high discard rate of formed artifacts, suggests a high mobility strategy, as predicted by Kelly and Todd (1988) for Paleoindians moving into uninhabited areas. Visits to the site ceased at about 9500 BP; the site was not re-used for another 2000 years. Later occupations were more intensive and a greater variety of activities took place (Handly 1993). It is likely that the role of the site in the settlement system changed from late-glacial to mid-Holocene times.

The early post-glacial activities at Charlie Lake Cave can be seen as a microcosm of what was probably happening over a much larger area - colonization of open, productive landscapes by high mobility hunter-gatherers; a readjustment to more forested environments with a greater diversity of fauna. However, the lack of comparative material from other early sites handicaps our understanding of the process of colonization, and the lack of early Holocene cultural components at Charlie Lake Cave means that we cannot assess the way in which human groups adapted to the arrival of coniferous forests.

References

Beaudoin, A.B., 1993. A compendium and evaluation of post-glacial pollen records in Alberta. *Canadian Journal of Archazology* 17, 92-112.

Borden, C.E., 1952. A uniform site designation scheme for Canada. *Anthropology in British Columbia* 3, 44-48.

Brink, J.W., 1997. Fat content in leg bones of *Bison bison*, and applications to archaeology. *Journal of Archaeological Science* 24, 259-274.

Brink, J.W., M. Wright, B. Dawe and D. Glaum, 1986. *Final Report of the 1984 Season at Head-Smashed-In Buffalo Jump, Alberta*. Edmonton: Archaeological Survey of Alberta Manuscript Series 9.

Burns, J.A., 1996. Vertebrate paleontology and the alleged ice-free corridor: the meat of the matter. *Quaternary International* 32, 107-112.

Driver, J.C., 1998a. Human adaptation at the Pleistocene/Holocene boundary in western Canada, 11,000 to 9,000 BP. *Quaternary International* 49/50, 141-150.

Driver, J.C., 1998b. Late Pleistocene collared lemming (*Dicrostonyx torquatus*) from northeastern British Columbia, Canada. *Journal of Vertebrate Paleontology* 18(4), 816-818.

Driver, J.C., 1999. Raven skeletons from Paleoindian contexts, Charlie Lake Cave, British Columbia. *American Antiquity* 64(2), 289-298.

Driver, J.C., M. Handly, K.R. Fladmark, D.E.Nelson, G.M. Sullivan and R. Preston, 1996. Stratigraphy, radiocarbon dating, and culture history of Charlie Lake Cave, British Columbia. *Arctic* 49(3), 265-277.

Fedje, D.W., J.M. White, M.C. Wilson, D.E. Nelson, J.S. Vogel, and J.R. Southon, 1995. Vermilion Lakes Site : adaptations and environments in the Canadian Rockies during the latest Pleistocene and early Holocene. *American Antiquity* 60, 81-108.

Fladmark, K.R., J.C. Driver and D. Alexander, 1988. The Palaeoindian component at Charlie Lake Cave (HbRf 39), British Columbia. *American Antiquity* 53(2), 371-384.

Handly, M.J., 1993. Lithic assemblage variability at Charlie Lake Cave (HbRf-39) : a stratified rockshelter in northeastern British Columbia. Unpublished M.A. thesis, Department of Anthropology, Trent University, Peterborough, Ontario.

Kelly, R.L. and L.C. Todd, 1988. Coming into the country: early Paleoindian hunting and mobility. *American Antiquity* 53(2), 231-244.

Lichti-Federovich, S., 1970. The pollen stratigraphy of a dated section of Late Pleistocene lake sediment from central Alberta. *Canadian Journal of Earth Science*7, 938-945.

MacDonald, G.M. , 1987. Postglacial development of the subalpine-boreal transition forest of western Canada. *Journal of Ecology* 75, 303-320.

MacDonald, G.M., R.P. Beukens and W.E.Kieser, 1991. Radiocarbon dating of limnic sediments: a comparative discussion and analysis. *Ecology* 72, 1150-1155.

MacDonald, G.M., R.P. Beukens, W.E.Kieser and D,H, Vitt, 1987. Comparative radiocarbon dating of terrestrial plant macrofossils and aquatic moss from the "ice-free corridor" of western Canada. *Geology* 15, 837-840.

MacDonald, G.M. and T.K. McLeod, 1996. The Holocene closing of the 'ice-free' corridor: a biogeographical perspective. *Quaternary International* 32, 87-95.

Mandryk, C.A.S., 1996. Late Wisconsinan deglaciation of Alberta: processes and paleogeography. *Quaternary International* 32, 79-85.

Mathewes, R.W., 1994. Evidence for Younger Dryas age cooling on the north Pacific coast of North America. *Quaternary Science Reviews* 12, 321-331.

Morlan, R., 1999. *Canadian Archaeological Radiocarbon Database*. Canadian Archaeological Association: http://www.canadianarchaeology.com.

Reeves, B.O.K., 1990. Communal bison hunters of the Northern Plains. In *Hunters of the Recent Past*, ed. L.B. Davis and B.O.K. Reeves. London: Unwin Hyman, pp.168-194.

White, J.M. and R.W. Mathewes, 1986. Postglaical vegetation and climatic change in the upper Peace River district, Alberta. *Canadian Journal of Botany* 64, 2305-2318.

Wilson, M.C., 1993. Radiocarbon dating of the ice-free corridor: problems and implications. In *The Palliser Triangle*, ed. R.W. Barendregt, M.C. Wilson and F.J. Jankunis. Lethbridge: University of Lethbridge, pp. 166-206.

Wilson, M.C., 1996. Late Quaternary vertebrates and the opening of the ice-free corridor, with special reference to the Genus *Bison*. *Quaternary International* 32, 97-105.

PALEOECOLOGICAL AND ARCHAEOLOGICAL IMPLICATIONS OF THE CHARLIE LAKE CAVE FAUNA, BRITISH COLUMBIA

JONATHAN C. DRIVER

We kindly thank the publisher, Archaeopress, for permission to reproduce this work.

This paper was written as a contribution to a volume of collected essays that honoured R. Dale Guthrie – a well-known paleontologist who specialized in ice age animals. It is the first report on animal bones that were recovered from the lower layers of the site during 1990 and 1991.

Because of Dr. Guthrie's numerous contributions to understanding the ice age environments of North America, I tried to link animal bone assemblages at Tse'K'wa to information about regional environments in the Peace River area at the end of the last ice age.

The paper provides a complete list of all the birds and mammals identified, as well as evidence for environmental change from open to forested landscapes. This information is then set in the regional information about the end of the last ice age, emphasizing geology and palynology (the study of ancient pollen).

The second part of the paper discusses human activities at the site, with a focus on the use of bison. There is good evidence that people were hunting and butchering bison, but accounting for the lack of some parts of the bison skeleton is difficult.

PALEOECOLOGICAL AND ARCHAEOLOGICAL IMPLICATIONS OF THE CHARLIE LAKE CAVE FAUNA, BRITISH COLUMBIA,10,500 TO 9,500 B.P.

Jonathan C. Driver
Department of Archaeology, Simon Fraser University

Charlie Lake Cave is located near the city of Fort St. John in northeastern British Columbia (Figure 1). Fort St. John lies to the east of the Rocky Mountains, in the heart of the putative "ice-free corridor." The site is situated on an outcrop of sandstone on a steep slope above a small creek that drains via the Beatton River to the nearby Peace River. Although the site is named after a small cave, most excavations have taken place in front of the cave mouth where a deep gully has been infilling gradually with sediments for the past 10,500 years. Fladmark excavated the site in 1983 where he demonstrated a long cultural and paleoenvironmental sequence, beginning with a Paleoindian occupation containing a late fluted point component, and ending with late prehistoric components (Fladmark 1996; Fladmark *et al.*. 1988). Three studies of the fauna from the 1983 excavations have been published (Driver 1988, 1996; Driver and Hobson 1992). Further excavations were undertaken in 1990 and 1991, directed by Driver. These excavations increased sample sizes of artifacts and fauna from all periods, and identified another cultural component (Driver *et al.* 1996; Handly 1993).

Although the site contains a sequence of artifacts and fauna spanning the last 10,500 radiocarbon years, this paper deals with the first 1000 years of the site's formation and occupational history, documenting a transition from early post-glacial to Holocene faunas. This paper discusses the nature of the early environments, the timing of the transition from open to forested conditions, and the human use of the early environments.

STRATIGRAPHY AND DATING

Stratigraphy, culture history and radiocarbon chronology have been discussed and illustrated elsewhere (Fladmark 1996; Fladmark *et al.* 1988; Driver *et al.* 1996), so only a brief summary is presented here. During the last glaciation of the region a cave was formed in sandstone bedrock, possibly by sub-glacial water. At about 10,500 B.P. a large slab of sandstone (about 12 x 5 x 4 meters) was detached from the face of the small escarpment in which the cave was situated. The slab split away from the cliff face along a vertical joint in the sandstone. When the slab was detached from the bedrock it moved about three meters downslope from the bedrock face, but remained in a vertical position. This created a gully bounded to the north (upslope) by a newly exposed escarpment face containing a cave and to the south (downslope) by one side of the vertical slab. The east and west ends of the gully were open, so that one could enter the gully by walking along the hillside at the base of the escarpment. The floor of the gully sloped steeply south and was littered with sandstone boulders and crushed sandstone left behind as the slab moved downhill. The cave was about three meters above the floor of the gully.

Upslope from the gully the hillside was mantled in glaciolacustrine sediments. Over a period of about 1000 radiocarbon years these were redeposited in the gully, forming a layer of variable thickness over the boulders on the floor. Because the gully floor slopes to the south, the greatest thickness of redeposited glaciolacustrine sediments was against the upslope side of the detached slab on the south (or downslope) side of the gully. Up to a meter of sediment accumulated here. By about 9,500 B.P. the rate of deposition slowed sufficiently to allow soil horizons to form. The subsequent history of deposition is a mixture of allochthonous slopewash and autochthonous weathered sandstone, with numerous soil horizons.

Site stratigraphy is complex, and numerous layers in the lower portion of the site can be resolved into a series of stratigraphic zones. The lowest boulders form Zone I, which contains no artifacts or fauna. The redeposited glaciolacustrine sediments are in Zone II. After the 1983 excavations this was divided into two subzones (Fladmark *et al.*. 1988; Driver 1988); as a result of the 1991 field season, we now recognise four subzones, IIa through IId (Driver *et al.* 1996). The initiation of soil horizons marks the beginning of Zone III, divided into eight subzones. In this paper we are concerned only with the earliest, Subzone IIIa. Radiocarbon dating places Subzones IIa and IIb between 10,500 and 10,000 B.P., while IIc and IId date from 10,000 to slightly before 9,500 B.P. Zone IIIa has a single date of about 9,500 B.P. (Driver *et al.* 1996).

Twenty three one-by-one meter excavation units were placed in the gully and the mouth of the cave in three seasons of excavation. Of these, thirteen units reached Subzone IIIa and lower. Faunal remains from nine of these units have been studied. Faunal specimens were recovered in situ and in 3mm screens.

RECOVERY AND IDENTIFICATION OF FAUNA

Table 1 lists all mammal and bird specimens from the nine excavation units which have been identified to family, genus or species level. Specimens identified to order or class and unidentified specimens have been excluded. A few fish bones were recovered, but the fish assemblage from the site will be reported separately. Frog and snake bones were present in the strata reported here, but were not identified further. Identifications were made with the aid of comparative collections at Simon Fraser University, University of Puget Sound, University of Washington (Burke Museum), University of Toronto, Royal Ontario Museum, and Canadian Museum of Nature. All specimens were catalogued individually and are reposited at Simon Fraser University.

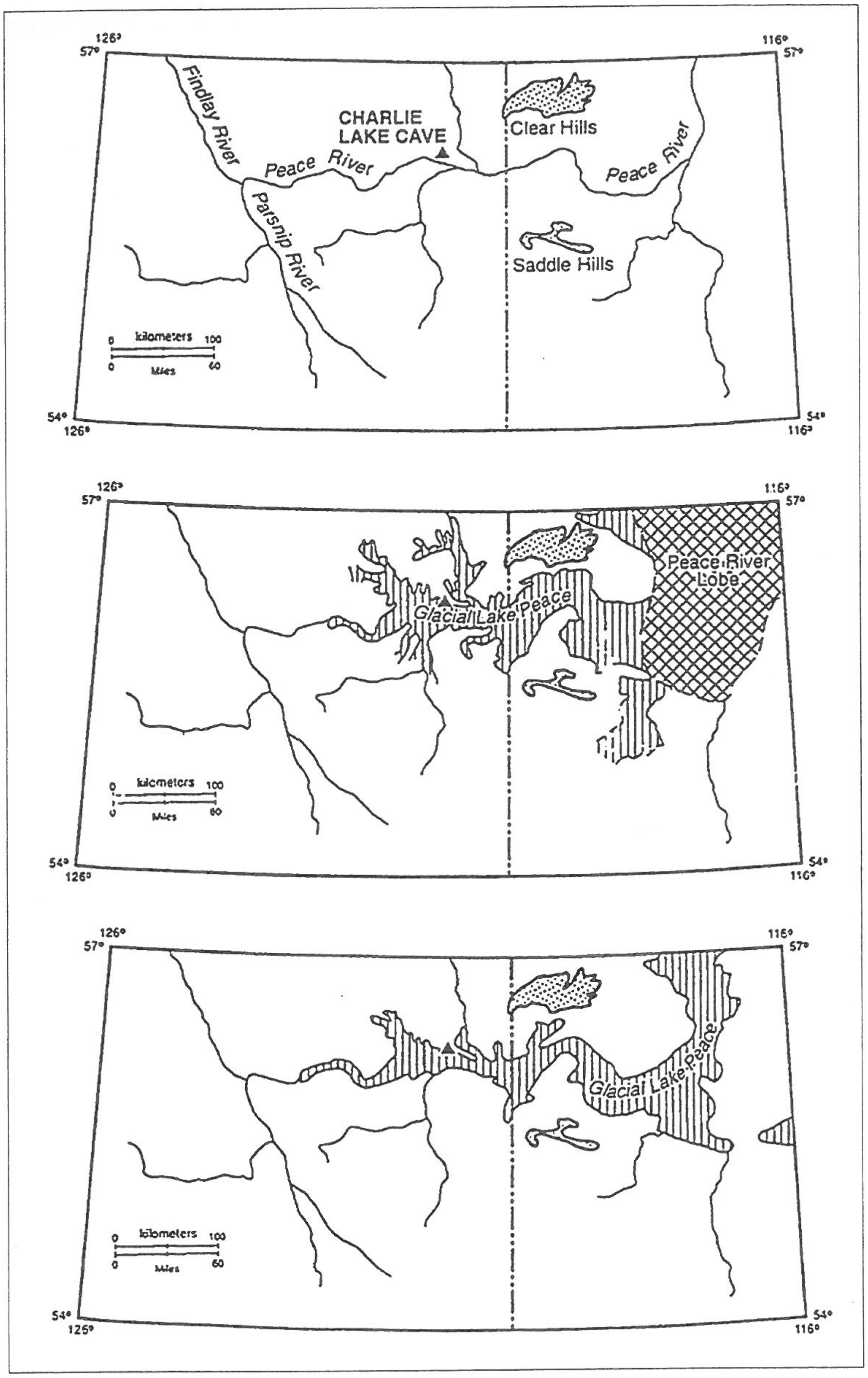


Figure 1. Location of Charlie Lake Cave in relation to modern topography (upper), Glacial Lake Peace, early Clayhurst Stage (middle), and Glacial Lake Peace, Indian Creek Stage (lower). Data from Mathews (1980).

A few identifications require further comment. Almost all lagomorphs at Charlie Lake Cave are identified as *Lepus americanus* (snowshoe hare), and this species dominates the mammal assemblage in most periods (Driver 1988). This species is distinguished from some other *Lepus* because it is much smaller, and differs from others of similar size *Sylvilagus* (cottontail rabbits) in cranial morphology. Measurements of selected post-cranial elements throughout the 10,500 year sequence show that a few early specimens are too large to be from *L. americanus*, and these are described as "large hare" in Table 1. In both size and morphology these may be from either arctic hare (*L. arcticus*) or one from one of the jackrabbits (*L. townsendii* or *L. californicus*).

As discussed elsewhere (Driver 1988) ground squirrels (*Spermophilus* sp.) are not identified to species, but most closely resemble *S. richardsonii* and *S. columbianus*. Collared lemming (*Dicrostonyx torquatus*) was identified from a single tooth in the identified sample. However, a complete mandible with associated teeth was found in a search of unanalyzed material from another excavation unit. Identification criteria are discussed elsewhere (Driver in press a).

FAUNA FROM SUBZONES IIA AND IIB

As there are very little fauna from Subzone IIa, and as the one radiocarbon date from this subzone is in the same range as the dates from Subzone IIb, the two subzones are considered together here. The earliest faunas from Charlie Lake Cave are notable for the presence of various animals which do not live in the Peace River region today, suggesting that environmental conditions were different from the boreal forest environments characterizing much of the Holocene in northern British Columbia. The only large mammal is *Bison*. The absence of bison cranial material precludes species identification, but limb bone measurements show it was significantly larger than modern species (Driver 1988). Although bison were present in the Peace River region until historic times, and while they are represented throughout the Charlie Lake Cave sequence, other artiodactyls such as deer, moose and elk are usually associated with them (see Stephenson et. al., this volume). The absence of cervids suggests a more open environment. Snowshoe hare (*Lepus americanus*) is poorly represented in the IIa/IIb fauna, co-occurring with larger specimens of *Lepus*, either a jackrabbit or Arctic hare. While snowshoe hare becomes very common in succeeding stratigraphic zones, the large hares disappear; only snowshoe hare is found in the region today. As all modern large *Lepus* species in North America prefer open habitats, it is likely that the large species from Charlie Lake Cave had similar habitat preferences. The dominant small mammal in IIa/IIb is *Spermophilus*. Although not all ground squirrels are associated with open environments, the Charlie Lake Cave specimens are closest to *S. richardsonii* or *S. columbianus*, both of which are found today in grasslands to the south of Charlie Lake Cave. *Dicrostonyx torquatus*, the collared lemming, is today confined to tundra habitats in the far north, although in Late Pleistocene times it was found to the south of the ice sheets (Mead and Mead 1989).

The bird assemblage is dominated by two species. Cliff swallow (*Hirundo pyrrhonota*) probably nested at the site; colonies are still found on sandstone cliffs around Charlie Lake today. Raven (*Corvus corax*) has a high NISP value (Table 1) because an almost complete skeleton was recovered from Subzone IIb. It is possible that this specimen was deposited at the site by people (Driver In press, b). In comparison with the later avian assemblages, water birds are notably lacking from the lowest fauna. The presence of woodpecker does suggest some tree cover in the area.

The combined fauna from IIa/IIb is not found as a living community today, because it contains species which are typical of areas to both the north and the south of the modern boreal forest. Ground squirrels are probably from a species found today in areas south of the boreal forest, while the lemming is now found to the north. The large lagomorph could be northern or southern, depending on whether it is a jackrabbit or Arctic hare. This mixture of "southern" and "northern" species has been reported many times for late glacial faunas (e.g. Lundelius *et al.*. 1983; Graham *et al.*. 1987; Graham 1992; FAUNMAP 1996). The absence of water birds is a notable contrast with later assemblages, and may suggest either that migratory routes were not well established, or that there were few productive local aquatic habitats.

FAUNA FROM SUBZONES IIC AND IID

The greater richness of the later Zone II assemblages is in part due to the increased size of the faunal sample. As can be seen from Table 1, larger assemblages have more identified taxa. Nevertheless, there are both quantitative and qualitative changes which suggest that an environmental change occurred at about 10,000 B.P. The variety of waterbirds suggests that productive aquatic habitats were established near the site. The birds represented are all found in the area today, and include western grebe, horned grebe, mallard, teal, ruddy duck, coot, and a rail. Among the upland birds, cliff swallow continues and grouse appears. A short-eared owl is represented by the bones of one foot. Ground squirrels remain an important part of the fauna, but snowshoe hare increases significantly, suggesting that forested environments were occupying increasingly more of the region around the site. Bison persists as the only large artiodactyl species.

FAUNA FROM SUBZONE IIIA

Trends begun in IIc and IId continue in IIIa. Aquatic mammals such as beaver and muskrat appear. Snowshoe hare dominates the small mammal assemblage, and ground squirrel disappears by the end of this subzone. An unusual occurrence is passenger pigeon, which appears by 9,000 B.P. and persists until historic times (Driver and Hobson 1992). By 9,000 B.P. the vertebrate fauna from the site consists entirely of species which could be found in the Peace River region in historic times, and suggests that a boreal forest with local wetlands was present.

TAXON		IIa, IIb	IIb/c	IIc, IId	IIIa	TOTAL
Aechmophorus sp.	Western or Clark's Grebe			7	7	14
Podiceps auritus	Horned grebe			10	4	14
Anas platyrhynchos	Mallard			1		1
Anas sp.	Tea’			1		1
Oxyura jamaicensis	Ruddy duck			1		1
Tetraonidae	Grouse		10	3	7	20
Fulica americana	Coot			11	1	12
Rallidae	Virginia or Sora rail			2		2
Ectopistes migratorius	Passenger Pigeon				1	1
Asio flammeus	Short-eared owl			8		8
Picidae	Woodpecker	1				1
Corvus corax	Raven	59		1		60
Hirundo pyrrhonota	Cliff swallow	5		20	1	26
Lepus sp.	Large hare	3		1		4
Lepus americanus	Snowshoe hare	2	44	201	167	414
Clethrionomys gapperi	Gapper's red-backed vole			3	2	5
Dicrostonyx torquatus	Collared lemming	1				1
Ondatra zibethicus	Muskrat				8	8
Peromyscus sp.	Deer mouse	1	2	1	1	5
Marmota sp.	Woodchuck/marmot	1		2	1	4
Eutamias sp.	Chipmunk				2	2
Spermophilus sp.	Ground squirrel	54		169	7	230
Sciuridae		5		3		8
Castor canadensis	Beaver				9	9
Canis sp.	Wolf-size canid			6		6
Canidae		2				2
Mustela nivalis	Least weasel				2	2
Mephitis mephitis	Striped skunk				1	1
Mustelidae	Weasel			1		1
Bison sp.	Bison	20	4	30	4	58
TOTAL		154	60	482	225	921
No. of discrete taxa		12	4	20	17	

Table 1. Identified fauna from Zone II and Subzone IIIa, Charlie Lake Cave, 1983 and 1990/1991 seasons.

MICROSTRATIGRAPHIC FAUNAL TRENDS

Zone II deposits are over one meter thick on the south side of the gully where vertebrate accumulations are relatively dense and bone preservation is quite good. The combination of abundant fauna and deep stratigraphy allows one to look at faunal changes in more detail than is revealed in the faunas organized by stratigraphic zones. Three excavation units have been selected for more detailed examination, because they combine abundant fauna, good stratigraphy, and a sequence of radiocarbon dates on animal bone. These are unit 3, excavated in 1983, and units 26 and 28, excavated in 1990 and 1991. The Zone II deposits in unit 3 were excavated in a series of arbitrary 10cm levels, and have not been divided into subzones. Unit 3 was close to the rock wall of the gully; because of the angle of the rock, the unit did not reach the lowest part of Zone II. Units 26 and 28 both contain a complete Zone II sequence, although no fauna was recovered from IIa in either unit. These two units were excavated stratigraphically, but some of the thicker layers were also subdivided and excavated in arbitrary levels. Depths below surface and radiocarbon dates allow Unit 3 levels to be correlated with Units 26 and 28.

In order to demonstrate the change from open to forested conditions, the absolute and relative frequency of ground squirrel and snowshoe hare remains are shown in Table 2. The radiocarbon dates are all from the excavation units studied, except the uppermost date which is from a unit adjacent to Unit 28. From about 10,500 to 10,000 B.P. ground squirrel was more common than snowshoe hare, conforming to the overall pattern for IIa/IIb (Table 1). Starting at about 10,000 B.P. there is an increase in the frequency of snowshoe hare relative to ground squirrel, but by about 9700 B.P. ground squirrel has almost completely disappeared and snowshoe hare is dominant. Tree ring calibration is not available for the full range of Zone II dates, but it appears that the transition from open to forested conditions is unlikely to have taken more than 500 calendar years. The following sections place this environmental change in a context of regional geology and palynology.

UNIT	SUBZONE	LAYERS	DATES	HARE NISP	SQUIRREL NISP	%HARE
26+28	IIIa	82-84,86,91	9490+/-140	59	0	100
3	IIIa	14		13	0	100
26+28	IId	93		22	0	100
3	II	15-1,-2		40	0	100
26+28	IIc	98 (upper)	9670+/-150	70	1	99
3	II	15-3,-4,-5		8	7	53
3	II	15-6	9990+/-150	14	35	29
26+28	IIc	98 (lower)		2	28	7
3	II	15-7,-8		1	23	4
3	II	15-9,-10	10100+/-210	0	36	0
26+28	IIb	104		0	18	0
26+28	IIb	105	10290+/-100 10560+/-80	0	14	0

Table 2. Absolute and relative frequencies of snowshoe hare and ground squirrel from excavation units 3, 26 and 28.

REGIONAL GEOLOGY

Mathews (1978) identified Cordilleran and Laurentide tills in the Peace River region, proposing that coalescence of eastern and western ice occurred at about 15,000 B.P. near Fort St. John. More recent work (Catto *et al.*. 1996; Bobrowsky and Rutter 1992) suggests that Cordilleran ice never extended as far east as Fort St. John during the late Pleistocene, and that there was a single late Pleistocene Laurentide advance dating later than 22,000 and earlier than 13,000 B.P. All authors agree that towards the end of the last glaciation Laurentide ice blocked drainage from the Rockies, creating extensive glacial lakes between the Rockies and the Laurentide ice. One of the largest of these lakes was Glacial Lake Peace. The chronology of the various stages of this lake is important for understanding the regional setting of Charlie Lake Cave.

Mathews (1980) has mapped the Glacial Lake Peace shorelines. Just below Charlie Lake Cave is a small remnant of a raised beach, at about 710 meters a.s.l. This elevation places it in Mathews' late Clayhurst stage, bearing in mind that on the Alberta/B.C. border beaches of this period are between 660 and 690 metres, and that there is a 0.4 metre per kilometer rise in elevation from east to west (Mathews 1978:12, 1980:17). All earlier stages of Glacial Lake Peace would have covered Charlie Lake Cave (see Figure 1).

In 1991 we excavated a stratigraphic section on the hill above the site and found a diamicton overlain by rythmites. This presumably reflects the Laurentide advance followed by a high glacial lake. The raised beach below the site is the result of a later, lower lake. Radiocarbon dates from the basal layers of Charlie Lake Cave average about 10,500 B.P., and are taken on terrestrial birds and mammals. Thus, all stages of Glacial Lake Peace prior to the late Clayhurst Stage must pre-date 10,500 B.P.

If Charlie Lake Cave was occupied when the raised beach below the site was being formed (late Clayhurst Stage), the site would have been situated at the end of a peninsula bounded to the west by a narrow arm of the lake, and to the east and south by extensive stretches of water. A similar situation, with less extensive water would have occurred during the Indian Creek stage which follows the late Clayhurst Stage (Figure 1, lower). Fladmark (1986:18-23) proposed this configuration for the earliest occupation at the site, suggesting that bison might have forded the shallow lake where it narrowed below the site, allowing hunters to ambush them as they emerged from the lake. However, new radiocarbon dates show that it is possible that Glacial Lake Peace had already drained prior to the occupation of Charlie Lake Cave, and that the Peace River was once again following its long-established drainage route.

Radiocarbon dates averaging 10,500 B.P. have been obtained on an articulated bison skeleton from terrace gravels within the Peace River valley near the Alberta/B.C. border (Apland and Harington 1994). The terrace gravels were deposited after the lowest stages of the glacial lake had drained. These dates are very similar to the radiocarbon dates from the base of Charlie Lake Cave, suggesting that the first occupation might have taken place after the drainage of the glacial lake. Based on available data, it appears that life did not return to the Peace River region until the drainage of Glacial Lake Peace, at about 10,500 B.P. However, there must have been a period of at least some centuries to develop an ecosystem capable of supporting bison herds and viable human social groups. There is currently no evidence for this from vertebrate fossils, but some palynological sequences provide relevant data.

REGIONAL PALYNOLOGY

Regardless of the status of the glacial lake, all elevations above Charlie Lake Cave must have supported terrestrial flora and fauna before the first human use of the site at 10,500 B.P. Although no pollen was preserved at Charlie Lake Cave, two palynological studies in nearby regions document a post-glacial sequence leading from open to forested environments. To the northeast, MacDonald's (1987) analysis of two lakes in the Clear Hills suggests a sparse post-glacial vegetation consisting of deciduous trees and shrubs such as aspen, birch and willow in association with herbs and grasses. Spruce arrived by 10,000 B.P. and was a dominant species by 9,800 B.P. in a boreal forest somewhat similar to today's northern boreal forest, although with a different species composition. To the southeast, a study of the Saddle Hills records similar early post-glacial vegetation, but both spruce and pine appear as early as 11,200 B.P. (White and Mathewes 1986). The Charlie Lake Cave dates and vertebrates suggest a somewhat later appearance of coniferous forest, with dates similar to those in the Clear Hills cores.

Most palynological sequences in previously glaciated areas situated along a 500 km wide area east of the Rockies show a similar post-glacial sequence of pioneering, colonizing non-coniferous vegetation succeeded by a coniferous forest (Driver 1998). It was into this early open environment that the first large mammals and humans migrated at the end of the Pleistocene. Although pollen deposition rates are low, for example, 1000 grains per cm2 per year in the early stages of the Clear Hills lakes, these rates are largely for non-arboreal taxa. As Guthrie (1985) pointed out, influx rates for pollen depend not only on biological productivity, but also on the types of plants represented. A comparison of influx rates for late Pleistocene/early Holocene samples in the Peace River region with modern Canadian prairie grasslands demonstrates similar rates for non-arboreal taxa, suggesting that the early vegetation communities may have been quite productive.

HUMAN ACTIVITIES AT CHARLIE LAKE CAVE COMPONENTS 1 AND 2

Three cultural components occur in Zone II and Subzone IIIa at Charlie Lake Cave (Driver *et al.* 1996; Handly 1993). Each component is defined by a relatively small number of artifacts and animal bones, and may represent only a few hours or days of human activity. The two lowest components, 1 and 2, are characterized by chert and quartzite stone tools, debitage from resharpening, and butchered bison bone. Component 1 dates to about 10,500 B.P. and Component 2 to about 10,000 B.P. The artifact inventory for both components includes carefully made chert artifacts, such as a projectile point and convergent scraper, and much larger quartzite artifacts which probably functioned as butchering tools, possibly for smashing bones to extract marrow (Driver at al. 1996). None of these artifacts were made on site, and the lack of debitage from tool manufacture suggests that hunters had "geared up" for a kill by preparing tools and implements elsewhere. Most of the quartzite artifacts could have been made expediently, and it is likely that they were discarded after a single use. Just over 100 specimens identified as either *Bison* or large artiodactyl were recovered from Zone II (Components 1 and 2) at Charlie Lake Cave (Table 3).

Determination of the precise number of specimens depends upon fragments that can be fitted together are counted. NISP figures in Table 3 count every specimen separately. MNE figures estimate the minimum number of complete elements required to account for all specimens recovered. As it is not known how many bison kills occurred at the site, the entire assemblage from Zone II is considered here. (Note that the specimens described here are from all Zone II deposits, not just those selected for detailed faunal analysis, and include specimens identified as large artiodactyl as well as bison. This is why the sample size is larger than the total for bison in Table 1).

The bison bones were recovered from fine grained sediments deposited in and around large boulders in Zone II. Preservation conditions were excellent in the southern half of the site where specimens seem to have been buried rapidly. Some indication of the excellent preservation is demonstrated by the recovery of fairly fragile bones such as a newborn calf's innominate or unfused epiphyses of

ELEMENT	NISP	MNE	CARNIVORE	CUTMARK
Cranium	9	1		
Teeth	3	3		
Cervical	1	1		
Thoracic	6	1	1	
Sacrum	1	1	1	
Vertebra	1	1		
Rib	3	1	2	1
Scapula	1	1		
Innominate	4	2	4	
Humerus	5	2	3	2
Radius	9	3	4	
Ulna	2	2	2	1
Carpal	11	11	3	
Metacarpus	3	2	1	
Metacarpus V	1	1		
Tibia	11	4	5	
Lat. mal/	2	2		
Tarsal	5	5	4	
Metatarsus	3	1	1	1
Metapodial	1	0		
Prox. phalanx	4	4	1	
Med. phalanx	9	9	4	
Dist. phalanx	8	8	3	
Sesamoid	4	4		
TOTAL	107	70	39	5

Table 3. Bison and large artiodactyl specimens from all Zone II deposits.

subadults. Another indicator of excellent preservation is the recovery of tracheal rings from the raven skeleton in Subzone IIb. Towards the northern side of the gully preservation was poor, although the number of bones recovered was conspicuously smaller. This is due to the greater amount of groundwater to the north, which seems to have leached bone from the sediments. The number of bison specimens per square metre in different areas of the gully gives some idea of the relative density of bones across the site. In the north the average is about 4 specimens per square metre, while in the centre it is 18, and in the south 12.

Because of good preservation conditions, surface modification of bone is easily seen and characterized. There is no evidence for significant abrasion resulting from transport by water. Bones are typically well preserved with sharply defined features. There is little evidence for weathering of bone surfaces, suggesting that the bones were buried rapidly. There is no evidence for differential weathering of upper and lower surfaces of the bones, which also suggests rapid burial.

Some bones were modified by people and animals prior to burial. Rodent activity is present, but very rare. However, just under 40% of the bison specimens exhibit traces of carnivore activity (Table 3), typically involving chewing of long bone ends, with punctures, furrows and crenulated edges (Binford 1981).

Cutmarks produced by stone tools attest to human interest in these bones (Fladmark *et al.* 1988). Cut marks have been found mainly on the forelimb - two examples on the humerus and one on the ulna suggest disarticulation of. the elbow. Cutmarks were also observed on a rib and a metatarsus Some bison bones were definitely transported to the gully as articulated sets of limb bones:

1) A complete ulna, radius and two carpals from an immature animal. It is likely that some immature phalanges are also from this specimen. This forelimb was scavenged by carnivores which chewed some of the carpals and phalanges and appear to have destroyed the metacarpus;
2) A largely complete ulna (with olecranon removed by carnivores), a radius smashed in the midshaft to obtain marrow, and four articulating carpals;
3) Four articulating carpals which cannot be fitted to any existing radius;
4) A complete forefoot, from the distal metacarpus down.
5) A proximal metatarsus and navicular-cuboid.
6) Various pairs of phalanges;
7) Complete tibia and lateral malleolus.

A significant proportion of bison bones arrived at the site as articulated portions of lower limbs, suggesting relatively little time between the death of the bison and deposition at the site. High frequency of carnivore damage might suggest bone transport by carnivores, but the close spatial association between stone artifacts and bison bones means that deposition by people is more likely. Because the gully was narrow, with a steep uneven floor, it is possible that people did not occupy the gully, but disposed of artifacts and bones into the gully from the hillside above. As discussed elsewhere (Driver, In press b) there may have been some ritual deposition taking place at the site, but much of the bison bone shows evidence for having been defleshed and broken for marrow before being deposited and before being damaged by carnivores.

Element frequencies are weighted towards the lower limbs. NISP and MNE figures show that the lower limbs are well represented when compared to the axial skeleton (Table 3). Element frequencies may be skewed from the expected distribution of elements by either cultural or natural processes (Lyman 1994). We must therefore ask whether the small sample of bison bones from the site owe their pattern of element representation to human behaviour or to natural processes. In other words, does the preponderance of lower limb bones reflect what was originally discarded by people, or have carnivores and other natural processes removed or destroyed other areas of the skeleton, leaving lower limbs as a residue?

One way of considering this is to look at bone density. Both carnivores and abiotic processes (such as weathering) typically destroy weaker and less dense bones first. Kreutzer (1992) has examined volume densities of modern bison bone in the belief that density measured in this way should be correlated with strength to withstand various mechanical and chemical weathering processes. If complete bison skeletons had been deposited at the site, it should be possible to see if low density bones occur in lower than predicted frequencies. However, because the original assemblage of bison bones at the site may not have consisted of all parts of the skeleton, this method cannot be used.

If we assume that the original sample of bison bones at the site did not consist of a representative sample of all elements of the skeleton, then we must develop predictions about how such an assemblage would be affected by processes which selectively removed weaker or less dense bones. In view of the good preservation of specimens and the lack of weathering, these predictions should concentrate on carnivore activity which is abundantly represented on the bones. The following predictions can be tested on the assemblage, but the small sample makes interpretation difficult. First, if low overall frequency of cranial and axial specimens is the result of carnivore destruction, then stronger and denser parts of the axial skeleton should be present.

Second, if carnivores have attacked lower limbs (as surface modification shows), there should be a preponderance of high density specimens and reduced numbers of lower density bones, and this pattern should be most obvious if carnivores have worked on the assemblage intensively. Third, for elements which are common in the assemblage, low density parts of the bones should be preferentially removed, leaving higher density parts intact.

The first prediction fails. The parts of the cranial area most likely to survive are teeth and parts of the mandible (Kreutzer 1992 Table 2). Teeth are underrepresented, and no portions of the mandible are present, even though volume densities of the mandible are similar to the tibia and radius, which are well represented. Furthermore, other areas of the axial skeleton, notably axis and atlas vertebrae, contain high density bone which should survive, but which is not found in the Charlie Lake Cave assemblages. Other parts of the axial skeleton with densities comparable to surviving limb bones include the scapula and parts of rib shafts, both of which are poorly represented.

The second prediction considers the limbs as a whole. There is some evidence to support the prediction that carnivores should selectively remove low density bones. The least dense of the major limb bones are the proximal humerus, and proximal and distal femur (Kreutzer 1992). No femur fragments were recovered, and only one fragment of proximal humerus (Table 4). These areas are high in bone grease (Brink 1997, see also Brink this volume) and therefore particularly likely to attract carnivores (e.g. Garvin 1987; Haynes 1982). It possible that upper limbs were deposited, but that carnivores selectively destroyed some specimens. However, the absence of any femur shaft fragments may mean that no femora were deposited in this area of the site.

ELEMENT	MN ENDS*	DENSITY**	FAT%***
Prox. humerus	1	.24	40.5
Dist. humerus	2	.38	22.0
Prox. radius	3	.38	(32.7)
Prox. ulna	2	.34	(32.7)
Dist. radius	3	.35	25.7
Prox. metacarpus	0	.59	8.9
Dist. metacarpus	1	.46	15.2
Prox. femur	0	.31	31.4
Dist. femur	0	.26	35.2
Prox. tibia	2	.41	33.5
Dist. tibia	4	.41	14.4
Prox. metatarsus	1	.52	12.4
Dist. metatarsus	1	.48	22.7

* minimum number of long bone ends, ** based on Kreutzer (1992) volume densitites, *** based on Brink (1997) combined value for proximal radius and ulna

Table 4. Element frequencies for bison and large artiodactyl limb bone ends.

The third prediction considers the relative representation of different parts of certain skeletal elements. Binford (1981) first suggested this method as a way of identifying assemblages affected by carnivores. Binford's work suggested that carnivores would preferentially attack less dense, more fatty long bone ends. Long bones with one end less dense than the other should show differential survival of the two ends. The two most common long bones at Charlie Lake Cave are tibia and radius. As measured by Kreutzer (1992), bone volume densities are similar for proximal and distal ends of both bones. However, fat content in these two long bones ranks them in the following order: proximal tibia, proximal radius/ulna, distal radius/ulna, distal tibia (Brink 1997 Table 1).

Following the same sequence of skeletal elements, figures for Charlie Lake Cave bison are 2, 2.5, 3 and 3 (Table 4). (Because Brink considered ulna and radius together, I have added Charlie Lake proximal radius and proximal ulna together and divided by two to reach the 2.5 value. If only proximal ulna is counted, this region is less well preserved). Thus, there is some evidence that the ends of bones most attractive to carnivores have been preferentially scavenged. However, we must also note that bones of comparable density but with a lower fat content (e.g. distal metacarpus and distal metatarsus) are more poorly represented than either tibia or radius. It may be that the assemblage is too small to discern clear patterns of carnivore activity at this level of detail, or that carnivore activity was not sufficiently intense to create a clearly defined pattern of damage

One cannot account for the differential representation of skeletal elements simply as a function of bone density or carnivore behavior. The disparity between the relatively well preserved limb elements, including some neonatal and juvenile material, and the almost complete absence of axial material cannot have been caused by natural processes such as carnivore activity and differential weathering, because high density axial elements are missing and some lower density limb bones are present. The high representation of limbs is probably the product of the original human discard activity, although carnivores may have selectively removed the weakest and fattiest limb bones - both ends of the femur and the proximal humerus. It should also be noted that assemblages which have been impacted heavily by carnivores contain high proportions of long bone diaphyses and splinters (Binford 1981; Haynes 1982), which is not the case at Charlie Lake Cave.

The cultural context in which the discard of articulated limb portions and artifacts occurred is difficult to establish on a small sample recovered from a restricted excavation area. From the end of the Pleistocene until the nineteenth century bison hunting was the primary way of life for the inhabitants of the grasslands of interior western Canada. The earliest human use of Charlie Lake Cave took place in an open environment in which, on the basis of paleontological evidence, bison were the most common large mammal (e.g. Churcher and Wilson 1979). It is not unexpected that bison hunting should have been important until boreal forest was established (see, however, Stephenson *et al.*. this volume). The bison assemblage and artifacts are consistent with material discarded at other bison kill sites.

Artifacts were brought to the site ready to use, and were discarded after use. There was little artifact manufacture taking place, although some resharpening occurred. Larger quartzite artifacts were probably used for smashing bones for marrow extraction, and impact points and spiral fractures on bones attest to this activity. Bone was not heavily processed, and there was patterned discard of skeletal elements, with this area of the site dominated by bones of the middle and lower limbs.

HUMAN ACTIVITIES AT CHARLIE LAKE CAVE COMPONENT 3

The third component is associated with Subzone IIIa, dating to about 9500 B.P. The main features of this component are (a) a large number of retouch flakes which suggest that at least two bifaces were resharpened, (b) another largely complete raven skeleton, and (c) a wedge-shaped microblade core associated with the skeleton. (Note that this raven skeleton does not appear in the totals in Table 1 because it was recovered from a unit in which the microfauna was not analysed in detail). The core is illustrated in Driver *et al.* (1996) and the raven is discussed in more detail elsewhere (Driver In press, b). By this time the site may have functioned as a lookout or game monitoring station where bifaces were prepared. The raven and microblade core may have been cached temporarily and abandoned, or they may have been deposited deliberately for ritual reasons.

CONCLUSION

The early deposits at Charlie Lake Cave contain some evidence about the people who first inhabited the post-glacial landscapes of western Canada, and some indications of the nature of the environment in which they lived. The early faunas contain a mixture of northern and southern species, but all seem to indicate a fairly open environment quite different from the boreal forest which developed between 10,000 and 9500 B.P. The lowest two components at Charlie Lake Cave were created during episodes of bison hunting and butchering. We do not have enough data to state whether bison were killed at the site, or whether the site contains refuse dumped into the gully from a nearby kill or processing area.

Archaeological sites dating earlier than 10,000 B.P. are very scarce in western Canada, and those with any quantity of faunal remains are rare (Driver 1998). Charlie Lake Cave and the Vermilion Lakes site near Banff (Fedje *et al.*. 1995) show that big game hunting was an important component of the early economy, and the short-lived open environment of the post-glacial period may have been very attractive to mobile hunter-gatherer bands who probably moved north along the eastern flanks of the Rocky Mountains between 11,500 and 10,500 B.P.

REFERENCES CITED

Apland, B. and C.R. Harington
1994 Pleistocene Bison Skeleton (*Bison bison cf. occidentalis*) from Clayhurst Crossing, British Columbia. *Geographie physique et Quaternaire* 48(2):213-223.

Binford, L.R.
1981 *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

Bobrowsky, P. and N. Rutter
1992 The Quaternary Geologic History of the Canadian Rocky Mountains. *Geographie physique et Quaternaire* 46(1):5-50.

Brink, J.W.
1997 Fat Content in Leg Bones of *Bison bison*, and Applications to Archaeology. *Journal of Archaeological Science* 24: 259-274.

Catto, N., D.G.E. Liverman, P.T. Bobrowsky and N. Rutter
1996 Laurentide, Cordilleran and Montane Glaciation in the Western Peace River-Grande Prairie Region, Alberta and British Columbia, Canada. *Quaternary International* 32:21-32.

Churcher, C.S. and M. Wilson
1979 Quaternary Mammals from the Eastern Peace River District, Alberta. *Journal of Paleontology* 53(1):71-76.

Driver, J.C.
1988 Late Pleistocene and Holocene Vertebrates and Palaeoenvironments from Charlie Lake Cave, Northeast British Columbia. *Canadian Journal of Earth Sciences* 25:1545-1553.

1996. The Significance of the Fauna from Charlie Lake Cave. In *Early Human Occupation in British Columbia*, edited by R. Carlson and L. Dalla Bona, pp. 21-28. University of British Columbia Press, Vancouver.

1998 Human Adaptation at the Pleistocene /Holocene Boundary in Western Canada, 11,000 to 9000 BP. *Quaternary International* 49/50:141-150.

In press (a) Late Pleistocene Collared Lemming (*Dicrostonyx torquatus*) from Northeastern British Columbia, Canada. *Journal of Vertebrate Paleontology*

In press (b) Raven Skeletons from Paleoindian Contexts, Charlie Lake Cave, British Columbia. *American Antiquity*

Driver, J.C., M. Handly, K.R. Fladmark, D.E.Nelson, G.M. Sullivan and R. Preston
1996 Stratigraphy, Radiocarbon Dating, and Culture History of Charlie Lake Cave, British Columbia. *Arctic* 49(3):265-277.

Driver, J.C. and K.A. Hobson
1992 A 10,500 Year Sequence of Bird Remains from the Southern Boreal Forest Region of Western Canada. *Arctic* 45(2):105-110.

FAUNMAP Working Group
1996 Spatial Response of Mammals to Late Quaternary Environmental Fluctuations. *Science* 272:1601-1606.

Fedje, D.W., J.M. White, M.C. Wilson, D.E. Nelson, J.S. Vogel, and J.R. Southon
1995 Vermilion Lakes Site: Adaptations and Environments in the Canadian Rockies During the Latest Pleistocene and Early Holocene. *American Antiquity* 60:81-108.

Fladmark, K.R.
1986. *British Columbia Prehistory*. National Museums of Canada, Ottawa.

1996 The Prehistory of Charlie Lake Cave. In *Early Human Occupation in British Columbia*, edited by R. Carlson and L. Dalla Bona, pp. 11-20. University of British Columbia Press, Vancouver.

RISE AND FALL OF THE BERINGIAN STEPPE BISON

BETH SHAPIRO & 26 OTHERS

This article was reprinted with permission from the American Association for the Advancement of Science. We kindly thank the publisher for permission to reproduce this work.

This article explores the movement of North American bison and the special significance of Tse'K'wa in this research, shedding insight into how the first Paleoindian peoples of Canada arrived at the land. One of the fascinating aspects about archaeology today is the speed with which new scientific techniques are developed and applied to archaeological materials. This paper demonstrates why it is so important to keep material safely stored after it has been excavated – because you never know when it will be valuable to a future researcher or when it can yield new information about the past.

Quite a few years after the excavations at Tse'K'wa were finished I was approached by Alan Cooper and Beth Shapiro of Oxford University about the possibility of sampling early bison bones from the site, to see if they still had DNA preserved. Beth was writing her doctoral thesis on the evolution of bison, and she was being supervised by Alan, a highly accomplished researcher into ancient DNA. It turned out that the Tse'K'wa bison were well preserved, and Beth was able to extract DNA and include it in the study of hundreds of samples from North America and Asia. As an added bonus, Beth and Alan arranged for radiocarbon dates to be run on every bone they studied.This added to our understanding of the age of the site's earliest material.

Beth summarized her doctoral research in this paper, published in the very prestigious journal "Science". The many contributors to her research were listed as co-authors, recognizing that each of us had contributed in a small way to the research, by sharing samples and ideas. While the paper mainly deals with Beth's conclusions about the evolutionary history of bison, for those interested in Tse'K'wa and the history of the early peoples of Canada, there was a fascinating tidbit of information contained in the Tse'K'wa bison DNA – they were from two quite distinct populations.

To understand the significance of this, we must first consider the impact of the extensive ice sheets that formed across Canada about 20,000 years ago. The ice sheets separated North American bison into two populations. One group of bison herds lived to the south of the ice sheets, in what is today, the continental USA and very southern parts of Saskatchewan, Alberta and B.C. The other population lived in unglaciated regions of, what is today, Yukon, Alaska and northeast Asia. These two populations can be distinguished by minor differences in their DNA. When Beth studied the bison fossils from across the vast region of their ice-age distribution she found that in every location except one the bison were either northern or southern types. The one exception was Tse'K'wa where bison from both the north and south were found.

The explanation for this seems fairly straightforward. When the western Canadian ice sheets melted and new pastures were developed, northern bison began to move south through the Yukon and into northern and central BC and Alberta. At the same time, the southern bison began to move north, also following pastures that developed on the recently de-glaciated landcapes. Finally, the northern and southern populations met in the Peace River region. There is no evidence that they bred with each other, and, based on the genetics of modern bison in North America it appears that the southern form survived and evolved into the bison we are familiar with today.

The Tse'K'wa data suggest the meeting of bison populations must have occurred around the same time the site was first occupied by humans, as it is very unlikely that two genetically distinct populations of bison could have lived in the same environment without interbreeding or one of them becoming extinct. This means the establishment of a viable migration route for animals (and people) from Alaska through Yukon, B.C., Alberta and into continental USA must have happened after the dates of the earliest human presence in the continental USA and South America. Therefore, the first people to enter North America could not have migrated through an ice-free corridor along the eastern slopes of the Rockies. Assuming they entered the Americas during the last ice age, then the most likely route would be down the coast of Alaska and British Columbia. Interestingly, this hypothesis was proposed by the director of the 1983 Tse'K'wa excavations, Knut Fladmark, in a paper published in 1979!

The Tse'K'wa stone artifacts lend support to this scenario. The earliest spear point at the site – the "fluted point" – is stylistically very similar to artifacts found in the south, which date a little earlier than those at Tse'K'wa. This supports the notion that the earliest inhabitants of the site were part of a human population that began to move north (perhaps out of southern Alberta and northern Montana) following the bison herds as they moved north to exploit the newly created grassland environments that formed as ice melted and glacial lakes drained away.

Rise and Fall of the Beringian Steppe Bison

Beth Shapiro,[1,2] Alexei J. Drummond,[2] Andrew Rambaut,[2]
Michael C. Wilson,[3] Paul E. Matheus,[4] Andrei V. Sher,[5]
Oliver G. Pybus,[2] M. Thomas P. Gilbert,[1,2] Ian Barnes,[6]
Jonas Binladen,[7] Eske Willerslev,[1,7] Anders J. Hansen,[7]
Gennady F. Baryshnikov,[8] James A. Burns,[9] Sergei Davydov,[10]
Jonathan C. Driver,[11] Duane G. Froese,[12] C. Richard Harington,[13]
Grant Keddie,[14] Pavel Kosintsev,[15] Michael L. Kunz,[16]
Larry D. Martin,[17] Robert O. Stephenson,[18] John Storer,[19]
Richard Tedford,[20] Sergei Zimov,[10] Alan Cooper[1,2]*

The widespread extinctions of large mammals at the end of the Pleistocene epoch have often been attributed to the depredations of humans; here we present genetic evidence that questions this assumption. We used ancient DNA and Bayesian techniques to reconstruct a detailed genetic history of bison throughout the late Pleistocene and Holocene epochs. Our analyses depict a large diverse population living throughout Beringia until around 37,000 years before the present, when the population's genetic diversity began to decline dramatically. The timing of this decline correlates with environmental changes associated with the onset of the last glacial cycle, whereas archaeological evidence does not support the presence of large populations of humans in Eastern Beringia until more than 15,000 years later.

Climatic and environmental changes during the Pleistocene epoch [from 2 million years ago (Ma) to 10,000 years before the present (ky B.P.)] played an important role in the distribution and diversity of modern plants and animals (*1*, *2*). In Beringia, local climate and geology created an ice-free refugium stretching from eastern Siberia to Canada's Northwest Territories (*3*). Periodic exposure of the Bering Land Bridge facilitated the exchange of a diverse megafauna (such as bison, mammoth, and musk ox) supported by tundra-steppe grasses and shrubs (*3*, *4*). Humans are believed to have colonized North America via this route, and the first well-accepted evidence of human settlement in Alaska dates to around 12 ky B.P. (*5*). The latest Pleistocene saw the extinction of most Beringian megafauna including mammoths, short-faced bears, and North American lions. The reasons for these extinctions remain unclear but are attributed most often to human impact (*6*, *7*) and climate change associated with the last glacial cycle (*8*).

Pleistocene bison fossils are abundant across Beringia and they provide an ideal marker of environmental change. Bison are believed to have first entered eastern Beringia from Asia during the middle Pleistocene [marine oxygen isotope stages (MISs) 8 to 6, circa (ca.) 300 to 130 ky B.P.] and then moved southward into central North America during the MIS 5 interglacial period (130 to 75 ky B.P.), where they were distributed across the continental United States (*9*). During this time, Beringian and central North American bison populations may have been periodically separated by glacial ice that formed over most of Canada (*10*, *11*). The timing and extent of genetic exchange between these areas remain unclear (*2*).

The abundance and diversity of bison fossils have prompted considerable paleontological and archaeological research into their use as stratigraphic markers. Extensive morphological diversity, however, has complicated discrimination between even the most accepted forms of fossil bison, and the lack of stratigraphy in Beringian sites has prevented the development of a chronological context. These complications create a complex literature of conflicting hypotheses about bison taxonomy and evolution (*9*, *12*). After a severe population bottleneck, which ocurred only 200 years ago (*13*), two subspecies survive in North America: *Bison bison bison*, the plains bison, and *B. b. athabascae*, the wood bison (*9*, *13*).

To investigate the evolution and demographic history of Pleistocene bison, we collected 442 bison fossils from Alaska, Canada, Siberia, China, and the lower 48 United States (*14*). We used ancient DNA techniques to sequence a 685–base pair (bp) fragment of the mitochondrial control region (*14*). Accelerator mass spectrometry radiocarbon dates were obtained for 220 samples, which spanned a period of >60 ky (*14*).

The association of radiocarbon dates with DNA sequences enables the calibration of evolutionary rates within individual species (*15*). Bayesian phylogenetic analyses produced an evolutionary rate estimate for the bison mitochondrial control region of 32% per million years (My) [95% highest posterior density (HPD): 23 to 41% per My] (*14*). This estimate is independent of paleontological calibrations but agrees with fossil-calibrated rates for cattle of 30.1% per My (*16*) and 38% per My (*17*). This rate was used to calculate the ages of key nodes in the bison genealogy (*14*). The most recent common ancestor (MRCA) of all bison included in this analysis lived around 136 ky B.P. (95% HPD: 164 to 111 ky B.P.). In the majority (66%) of estimated trees, Eurasian bison cluster into a single clade, with a MRCA between 141 and 89 ky B.P. Although

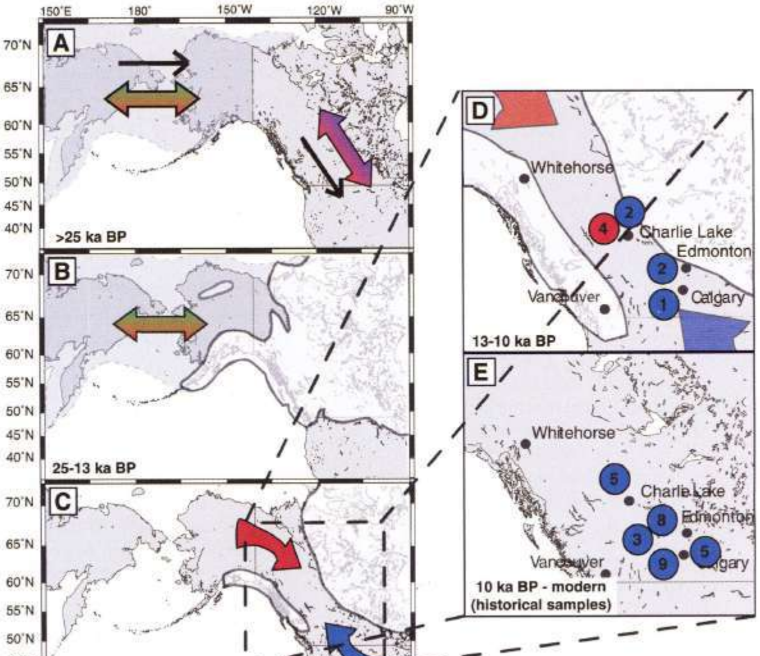


Fig. 1. Distribution of bison in Beringia and central North America through time. (**A** to **C**) Double-headed arrows show gene flow between regions. Black arrows indicate colonization events. Circles in maps (**D**) and (**E**) designate either northern (red) or southern (blue) ancestry and the number of samples from that location.

---

[1]Henry Wellcome Ancient Biomolecules Centre, [2]Department of Zoology, Oxford University, South Parks Road, Oxford OX13PS, UK. [3]Department of Geology and Department of Anthropology, Douglas College, Post Office Box 2503, New Westminster, British Columbia V3L 5B2, Canada. [4]Alaska Quaternary Center and Institute of Arctic Biology, University of Alaska Fairbanks, 900 Yukon Drive, Fairbanks, AK 99775–5940, USA. [5]Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 33 Leninsky Prospect, 119071 Moscow, Russia. [6]The Centre for Genetic Anthropology, Department of Biology, Darwin Building, University College London, Gower Street, London WC1E 6BT, UK. [7]Department of Evolutionary Biology, Zoological Institute, University of Copenhagen, Universitetsparken 15–2100 Copenhagen, Denmark. [8]Zoological Institute, Russian Academy of Sciences, 199034 St. Petersburg, Russia. [9]Quaternary Paleontology, Provincial Museum of Alberta, Edmonton, Alberta T5N 0M6, Canada. [10]North-East Scientific Station of Russian Academy of Science, Post Office Box 18, Cherskii, Republic Sakha-Yakutia, Russia. [11]Department of Archaeology, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada. [12]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2E3, Canada. [13]Canadian Museum of Nature (Paleobiology), Ottawa, Ontario K1P 6P4, Canada. [14]Department of Archaeology, Royal British Columbia Museum, 675 Belleville Street, Victoria, British Columbia V8V 1X4, Canada. [15]Institute of Plant and Animal Ecology, Russian Academy of Sciences, 202 8 Martas Street, Ekaterinburg 620144, Russia. [16]Bureau of Land Management, 1150 University Avenue, Fairbanks, AK 99708 USA. [17]Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS 66045, USA. [18]Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701, USA. [19]Yukon Paleontologist, Heritage Resources, Yukon Department of Tourism and Culture, Box 2703, Whitehorse, Yukon Territory YTY1A 2C6, Canada. [20]Department of Paleontology, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024, USA.

*To whom correspondence should be addressed. E-mail: alan.cooper@zoo.ox.ac.uk

these two estimates overlap, the age of the MRCA of Eurasian bison was the same as that of the root in 4.8% of 135,000 posterior genealogies (with a Bayes factor of 20.83 that the Eurasian MRCA is not also the MRCA of all clades), suggesting that the Eurasian clade is not the oldest in the tree. This suggests that late Pleistocene bison from the Ural Mountains to northern China are descendants of one or more dispersals from North America. Several North American lineages fall within the Eurasian clade, indicating subsequent asymmetric genetic exchange, predominantly from Asia to North America.

Figure 1A depicts inferred gene flow between bison populations in Beringia and central North America during MIS 3 (~60 to 25 ky B.P.), which is the interstadial period before the Last Glacial Maximum (LGM, ca. 22 to 18 ky B.P.). Bison were continuously distributed from eastern Beringia southward into central North America during this period, before the formation of the Laurentide (eastern) and Cordilleran (western) ice sheets created a barrier to north-south faunal exchange. Although any coalescence between these ice masses was brief (*11*), the absence of faunal remains aged 22 to12 ky B.P. (Fig. 1B) (*18*) indicates that the area was uninhabitable by large mammals during this time. Bison fossils in central North America during the LGM are sparsely distributed across the continent (*9*). DNA could be retrieved only from two specimens from this period, both from Natural Trap Cave, Wyoming (20,020 ± 150 and 20,380 ± 90 ky B.P.). These specimens are not closely related (*14*), indicating that populations south of the ice retained some genetic diversity until the LGM.

The ice sheets began to retreat around 14 ky B.P., forming an ice-free corridor (IFC) through which dispersal between Beringia and North America could occur. The first observed bison haplotypes in the IFC are southern in origin (Fig. 1, C and D), with the oldest specimen being in southern Alberta by 11.3 ky B.P., and others near Athabasca, northern Alberta, by 10.4 ky B.P. This finding is consistent with evidence that the first faunal assemblages and archaeological presence in the IFC were southern in origin (*18–20*). The opening of the northern end of the IFC saw a limited southward dispersal of Beringian bison, with a subset of the northern diversity found near the Peace River (northwestern British Columbia) by 11.2 to 10.2 ky B.P. (Fig. 1C) (*14*). Southern bison are also found in this area around 10.5 ky B.P., making it the only location where post-LGM northern and southern clades occurred at the same time. Subsequent genetic exchange between Beringia and central North America was limited by the rapid establishment of spruce forest across Alberta around 10 ky B.P. (*21*) and by the widespread development of peatland across western and northwestern Canada (*22*). North of these ecological barriers, grasslands were reduced by invading trees and shrubs, yet despite the decrease in quality and quantity of habitat (*3*), bison persisted in eastern Beringia until a few hundred years ago (*14*, *23*).

It has been hypothesized that modern bison descended from Beringian bison that moved south through the IFC after the LGM (*9*, *19*) and have since undergone a decline in diversity due to over-hunting and habitat loss (*13*). In contrast, our data show that modern bison are descended from populations that were south of the ice before the LGM and that diversity has been restricted to at least 12 ky B.P., around the time of the megafaunal extinctions. All modern bison belong to a clade distinct from Beringian bison. This clade has a MRCA between 22 and 15 ky B.P., which is coincident with the separation of northern and southern populations by the western Canadian ice barrier. This clade diverged from Beringian bison by 83 to 64 ky B.P. and was presumably part of an early dispersal from Beringia, as indicated by the long branch separating it from Beringian bison (*14*). If other remnants of these early dispersals survived the LGM, they contributed no mitochondrial haplotypes to modern populations.

Coalescent theory is used to evaluate the likelihood of a demographic history, given plausible genealogies (*24*). Under a coalescent model, the timing of divergence dates provides information about effective population sizes through time. To visualize this for bison, a technique called the skyline plot was used (*14*, *25*). The results showed two distinct demographic trends since the MRCA, suggesting that a simple demographic model, such as constant population size or exponential growth, was insufficient to explain the evolutionary history of Beringian bison. We therefore extended the Bayesian coalescent method (*26*) to a two-epoch demographic model with exponential population growth at rate r_{early}, until a transition time, t_{trans}, after which a new exponential rate, r_{late}, applies until the present effective population size, N_0, is reached (Fig. 2A). In this model, both the early and late epochs can have positive or negative growth rates, with both the rates and the time of transition estimated directly from the data.

The analysis strongly supported a boom-bust demographic model (Table 1), in which

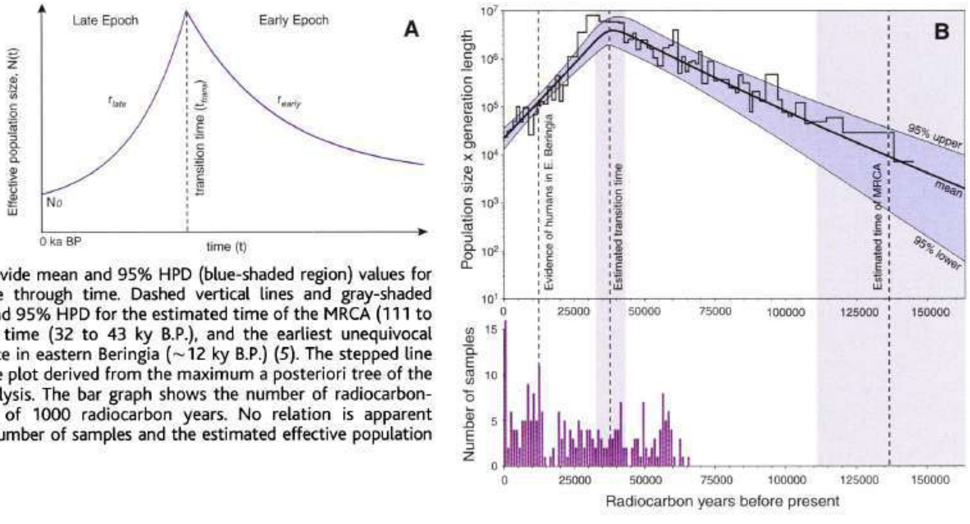


Fig. 2. (**A**) The two-epoch demographic model with four demographic parameters: N_0, r_{early}, r_{late}, and t_{trans}. The effective population size is a compound variable considered linearly proportional to census population size. (**B**) Log-linear plot describing the results of the full Bayesian analyses. Smoothed curves provide mean and 95% HPD (blue-shaded region) values for effective population size through time. Dashed vertical lines and gray-shaded regions describe mean and 95% HPD for the estimated time of the MRCA (111 to 164 ky B.P.), transition time (32 to 43 ky B.P.), and the earliest unequivocal reported human presence in eastern Beringia (~12 ky B.P.) (*5*). The stepped line is the generalized skyline plot derived from the maximum a posteriori tree of the exponential growth analysis. The bar graph shows the number of radiocarbon-dated samples in bins of 1000 radiocarbon years. No relation is apparent between the absolute number of samples and the estimated effective population size or transition time.

Table 1. Results of Bayesian analyses assuming constant population size, exponential growth, and a two-epoch model for the full analysis of 191 bison associated with finite radiocarbon dates (*14*). Model parameters are as defined in (*26*). The large difference between the mean goodness-of-fit statistics [ln(posterior)] indicates that under either the Akaike information criterion or Bayesian information criterion tests, the two-epoch model is a significantly better fit to the data than the simpler models.

	Constant size			Exponential growth			Two epoch		
	Lower	Mean	Upper	Lower	Mean	Upper	Lower	Mean	Upper
Age estimates (yr B.P.)									
Root height	117,000	152,000	189,000	113,000	146,000	181,000	111,000	136,000	164,000
Modern/southern clade	20,200	28,000	36,600	18,600	26,400	35,000	15,400	23,200	32,200
Eurasian clade	85,000	116,000	151,000	83,000	112,000	144,000	89,000	114,000	141,000
Model parameters									
Mean ln(posterior)		−6530.795			−6517.35			−6394.568	
Mutation rate (substitutions/site/year)	2.79×10^{-7}	3.78×10^{-7}	4.85×10^{-7}	2.30×10^{-7}	3.20×10^{-7}	4.13×10^{-7}	2.30×10^{-7}	3.20×10^{-7}	4.13×10^{-7}
Kappa	19	27	37	19	27.4	37	19	27	37
Shape parameter	0.22	0.35	0.49	0.22	0.35	0.49	0.22	0.35	0.5
Proportion of invariant sites	0.33	0.45	0.56	0.33	0.45	0.56	0.34	0.45	0.56

an exponential expansion of the bison population was followed by a rapid decline, with a transition around 37 ky B.P. (Fig. 2B). At the height of the boom, the population size was around 230 times (95% HPD: 71 to 454 times) that of the modern population. When this model is applied to the modern clade alone, a growth period peaks around 1000 years ago (95% HPD: 63 to 2300 yr B.P.) and is followed by a rapid decline (*14*), which is consistent with historical records of a population bottleneck in the late 1800s (*13*). These results illustrate the power of this method to recover past demographic signals.

The effects of population subdivision and patch extinction and recolonization on coalescence patterns have not been fully characterized, yet they can influence demographic estimates such as skyline plots (*27*). To test for the effect of population subdivision on our models, the two-epoch analysis was repeated first without the Eurasian bison and then without both Eurasian and central North American bison. The results of these analyses were consistent with those for the entire data set (*14*), suggesting that the assumption of panmixia does not affect the analysis. These results suggest that the major signal for the boom-bust scenario came from the well-represented eastern Beringian population.

The timing of the decline in Beringian bison populations (Fig. 2B) predates the climatic events of the LGM and events at the Pleistocene-Holocene boundary. The bison population was growing rapidly throughout MIS 4 and 3 (~75 to 25 ky B.P.), approximately doubling every 10,200 (95% HPD: 7500 to 15,500) years. The reversal of this doubling trend at 42 to 32 ky B.P. and the subsequent dramatic decrease in population size are coincident with the warmest part of MIS 3, which is marked by a reduction in steppe-tundra due to treecover reaching its late Pleistocene maximum (*28*). Modern boreal forests serve as a barrier to bison dispersal because they are difficult to traverse and provide few food sources (*3*). After the interstadial, cold and arid conditions increasingly dominated, and some component of these ecological changes may have been sufficient to stress bison populations across Beringia. Previous reports of local extinction of brown bears (*29*) and hemionid horses (*8*) in Alaska around 32 to 35 ky B.P. support the possibility of a larger scale environmental change affecting populations of large mammals.

These results have considerable implications for understanding the end-Pleistocene mass extinctions, because they offer the first evidence of the initial decline of a population, rather than simply the resulting extinction event. These events predate archaeological evidence of significant human presence in eastern Beringia (*5*), arguing that environmental changes leading up to the LGM were the major cause of the observed changes in genetic diversity. If other species were similarly affected, differences in how these species responded to environmental stress may help to explain the staggered nature of the megafaunal extinctions (*7*, *30*). However, it is possible that human populations were present in eastern Beringia by 30 ky B.P., with reports of human-modified artifacts as old as 42 to 25 ky B.P. from the Old Crow basin in Canada's Yukon Territory (*31*). Although the archaeological significance of these specimens is disputed and the number of individuals would be low, the specimens are consistent with the timing of the population crash in bison. This emphasizes that future studies of the end–Pleistocene mass extinctions in North America should include events before the LGM.

Ancient DNA is a powerful tool for studying evolutionary processes such as the response of organisms to environmental change. It should be possible to construct a detailed paleoecological history for late Pleistocene Beringia using similar methods for other taxa. Almost none of the genetic diversity present in Pleistocene bison survived into Holocene populations, erasing signals of the complex population dynamics that took place as recently as 10,000 years ago.

References and Notes

1. G. Hewitt, *Nature* **405**, 907 (2000).
2. R. W. Graham *et al.*, *Science* **272**, 1601 (1996).
3. R. D. Guthrie, *Frozen Fauna of the Mammoth Steppe* (Univ. of Chicago Press, Chicago, 1990).
4. G. D. Zazula *et al.*, *Nature* **423**, 603 (2003).
5. D. R. Yesner, *Quat. Sci. Rev.* **20**, 315 (2001).
6. B. W. Brook, D. Bowman, *J. Biogeogr.* **31**, 517 (2004).
7. J. Alroy, *Science* **292**, 1893 (2001).
8. R. D. Guthrie, *Nature* **426**, 169 (2003).
9. J. N. McDonald, *North American Bison: Their Classification and Evolution* (Univ. of California Press, Berkeley, CA, 1981).
10. C. A. S. Mandryk, H. Josenhans, D. W. Fedje, R. W. Matthewes, *Quat. Sci. Rev.* **20**, 301 (2001).
11. A. S. Dyke *et al.*, *Quat. Sci. Rev.* **21**, 9 (2002).
12. M. F. Skinner, O. C. Kaisen, *Bull. Am. Mus. Nat. Hist.* **89**, 126 (1947).
13. F. G. Roe, *The North American Buffalo*, (Univ. of Toronto Press, Toronto, ON, ed. 2, 1970).
14. Materials and methods are available as supporting material on *Science* Online.
15. D. M. Lambert *et al.*, *Science* **295**, 2270 (2002).
16. D. G. Bradley, D. E. MacHugh, P. Cunningham, R. T. Loftus, *Proc. Natl. Acad. Sci. U.S.A.* **93**, 5131 (1996).
17. C. S. Troy *et al.*, *Nature* **410**, 1088 (2001).
18. J. A. Burns, *Quat. Int.* **32**, 107 (1996).
19. M. C. Wilson, *Quat. Int.* **32**, 97 (1996).
20. J. C. Driver, in *People and Wildlife in Northern North America*, S. C. Gerlach, M. S. Murray, Eds. (British Archaeological Reports, International Series 944, Archaeopress, Oxford, 2001), pp. 13–22.
21. N. Catto, D. G. E. Liverman, P. T. Bobrowsky, N. Rutter, *Quat. Int.* **32**, 21 (1996).
22. L. A. Halsey, D. H. Vitt, I. E. Bauer, *Clim. Change* **40**, 315 (1998).
23. R. O. Stephenson *et al.*, in *People and Wildlife in Northern North America*, S. C. Gerlach, M. S. Murray, Eds. (British Archaeological Reports, International Series 944, Archaeopress, Oxford, 2001), pp. 125–148.
24. R. C. Griffiths, S. Tavare, *Philos. Trans. R. Soc. London Ser. B* **344**, 403 (1994).

25. K. Strimmer, O. G. Pybus, *Mol. Biol. Evol.* **18**, 2298 (2001).
26. A. J. Drummond, G. K. Nicholls, A. G. Rodrigo, W. Solomon, *Genetics* **161**, 1307 (2002).
27. J. R. Pannell, *Evolution* **57**, 949 (2003).
28. P. M. Anderson, A. V. Lozhkin, *Quat. Sci. Rev.* **20**, 93 (2001).
29. I. Barnes, P. E. Matheus, B. Shapiro, D. Jensen, A. Cooper, *Science* **295**, 2267 (2002).
30. D. K. Grayson, D. J. Meltzer, *J. Archaeol. Sci.* **30**, 585 (2003).
31. R. E. Morlan, *Quat. Res.* **60**, 123 (2003).
32. We thank the museums and collections that donated material and T. Higham, A. Beaudoin, K. Shepherd, R. D. Guthrie, B. Potter, C. Adkins, D. Gilichinsky, R. Gangloff, S. C. Gerlach, C. Li, N. K. Vereshchagin, T. Kuznetsova, G. Boeskorov, the Alaska Bureau of Land Management, and the Yukon Heritage Branch for samples, logistical support, and assistance with analyses. We thank D. Rubenstein, R. Fortey, and P. Harvey for comments on the manuscript; Balliol College; the Royal Society; the Natural Environment Research Council; the Biotechnology and Biological Sciences Research Council; Rhodes Trust; Wellcome and Leverhulme Trusts for financial support; and Oxford Radiocarbon Dating Service and Lawrence Livermore National Laboratory for carbon dating.

Supporting Online Material
www.sciencemag.org/cgi/content/full/306/5701/1561/DC1
Materials and Methods
SOM Text
Figs. S1 to S5
Tables S1 to S4
References

4 June 2004; accepted 4 October 2004

Periodical Cicadas as Resource Pulses in North American Forests

Louie H. Yang

Resource pulses are occasional events of ephemeral resource superabundance that occur in many ecosystems. Aboveground consumers in diverse communities often respond strongly to resource pulses, but few studies have investigated the belowground consequences of resource pulses in natural ecosystems. This study shows that resource pulses of 17-year periodical cicadas (*Magicicada* spp.) directly increase microbial biomass and nitrogen availability in forest soils, with indirect effects on growth and reproduction in forest plants. These findings suggest that pulses of periodical cicadas create "bottom-up cascades," resulting in strong and reciprocal links between the aboveground and belowground components of a North American forest ecosystem.

Ecologists are increasingly investigating the effects of resource pulses in natural systems (*1*). Examples of resource pulses include mast years of unusually heavy seed production (*2–4*), eruptive plant growth after El Niño rainfalls (*5–8*), postspawning salmon mortality in riparian communities (*9, 10*), and large-scale insect outbreaks (*3, 11–13*). Despite great variation in the specific characteristics of these resource pulses, each represents a brief, infrequent event of high resource availability. Resource pulses are of broad interest because they provide extreme spatiotemporal variability

namics after ecological perturbations and empirical studies in diverse systems have demonstrated that resource pulses are often substantial perturbations with strong effects on consumer populations, especially among opportunistic generalist species (*1*).

Resource pulses have well-documented effects on aboveground consumers, and they may also provide important inputs to belowground systems (*1, 16*). In many pulsed systems, only a small proportion of resource biomass is consumed aboveground (*17–19*), and aboveground predator satiation during resource pulses could allow large belowground inputs. Many belowground organisms are well-adapted to take advantage of resource pulses because of their high intrinsic rates of growth and rapid foraging responses (*20, 21*). Studies in natural systems support the idea that aboveground resource pulses may contribute to belowground systems. For example, mast events in boreal forests produce large inputs of rapidly decomposed spruce seeds that increase soil nitrogen availability (*22*), and large-scale gypsy moth outbreaks in temperate forests influence nutrient cycling through defoliation and frass deposition (*11*).

s in regulating plant

bodies are an unimpo

mass component (*23*). However, the unusual life history of periodical cicadas suggests that

st

th

Amer umber and biomass (*24*), but their role in forest ecosystems is largely unrecognized because of their long belowground life history. Adult periodical cicadas emerge synchronously across large geographic areas, or "broods," often on a scale of 10^5 km². The spatial distribution of cicadas is highly variable and dynamic on small scales (<1 km) and is influenced by fragmentation in forest habitats (*17, 23–26*). Yet, cicadas are broadly distributed across a large and diverse area, with a cumulative range encompassing much of the eastern United States (fig. S1). Adult cicadas are aboveground for less than 6 weeks (*26*). Cicada emergence densities ranging from 3 to 350 cicadas m^{-2} are well documented (*26*), and most cicadas escape predation at high densities (*17, 18*). Direct measures of cicada densities in 2002 and 2004 support previously reported density estimates (*27*). In dense populations, the cumulative biomass of periodical cicadas is among the greatest of any terrestrial animal (*24*) and represents a substantial flux of high-quality biomass (*23, 28, 29*). Little is known about the belowground effects of this resource pulse.

Here, I investigate the direct belowground and indirect aboveground effects of cicada litter inputs resulting from cicada resource pulses. I conducted field experiments during three con-

Fig. 1. Cicada litterfall increases soil bacterial and fungal PLFAs relative to those of controls, indicating increased microbial biomass. (A) Bacterial PLFAs in cicada-supplemented and control plots 7 and 28 days after experimental cicada pulse. (B) Fungal PLFAs in cicada-supplemented and control plots 7 and 28 days after experimental cicada pulse. Open circles represent control plots, and filled circles represent plots receiving 120 cicadas m^{-2}. Error bars show mean ± SE.

Center for Population Biology, Section of Evolution and Ecology, University of California, One Shields Avenue, Davis, CA 95616, USA. E-mail: lhyang@ucdavis.edu

THE PALEOINDIAN BISON ASSEMBLAGE FROM CHARLIE LAKE CAVE, BRITISH COLUMBIA

JONATHAN C. DRIVER, CLAUDINE VALLIÈRES

We kindly thank the publisher, Canadian Archaeological Association, for permission to reproduce this work.

This paper discusses the bison bones from the lower layers, with a focus on the human behaviour that resulted in them being deposited at the site. Excavations at Tse'K'wa uncovered about 100 late ice age bison bones from the lowest layers. These were certainly brought there by people, because they show signs of having been butchered. Some bones have shallow cut marks (made by stone knives) on their surface. Others have been smashed open to obtain the fatty marrow inside them. (While we tend to avoid it these days, fat is essential for a healthy diet for people who rely heavily on meat. Bone marrow is an excellent source of fat).

Archaeologists have used evidence from animal bones to interpret the activities that take place at a site. For example, kill sites often contain the parts of an animal (such as the heads and the hooves) that were not taken back to camp; on the other hand, campsites are often places where we see intensive processing of bones to extract nutrients, so bones are often found broken into many pieces. This paper is based on the M.A. thesis of Claudine Vallieres, who undertook a detailed study of the bison bones from the early cultural layers at the site.

The Tse'K'wa bison are a bit of a puzzle. The bones don't resemble what is usually found at kill sites, so we know that this isn't a "buffalo jump". The almost complete absence of skulls, backbone and ribs, as well as the low numbers of shoulder and hip bones, suggest that people were mainly bringing bison legs to the site. In particular, the middle and lower parts of the leg seem best represented.

We considered the possibility that other parts of the body had been brought to the site originally, and that all the weakest bones (such as the backbone and ribs) had been destroyed subsequently by scavenging animals (such as wolves or bears) or by natural weathering. While there are some bones that have been chewed by large carnivores, we would expect that at least some harder parts of the “missing” bones would survive – especially the teeth and some of the more dense bones. There is no evidence that bones were subject to destruction by weathering – they are very well preserved and their surfaces show little sign of being exposed to the elements for any length of time. So we concluded that the pattern we were seeing was not the result of weaker bones being destroyed.

We also noted that the evidence from the stone tools was somewhat unusual. We had found quite a number of large, heavy quartzite chopping tools in the same layers as the bison. Interestingly, none of these had been made at the site (there were no stone chips left behind from their manufacture) – so they must have been made elsewhere, brought to the site, used, and then discarded. There were a few smaller, sharper stone tools, but again very little evidence that they had been made there. So people seem to have been bringing bison legs to the site, together with fully finished stone tools, butchering the bison, and then leaving bones and stone tools there.

But there was no evidence that this was a campsite. There was no trace of fire and no evidence for the other tasks that one would expect at a place where people lived, such as manufacture of tools or preparation of hides. Looking through the archaeological literature revealed that ice caves in the western United States were used for thousands of years for meat storage, and both the animal bones and the stone tools in those caves were similar to those found at Tse’K’wa. We therefore proposed that at least some of the bison bones had been stored at the site (perhaps in the cave) during the late fall or winter, as an emergency food supply.

The Palaeoindian Bison Assemblage from Charlie Lake Cave, British Columbia

Jonathan C. Driver[†] and Claudine Vallières[‡]

ABSTRACT. A small assemblage of bison bones from the Palaeoindian (10,700 to 9500 BP) components at Charlie Lake Cave, British Columbia is dominated by elements from the middle and lower limbs. The skeletal element frequencies are not typical of a kill site. The lithic assemblage, the lack of evidence for burning, and the ratio of long bone shaft fragments to epiphyses suggest that the assemblage was not produced at a residential site nor at a specialized processing area. We propose that the assemblage resulted from storage of frozen bison limbs in a series of meat caches, probably located in a small cave that would have been difficult for scavengers to enter.

RÉSUMÉ. Un petit assemblage d'ossements de bison provenant des composantes paléoindiennes (10,700 à 9500 AA) du site Charlie Lake Cave, Colombie-Britannique, est dominé par des éléments des membres inférieurs et moyens. Les fréquences d'éléments squelettiques ne sont pas typiques d'un site de tuerie. L'assemblage lithique, l'absence d'indice de feu, et le ratio entre les fragments de diaphyses d'os longs et les épiphyses suggèrent que l'assemblage n'est ni le produit d'un site résidentiel, ni celui d'une aire de boucherie spécialisée. Nous proposons que cet assemblage reflète l'entreposage de membres de bison gelés dans une série de caches à viande, probablement localisées dans une petite cave, difficilement accessible aux charognards.

CHARLIE LAKE CAVE (CLC) IS ONE of the few archaeological sites in western Canada that has been dated to >10,000 BP (Driver 1998a) and is a rare Canadian example of a Palaeoindian site that contains well-preserved faunal remains in clear association with stone tools. The site location, structure, dating and culture history have been described in some detail in previous publications (Driver *et al.* 1996; Fladmark 1996; Fladmark *et al.* 1988). Most faunal studies of the site have emphasized palaeoecological analysis, notably the marked transition between late Pleistocene and early Holocene faunas (Driver 1988, 1998b, 1999a, 2001). An analysis of raven skeletons has suggested Palaeoindian ritual use of the site (Driver 1999b), but little attention has been paid to the activities represented by other culturally deposited faunal remains. In this paper we discuss the bison bone assemblage dating from about 10,500 to 9500 BP (all dates uncalibrated). We describe the collection, evaluate different hypotheses for the processes that created the assemblage, and suggest some implications for interpretation of Palaeoindian adaptations.

Located in northeastern British Columbia, CLC (HbRf–39) lies to the east of the Rocky Mountains in rolling

---

[†] Department of Archaeology
Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6 [driver@sfu.ca]

[‡] Department of Anthropology, McGill University, 855 Sherbrooke Street W., Montreal, QC H3A 2T7 [Claudine.vallieres@mail.mcgill.ca]

terrain mantled by glaciolacustrine deposits. The site has an unusual topography (Figure 1). Sandstone bedrock outcrops as a low cliff along the side of a hill overlooking a creek. In the cliff is a small cave probably formed by subglacial water exploiting joints in the sandstone. After the formation of the cave, and probably after ice melted and glacial lakes drained, a very large slab of sandstone ("the parapet" in Figure 1) became detached from the vertical cliff face and moved down slope a few meters. The slab remained in an upright position, partly because its base was wider than its apex, and partly because it was supported on the down slope side by glacial sediments that covered the hillside. The down slope movement of this slab created a steep-walled gully running parallel to the hillside, whose north (up slope) side consisted of the vertical face of the bedrock cliff from which the slab had detached. The cave was exposed in this face a few meters above the floor of the newly created gully. The south (down slope) wall of the gully was formed by the north (up slope) side of the vertical slab. The floor of the gully sloped steeply from north to south, and was littered with sandstone boulders and crushed sandstone (stratigraphic Zone I). The gully was only a few meters wide at the base.

Shortly after the formation of the gully, sediments began to accumulate. For the most part these were redeposited glaciolacustrine deposits derived from the hillside above the gully. As these were washed over the edge of the cliff and into the gully, their further down slope movement was impeded by the large slab, thus allowing sediments to build up in the gully. The steep slope of the gully floor caused a thicker accumulation of sediments on the south side of the gully,

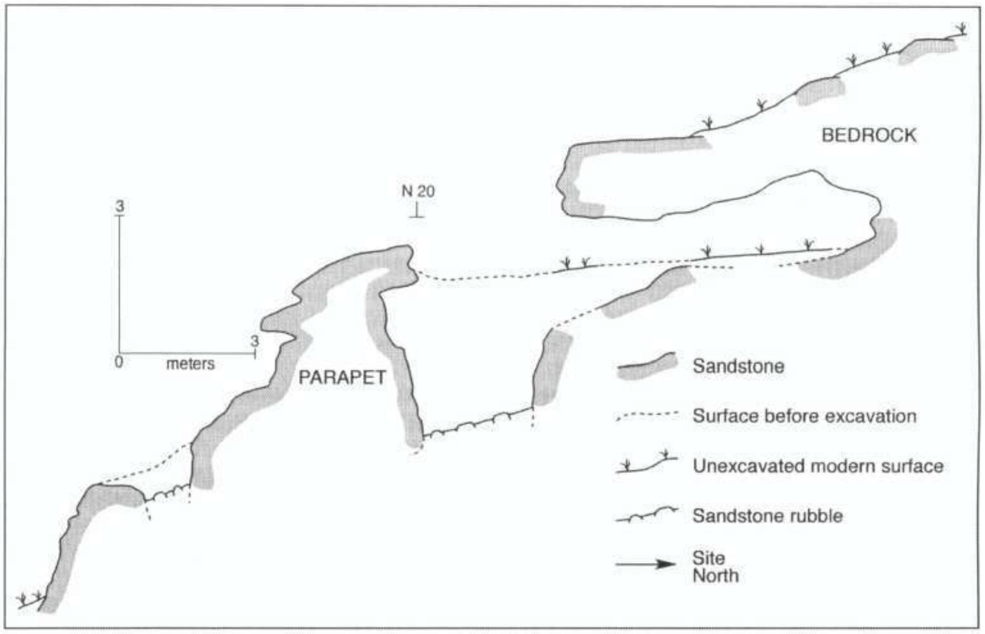


FIGURE 1. Cross-section of Charlie Lake Cave site, showing position of gully in which bison bones were deposited. Reprinted by permission from *American Antiquity* 64(2).

where excavations revealed up to 1 meter of fine sediments deposited between 10,700 and 9500 BP (stratigraphic Zone II). Over the southern two-thirds of the gully these sediments allowed excellent preservation of bone. However on the north side there has been continual leaching of deposits due to runoff from the hillside above the site. As a result, there is virtually no bone preserved on the north side of the gully. Although the rate of sediment deposition was reduced after 9500 BP, deposits continued to accumulate throughout the Holocene, together with cultural and faunal material (Driver *et al.* 1996; Fladmark *et al.* 1988). The lowest layers of Zone III, that form subzone IIIa were also included in this analysis. This was done because a few bison specimens recovered from the base of IIIa could be articulated with specimens in the upper part of Zone II.

As can be seen from Figure 1, because the floor of the cave was located well above the base of the gully, and because there was no source for sediments to be deposited in the cave, very little sediment accumulated in the cave itself until late Holocene times, when the level of sediment in the gully reached the same level as the floor of the cave. Archaeological excavations have therefore concentrated in the gully, with most lithic and faunal specimens from Zone II being found at the bottom of the gully just to the west of the cave entrance (Figure 2).

The dating of post-glacial events along the eastern foothills and adjacent plains of the Canadian Rockies has been bedeviled by a long-standing discussion concerning the "ice-free corridor". Enthusiasm to date organic materials has led to unsuitable samples being selected. For example, MacDonald *et al.* (1987, 1991) show that radiocarbon dates on plant remains from lake bed cores are inaccurate because some aquatic plants incorporate dissolved carbonates derived from ancient limestone. A review by Arnold (2002) suggests that a significant

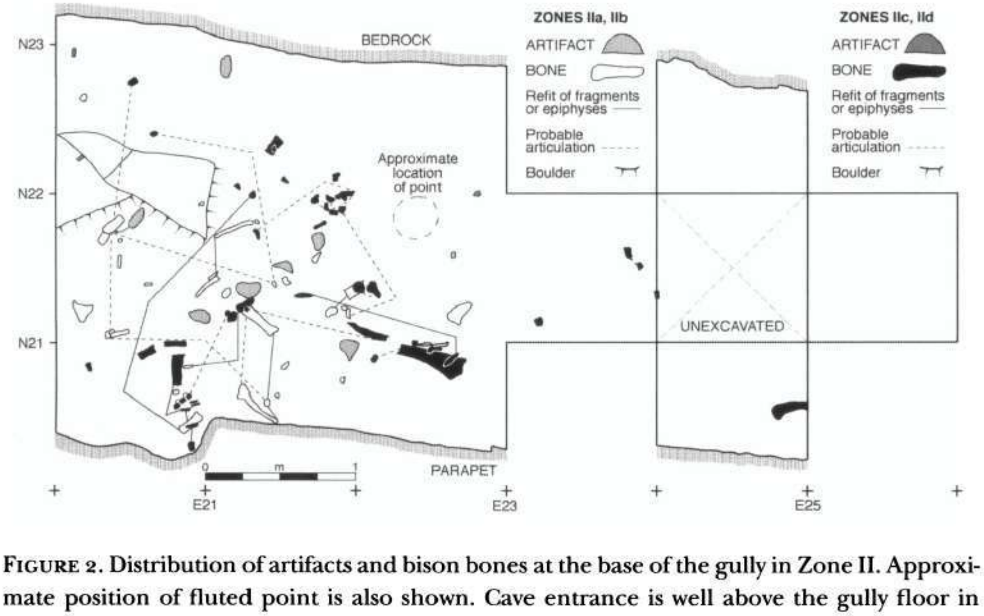


Figure 2. Distribution of artifacts and bison bones at the base of the gully in Zone II. Approximate position of fluted point is also shown. Cave entrance is well above the gully floor in bedrock approximately E24 to E25. Reprinted by permission from *American Antiquity* 64(2).

number of radiocarbon dates from this region are not dating events to which they are supposedly connected. In the Charlie Lake area there is evidence for a Laurentide ice advance after 22,000 BP and before 13,000 BP (Catto *et al.* 1996; Hartman 2005). This was followed by a period when Glacial Lake Peace covered much of the area, including CLC, but the lake is poorly dated. However, an articulated bison skeleton dating to about 10,500 BP was recovered from gravels within the modern Peace River valley (Apland and Harington 1994) and similar radiocarbon dates are found under sediment fans that post-date the earliest Peace River terraces (Geertsma and Jull 2002), so Glacial Lake Peace must have drained and the Peace River must have begun its incision by the time that people occupied CLC.

Northeast of CLC MacDonald (1987) documented a pre-10,000 BP vegetation of shrubs, herbs and grasses, with spruce forest arriving by 10,000 BP. Studies of vertebrates from CLC suggest a similar sequence of open landscape at 10,700 BP, with boreal forest and associated vertebrates arriving around 10,000 BP (Driver 1988, 2001). Recent maps of major vegetation zones in the western interior of North America constructed from pollen core data also suggest a transition from open to forested landscapes in northeastern British Columbia between 12,000 and 10,000 BP (Strong and Hills 2005). It therefore seems likely that Glacial Lake Peace drained some time before 10,700 BP, allowing the establishment of a pioneer vegetation of grasses, herbs and shrubs around CLC. It was on to that landscape that Palaeoindians moved. By 10,000 BP the open landscape was being replaced in the CLC area by boreal forest, and this is best documented in the vertebrate fauna by the decline in ground squirrels and their replacement by snowshoe hare (Driver 2001).

THE BISON ASSEMBLAGE

Excavations at CLC attempted to follow stratigraphic layers, but when these were thicker than 10 cm they were arbitrarily subdivided. The thick lower deposits at the site were formed rapidly by redeposition of glacial lake sediments and are relatively homogeneous, so arbitrary levels were used when stratigraphic boundaries could not be identified. An attempt was made to "contour" these levels to the overall slope of the deposits. Distribution of elements from a complete raven skeleton show that sediments sloped steeply and that there was probably down slope movement of bones after deposition (Driver 1999b). It is also possible that some slumping of these sediments occurred. Refitting of bison bone fragments and rearticulation of specimens (Vallières 2004) shows that there was both lateral and vertical movement of specimens, probably due to the steeply sloping, unstable sediments in the bottom of the gully (Figure 2).

Vallières reanalyzed the bison assemblage, independently of the original analysis by Driver (see Vallières 2004). As a result, there are some minor differences between numbers reported here and in previous publications. Some of these differences are due to a minor re-evaluation of stratigraphy prior to the second analysis. In addition, there were a couple of coding errors in both analyses. Some specimens that could be refitted were considered as one specimen in one analysis and two specimens in the other. Such differences are to be expected when different analysts work on the same material. In this paper we have followed Vallières' (2004) identifications, except in the case of coding errors, that have been corrected for this report.

During analysis, some specimens were identified positively as *Bison*, and these are specimens that display enough diagnostic features to be sure that they are not from other large artiodactyl genera present in North America during the late Pleistocene. Ancient DNA analysis has confirmed the identity of four of these specimens as *Bison* (Shapiro *et al.* 2004). Other specimens were identified to a more generic category, such as "large ungulate". Because all of the identifiable large mammal specimens from this period at CLC are from *Bison*, we have felt justified in assuming that all large ungulate specimens are also from *Bison*, and when we refer to *Bison* throughout this paper we are including specimens identified only to the "large ungulate" category. Following Driver (1992) we only consider specimens identifiable if the skeletal element can be specified.

As reported elsewhere (Driver 1988) the CLC bison were significantly larger than middle and late Holocene bison, and the dimensions of their limb bones are consistent with other late Pleistocene/early Holocene specimens from the region. Lack of cranial material precludes assessment of their relationship to other bison populations using morphological traits. However, analysis of ancient DNA from four specimens demonstrated that some CLC specimens had maternal ancestry from Beringian populations in the north, whereas others were descended from populations that lived south of the late glacial ice sheets (Shapiro *et al.* 2004). This suggests that post-glacial colonization of the eastern slopes and adjacent plains regions was undertaken by southern populations moving north, and by northern populations moving south, and apparently meeting at about 10,500 BP. This conclusion was reached earlier by Wilson (1996) from morphological evidence, and he attributed this, as do we, to the final opening of a viable corridor down the east slopes and foothills of the Rockies just before the end of the Pleistocene. CLC is currently the only known site in North America where both bison clades are found commingled.

The complete bison assemblage from Zone II and Subzone IIIa is presented in Table 1. As can be seen, the sample is quite small relative to Palaeoindian sites in the western interior of the USA. However, this is still the largest, best preserved and best dated bison assemblage from a pre-10,000 BP Palaeoindian archaeological site in western Canada. One of the problems of analyzing the assemblage as a single unit is the likelihood that it represents multiple events. There are a number of lines of evidence that point to this. First, bison specimens were obtained from a reasonably well stratified sequence. Even though some mixing has occurred, radiocarbon dates fit well with stratigraphy (e.g., Driver 2001) and it is likely that there was more than one depositional event. Second, ancient DNA demonstrates that two distinct populations were hunted, suggesting a minimum of two hunting episodes. Third, radiocarbon dates on bison collagen range from 10,770 to 9760 BP (see Driver *et al.* 1996 and Shapiro *et al.* 2004 for date lists), and this suggests that bison were deposited on more than one occasion at CLC.

So, if the assemblage is the result of multiple events, why consider it as a single assemblage? First, most archaeological assemblages are probably the product of multiple events. In fact, we have very few methods that allow us to discover how many discrete occupation events are represented on transitory hunter-gatherer sites, and many sites that are referred to as "single component" cannot be shown to be the result of a single episode of occupation. Bailey (2007) has discussed this at some length, employing the phrase "cumulative palimpsest" to refer to the mixing or integration of material residues of discrete activities. Lyman (2003) points out that most archaeological assemblages are "time averaged". In other words, they usually represent a series of discrete events that the processes of site formation, excavation and dating compress into a single analytical unit. At Charlie Lake Cave we cannot disentangle the discrete events that created a rather small sample of animal bones that span more than a millennium. Second, we have evidence at CLC for some mixing of deposits. Bison skeletal elements can be refitted and rearticulated within Zone II deposits, so even if discrete events were once present, subsequent site formation processes have blurred them. Because we cannot isolate discrete depositional events, we have to assume that the kinds of activities that resulted in bison bone deposition at the site were similar during each event, and that the assemblage has some kind of validity as a marker of human activity. We emphasize that this is a frequent, unwrit-

TABLE 1. Bison elements, Zones II and IIIa, Charlie Lake Cave, 1983 and 1991 seasons. w=whole. f=fragment. p=proximal. d=distal. s=diaphysis.

Element	Right	Left	Unsided	MNE
Cranium			ffffffffffff	1
Tooth			w	
Cervical 3–7			f	1
Thoracic			ffffff	1
Sacrum			f	1
Rib			fff	3
Scapula	f			1
Humerus	ppddds	s		4
Radius	pppds	wddss		5
Ulna	p	p		3
Carpal	wwwwwwww	ww		3 sets
Metacarpal	ds			2
Innominate		ffff		2
Tibia	wd	pddssss	pd	6
Tarsal	wwff	wff		3 sets
Metatarsal	p	d		2
Prox. phalanx			www	3
Medial phalanx			wwwwpdd	7
Distal phalanx			wwwwwddf	8
Sesamoid			www	3

ten assumption of most archaeological studies of hunter-gatherer sites.

THE LITHIC ASSEMBLAGE

The Palaeoindian lithic assemblage (Driver *et al.* 1996; Handly 1993) has been divided into three chronological components. The first two are most strongly associated with the bison assemblage, and consist of 51 specimens. The third component dates to about 9500 BP, and there is little associated bison bone. Almost all of the 162 specimens in component 3 are debitage resulting from the production or maintenance of two bifaces. We therefore focus on components 1 and 2, where the artefacts are most strongly associated with the bison assemblage.

In addition to 36 pieces of debitage, components 1 and 2 contain 15 further modified artifacts, including a projectile point. Eight are large quartzite tools, with weights ranging from 300 to 2,400 grams (see Driver *et al.* 1996 and Handly 1993 for illustrations). In spite of the variety in weight, there is uniformity in maximum dimensions, with seven specimens between 13 and 17 cm in length, and the largest 21 cm. Technologically, these range from barely retouched cobbles to a symmetrical biface and a uniface. Remarkably, there is no quartzite debitage from the components, although there is plenty of chert debitage. Therefore these tools were produced elsewhere, brought to the site, used and then discarded without resharpening.

ELEMENT FREQUENCIES AND BONE DENSITY

Element frequencies are presented in Table 1. Each specimen is represented by a simple code, signifying what portion of the element was represented, and specimens are assigned a side where appropriate. Minimum number of elements (MNE) calculations were based on visual examination of the entire collection, and in some cases are not clearly deducible from the number of identified specimens (NISP) data in Table 1. For example, the six thoracic fragments are all conjoinable, and were reconstructed as a single neural spine. One humerus shaft fragment overlapped with the same anatomical area on three distal humeri, and therefore an MNE of four was calculated. An ulna shaft fragment was fused to a radius shaft fragment (with the specimen recorded as a radius), creating a third MNE for ulna, even though only two fragments are recorded. This analysis resulted in somewhat higher MNE values for some long bones than would be deduced simply from the NISP data alone. Carpal and tarsal MNE values are presented as the minimum number of sets, rather than as MNE values for each individual carpal or tarsal.

Table 1 shows that the CLC assemblage is not a random sample of skeletal elements. Certain areas of the body are underrepresented (e.g., ribs and vertebrae), while limb elements are better represented. One of the most robust conclusions of taphonomic studies in zooarchaeology is that differential destruction of skeletal elements of large mammals can be caused by a range of agents, but that patterns of element loss and survival are highly correlated with bone density (e.g., Binford 1981; Brain 1981; Lyman 1994). While early studies used qualitative assessments, later studies have become increasingly sophisticated in measuring density values (Lam *et al.* 2003; Lyman 1994). Whenever skeletal element frequencies deviate from those expected in a complete skeleton, an obvious first approach is to see whether there is a correlation between bone density and the elements represented in an assemblage. This is not a straightforward process. First, many published bone density values incorporate methodological problems (Lam *et al.* 2003; Lam and Pearson 2004). Second, there is a general correlation between bone density and the meat value of many parts of the mammalian body, such that low density bones tend to be from areas of the body with high meat values (Grayson 1989; Lyman 1985). Human behavior, such as removal of high meat value bones from a kill site, may therefore be confused with natural taphonomic processes, such as carnivores destroying low density elements. Third, bone density and strength values differ for the same element when mature and immature specimens are considered. In spite of these problems, it is important to establish whether or not patterns of element frequency are linked to, or independent of, bone density and morphology.

Both natural and cultural processes can affect element frequencies. One way to distinguish human decisions about bone transport from density-mediated destruction of bone is to measure the relative frequency of proximal and distal portions of limb bones, using skeletal elements where proximal and distal ends have different densities (Binford 1981). Assuming that people are likely to transport complete skeletal elements, divergent representation of proximal and distal ends should indicate that natural bone destruction played a role in structuring the assemblage. At CLC the humerus, radius and tibia can be assessed in this way. The ratio of denser to less dense ends is as follows. Distal to proximal humerus: 2:1. Proximal to distal radius: 1:1. Distal to proximal tibia: 2:1. Clearly there is some preferential destruction of less dense long bone ends, probably by carnivores (see below). However, the survival of some immature specimens and some of the most desirable bones for carnivore consumption suggests that intensive ravaging of the assemblage did not occur. The ratio of long bone shaft fragments to epiphyses is about 1:1, and one would expect higher ratios in assemblages that were intensively processed by carnivores (Blumenschine and Marean 1993).

Table 1 shows that the CLC bison assemblage is over-represented in elements from the limbs, but equally dense or denser elements from other areas of the skeleton are either missing or present in insignificant quantities. For example, teeth, parts of the cranium, mandible, some vertebrae, the scapula and the innominate exhibit densities at least as great as those in some limb bones (Kreutzer 1992), but the axial skeleton is underrepresented at CLC. Generally, element frequency data show that density-mediated taphonomic processes, such as weathering or carnivore activity are unlikely to be the causes of overall skeletal element representation. If only high density and low meat value elements were surviving we would surely expect to see more teeth and petrous bones, as well as parts of the axial skeleton with densities comparable to limb bones.

Another way of examining the role of bone density is to plot frequency of skeletal elements against bone density. If there is a positive correlation between bone density and relative frequency of elements, we would suspect that one or more density-mediated processes had shaped the assemblage. Figure 3 plots the minimum number of animal units (MAU) values of selected areas of the limb bones against their density (Kreutzer 1992). Values are presented in Table 2. Elements of the axial skeleton are not shown, because all would cluster on the extreme left hand side

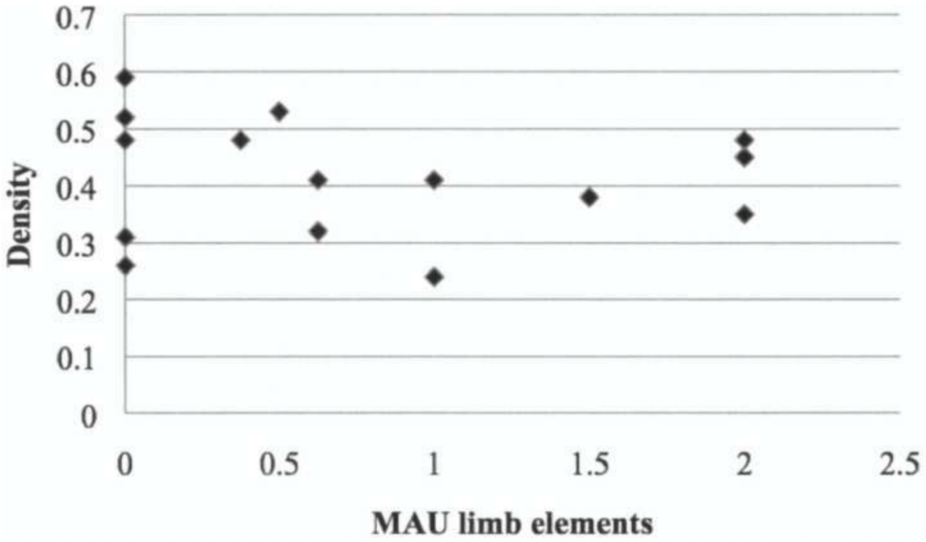


Figure 3. MAU values for selected areas of bison limb bones at Charlie Lake Cave plotted against bone density values for the same locations on modern bison limb bones.

Table 2. MAU values and bone density (Kreutzer 1992) for selected areas of bison limb bones at Charlie Lake Cave.

Element	MAU	Density
P Hum	1	0.24
D Hum	1.5	0.38
P Rad	2	0.48
D Rad	2	0.35
D MC	0.5	0.53
P Tib	1	0.41
D Tib	2	0.45
P 1phal	0.375	0.48
P 2phal	0.625	0.41
P 3phal	0.625	0.32
P MC	0	0.59
P MT	0	0.52
D MT	0	0.48
P Fem	0	0.31
D Fem	0	0.26

of the plot, due to MAU values close to zero. Figure 3 clearly shows that there is no relationship between frequency of a skeletal element and its density. So even if only limb elements were transported to the site, the assemblage has not been altered significantly after deposition by density-mediated processes.

Most of the CLC bison specimens are very well preserved, with no evidence for transportation by water, and little evidence of differential weathering to suggest lengthy exposure on the ground surface. Surfaces are well enough preserved to display cutmarks. The primary natural taphonomic process represented is carnivore chewing but this did not result in wholesale removal of lower density long bone ends. The survival of long bone ends that are attractive to carnivores (e.g., the proximal tibia) suggests that carnivore damage has not been so severe as to account for the almost completely absent axial skeleton. In addition there is only a single example of a long bone where both epiphyses have been removed, leaving a diaphysis with two chewed ends, a classic indicator of carnivore activity (Binford 1981).

Carnivore damage was assessed for 78 specimens (the reduced number being due to refitting and to removal of small cranial fragments from the analysis). Damage was coded as 0 (no damage), 1 (carnivore activity, but no destruction of anatomical features), 2 (destruction of at least one feature, such as an articular end), and 3 (heavy damage). Of the 78 specimens, 21 showed no damage, 27 were in class 1, 14 were in class 2, and ten were in class 3. Six could not be analyzed due to weathering.

In summary, although carnivore damage was the most obvious taphonomic process, it does not seem to have been sufficient to produce obvious patterns in the preservation of limb bones, and therefore cannot be the reason for the almost complete absence of the axial skeleton. The latter point is further supported by the fact that some dense areas of the axial skeleton are almost completely absent, whereas more vulnerable areas of the limbs (e.g., proximal tibia) survive.

HYPOTHESES FOR ASSEMBLAGE COMPOSITION

If density-dependent attritional processes did not shape the skeletal element frequencies, cultural processes may be responsible. An explanation involving cultural behaviour must account for a number of features of the assemblage. First, when compared with the utility data derived for bison by Emerson (1990), the MNE and MAU values from CLC show that high utility elements such as ribs and thoracic vertebrae are rare. Second, there is a strong presence of mid-utility elements (including leg elements such as tibia, ulna/radius and humerus), and variable representation of low-utility elements. Low-utility areas of the axial and cranial regions are poorly represented, but low utility parts of the limbs (e.g., phalanges) are well represented. Third, both people and carnivores left evidence of their interaction with the bison specimens. Fourth, some specimens were deposited as articulated elements. Fifth, some specimens were broken into pieces that can be refitted.

The first hypothesis is that CLC is a primary kill site. This might be supported by the articulated specimens, the lack of burning on bones, and the small lithic assemblage with little evidence for artifact production or maintenance. To account for the lack of some elements and the bone damage, we would have to postulate removal of some body parts by people, and subsequent carnivore scavenging. This hypothesis cannot account for a number of features of the site. Unlike many kills, there are no partially or fully articulated skeletons. There is also a lack of heavy crania that are typically left at kill sites. The stone tool assemblage includes only one projectile point. We conclude that there is no good evidence that CLC represents the location of a mass kill or of a series of individual kills.

It therefore seems more likely that this assemblage consists of specimens that were brought from a kill site to CLC and then deposited. Given the presence of lithic artifacts in the deposits, and cutmarks and percussion points on the bison specimens, we assume initial transportation by people.

The second hypothesis is that the assemblage was deposited at either a residential site or a butchering and processing site located near a kill site. It seems unlikely that these specimens were transported to CLC because they were associated with large quantities of meat. Selection for mid and lower limbs would not be an effective way of maximizing the meat that could be transported. An assemblage dominated by long bones might have been accumulated because of the marrow content of diaphyses or grease content of long bone ends, as proposed by Hill *et al.* (2008) for the Clary Ranch site in Nebraska, and as modeled by Emerson (1993). However, this does not explain five features of the CLC assemblage: (a) the absence of the femur; (b) the relatively low frequencies of metapodials that contain high quality marrow; (c) the presence of some long bones that have not been broken open to obtain marrow; (d) the absence of any evidence for processing of epiphyses to obtain within-bone grease, and (e) the lack of long bone shaft fragments. Furthermore, there is no evidence for hearths, there is no charcoal in the sediments, none of the specimens is burnt, and there is little evidence for lithic artefact production, all of which we might expect in a location where residential and processing activities occurred.

A third hypothesis is that the gully lay downhill from a residential camp or butchery/processing area on the hillside above the gully, and that these faunal and lithic specimens are simply discarded material that either has been thrown into the gully or moved downslope. However, many of the same concerns apply, and the lack of weathering on the faunal specimens makes it unlikely that slow downslope movement brought them to the gully.

A fourth hypothesis, and the one that we favour, is that the bison limbs were cached at the site. There has been less discussion in the literature about the characteristics of meat caches, although this possibility has been noted as a potential Palaeoindian strategy (Frison 1998). We suggest that the CLC bison assemblage consists of the remains of a succession of meat caches, some utilized (hence the bone breakage) and others abandoned (hence the complete specimens). Unfortunately, we have relatively little ethnographic data on the content of meat caches from the northern Plains and Rocky Mountains. Friesen (2001) documents caribou storage in the Canadian Arctic dominated by cranial and axial elements. These specimens were likely dried before being cached, and Friesen notes that axial elements are more likely to be preserved during storage of dried meat, due to higher surface area:volume ratios for the meat. Driver (1990) showed that long-distance transport of (probably dried) bison meat in New Mexico was represented almost exclusively by axial elements.

The most direct evidence for frozen caches of bison comes from caves in Idaho (Henrickson 2003). Spanning periods from about 8000 to 1000 BP, disarticulated bison bones were stored in brush-lined features within the frozen caves. Some caches seem to have been left intact, while others were recovered and the bones scattered during butchery. The MNE values from these sites are compared to MNE data from CLC in Table 3.

CLC and the Idaho assemblages share some characteristics, such as low values for vertebrae and high values for fore and hind limbs. The main difference between the two assemblages is that CLC has more elements from the feet, whereas the Idaho sites have better representation of ribs. Henrickson (personal communication 2005) reports that the values for ribs in her samples are based on number of fragments, and are not MNE calculations, so the difference between the two assemblages may not be as great as the data suggest. However, even when measured by number of fragments, CLC contains few ribs and significantly more phalanges in relation to other limb elements, so there are still differences between the Idaho and CLC assemblages.

The hypothesis that the CLC assemblage results from meat caches is supported by other evidence. As noted previously, certain characteristics of a residential site are missing from the archaeological record. There is no evidence for hearths, none of the Palaeoindian faunal specimens are burnt, and there is no charcoal in the Palaeoindian layers. We suggest that this is consistent with the cache hypothesis. We also propose that the large quartzite tools were either cached with the meat for future use, or were brought to the site in anticipation of making use of the cached supplies. This would explain the absence of quartzite debitage. Henrikson (2003) documents a somewhat different recovery strategy for the Idaho ice caves, with antler picks and stone hammers being used to break open the ice over the cached meat. (But note that these tools were discarded beside the cache, as we are also hypothesizing for CLC). If CLC was the site of a cache, it is unlikely that the meat would have been covered with ice, because the cave is small and dry; we suspect that the large tools may have been used to disarticulate frozen limbs.

TABLE 3. Comparison of MNE of Idaho ice cave bison and CLC bison.

Element	Idaho	CLC
Cranium	1	1
Mandible	2	0
Vertebrae	3	3
Scapula	4	1
Rib	23	3
Innominate	1	2
Humerus	3	4
Radius	5	5
Ulna	5	3
Femur	4	0
Tibia	8	6
Metapodial	2	4
Carpal	0	3 (sets)
Tarsal	1	3 (sets)
Phalanx	1	18

In summary, we believe that Palaeoindians used CLC as a meat cache. There are a number of other considerations that support this interpretation. The gully itself would not be an attractive habitation site. With a steeply sloping floor and narrow walls it would have been inconvenient and cold without the use of fire (for which we have no evidence). On the other hand, the cave would have been an excellent place to store meat. Even today it is very dry with a shallow layer of dusty sediment that preserves plant material and other organics. At the end of the Pleistocene the entrance to the cave was in a vertical sandstone face at least two meters above the floor of the gully and thus would have been difficult for scavengers to access. The differential treatment of long bones might reflect two different outcomes of caching. In some cases hunters returned to the cache, butchered limbs and broke the bones to obtain marrow. This resulted in scattered fragments of elements. In other cases the cache was not used; when the cave was visited to create a new cache, the complete elements of the previous cache were dumped into the gully, and preserved as unmodified specimens.

CACHES, SUBSISTENCE AND PALAEOENVIRONMENTS

One of the problems of late Pleistocene archaeology is understanding the nature of environments in which hunter-gatherer groups operated. It has been suggested that late Pleistocene environments south of the ice sheets do not have direct analogues in late Holocene North America, because they were patchier and "mosaic"-like (e.g., FAUNMAP 1996; Graham 1976; Lundelius *et al.* 1983; Stafford *et al.* 1999). For this reason, Burke (2004) argues that hunter-gatherer settlement systems modeled from modern arctic and subarctic hunter-gatherers cannot be applied directly to situations in late Pleistocene mid-latitude locations.

The immediate post-glacial environment in the Peace River region is difficult to reconstruct based on available evidence, because there have been relatively few palynological sequences and faunal assemblages reported. However, based on what evidence is available, we would argue for an environment that was broadly zoned, with low species diversity and little evidence for a mosaic of habitats.

The few palynological sequences that have been published do not provide much evidence for habitat diversity. Immediate post-glacial landscapes may have been frozen and almost certainly lacked soil, so initial plant colonizers must have been those capable of surviving on poor soils. Furthermore, until nitrogen-fixing plants were established, soils would have remained poor (Pielou 1991: 89–90). Pollen diagrams have been published from regions to the north, east and south of CLC. Pre-10,000 BP pollen from Lone Fox Lake (east and slightly north of CLC) is dominated by birch, aspen, willow, sagebrush, cheno-ams, grasses and sedges. A very similar set of plants was also found at the nearby Yesterday Lake, and also at Snowshoe Lake, another 100 km north (MacDonald 1987). Further south, at Boone Lake a detailed postglacial pollen sequence has been recorded (White and Mathewes 1986). Beginning as early as 11,700 BP with an assemblage of aspen, willow, sagebrush, grasses and sedges, the local vegetation saw the addition of alder and birch by 11,200 BP. However, shortly before 11,000 BP coniferous pollen became dominant, suggesting that spruce forests were advancing from the south by this period. Faunal data from CLC (Driver 1988, 2001) and the pollen data from lakes to the east and north of CLC suggest that spruce forests did not reach the Peace River valley and regions to the north until about 10,000 BP.

MacDonald and McLeod (1996) suggest that the late Pleistocene vegetation of the "western corridor" east of the Rockies was similar over much of its length. However, they also caution that most pollen has been identified to genus level or higher, and therefore this apparent homogeneity may mask greater species (and hence habitat) diversity. Beaudoin and Oetelaar (2003) suggest that an open, shrubby landscape characterized the foothills region of the Rocky Mountains, with grassland further east.

Although a variety of mammalian species have been recovered from Late Pleistocene deposits (mainly gravel pits) in the Peace River region (Churcher and Wilson 1979), it is not clear how many of these would date to the same period as CLC. However, the earliest dated bison from the region fall within the same range of dates as CLC (e.g., Apland and Harington 1994; Wilson 1996), and there are no other large mammals from the region that have been directly radiocarbon dated to this period. This suggests a regional fauna impoverished in large mammal species, in contrast to the greater variety of large mammals from slightly earlier deposits in southern Alberta (Beaudoin and Oetelaar 2003; McNeil *et al.* 2004; Wilson 1996). The Peace River region fauna may have been impoverished for two reasons. First, early communities would be composed of animal species capable of migrating into the area and capable of surviving on a relatively low diversity vegetative community dominated by grasses, herbs and shrubs. Second, the potential pool of large mammals (both to the north and the south) was depleted of species by Late Pleistocene extinctions that mainly pre-date 10,500 BP. Thus, even if the Peace River post-glacial environments had been suitable for species such as horse or mammoth, those taxa were already extinct by the time the Peace River region became habitable.

Bird and mammal remains from Charlie Lake Cave are consistent with the pollen data (Driver 2001). An open landscape occurred from about 10,500 to 10,000 BP, at which time forest species make their appearance, and then dominate the assemblage by 9500 BP. Given both local and regional evidence for an open, low diversity landscape, we should examine the potential role for meat caches in such an environment.

In hunter-gatherer societies food storage is important for three reasons connected to subsistence. First, stored food allows people to get through periods when food is unavailable. These periods may be predictable, especially in environments with highly seasonal climate and resource availability, or they may be random, caused by unpredictable events, such as unexpected weather conditions. For Palaeoindians moving into uninhabited (and therefore unknown) landscapes, storage would also provide security from shortages caused by lack of knowledge. Meltzer (2002) suggests that the relatively common occurrence of early Palaeoindian lithic caches is explained by the need of mobile foragers to have a secure supply of raw material as they explore landscapes about which they have insufficient knowledge. Second, storage allows individuals and groups to take advantage of seasonal peaks in resource abundance. If more food is obtained than can be used immediately, storage allows the benefit of that food to be spread over a longer period of time. Third, storage may facilitate sharing (Waguespack 2002), providing a social mechanism for food redistribution in times of shortage.

On the northwestern Plains, the development of a sophisticated system for preparing and storing bison products is documented in mid- to late-Holocene times mainly by the presence of fire-cracked rock and boiling pits associated with the rendering of grease for the production of pemmican (Reeves 1990). Although there is no evidence for pemmican production in Palaeoindian sites, some archaeologists have suggested that frozen meat caches might have been used to store meat acquired during late fall or early winter kills, when animals would have been in good condition and meat could be kept cold (Frison 1998). Frozen caches are a rather special form of storage, because, unlike dried meat or pemmican, they are not transportable and the storage system fails once the weather changes. For the cache to be used effectively, the hunter must remain within a reasonable distance of the cache, so that retrieving meat and fat does not impose too great an energy burden.

Storage of food for subsistence purposes is likely to occur when there is seasonal variation in the availability of one species, and a lack of alternative resources. The Peace River environment in early post-glacial times probably met these conditions. Excavations at CLC show that bison was the only large ungulate hunted. Although negative evidence must be treated cautiously, no other large herbivores seem to have been present in the region at this period. Fish were another important staple of the boreal forest diet of First Nations peoples in more recent times, and are present at Charlie Lake quite early, but do not appear in any quantity at the site until the mid-Holocene. There were good reasons for caching bison meat. Predators that subsist on single species are vulnerable to random fluctuations in prey abundance. Most large mammal prey species will exhibit such fluctuations, and this means that successful predators (including humans) are likely to experience times of abundance and scarcity. In an environment with relatively few alternate resources, storage would be an important strategy to reduce the likelihood of starvation. The other strategy would be mobility as argued by Kelly and Todd (1988). At present we have insufficient data to evaluate northern Palaeoindian mobility in any detail, although the lack of exotic lithics at CLC argues against lengthy annual rounds. Furthermore, there is in any case no reason to assume that mobility and storage strategies must be exclusive of each other.

CONCLUSIONS

Although there seems to be little doubt that bison hunting was the primary subsistence focus of later Palaeoindians in the northern and western plains of North America, there is variation in how bison were killed and processed (e.g., Hill *et al.* 2008), as well as variation in the composition of faunal assemblages over this large area (e.g., Hill 2008; Kornfeld and Larson 2008). The bison assemblage from CLC is smaller than most, but it is distinctive due to the dominance of fairly lightly butchered bones of the mid and lower limbs. We believe that these specimens were transported from a kill location, because of the absence of cranial and axial bones. However, they do not seem to be the residue of a processing site or a habitation site, due to the lack of many features that we might expect to find, including evidence of fire, production and maintenance of stone tools, and more intensive fragmentation of limb bones. We suggest that middle and lower legs were selected for cold storage in order to preserve meat and fat (marrow) for future use, and that the CLC assemblage reflects a mix of processed and unprocessed items from a series of storage events in the dry, inaccessible cave.

Acknowledgements. This research was funded by grants from the Social Sciences and Humanities Research Council to Jon Driver and Knut Fladmark. We are grateful to Suzann Henrikson for sharing details of her data from the Idaho lava tubes. Thanks to two anonymous reviewers, R. Lee Lyman, and the CJA editor, Gerry Oetelaar for a number of suggestions that have improved our work.

REFERENCES CITED

Apland, B., and C.R. Harington
1994 Pleistocene Bison Skeleton (*Bison bison* cf. *occidentalis*) from Clayhurst Crossing, British Columbia. *Géographie Physique et Quaternaire* 48: 213–223.

Arnold, T.G.
2002 Radiocarbon Dates from the Ice-Free Corridor. *Radiocarbon* 44: 437–454.

Bailey, G.
2007 Time Perspectives, Palimpsests and the Archaeology of Time. *Journal of Anthropological Archaeology* 26: 198–223.

Beaudoin, A. B., and G. A. Oetelaar
2003 The Changing Ecophysical Landscape of Southern Alberta During the Late Pleistocene and Early Holocene. *Plains Anthropologist* 48: 187–207.

Binford, L. R.
1981 *Bones: Ancient Men and Modern Myths.* Academic Press, New York.

Blumenschine, R. J., and C. W. Marean
1993 A Carnivore's View of Archaeological Bone Assemblages. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains,* edited by J. M. Hudson, pp. 273–300. Occasional Paper No. 21. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Brain, C. K.
1981 *The Hunters or the Hunted? An Introduction to African Cave Taphonomy.* University of Chicago Press, Chicago.

Burke, A. M.
2004 Alternative Models of Spatial Organization for Pleistocene Hunter-Gatherers. In *Hunters and Gatherers in Theory and Archaeology,* edited by G. M. Crothers, pp. 192–210. Occasional Paper No. 31. Center for Archaeological Investigations, Southern Illinois University at Carbondale, Carbondale.

Catto, N., D. G. E. Liverman, P. T. Bobrowsky, and N. Rutter
1996 Laurentide, Cordilleran, and Montane Glaciation in the Western Peace River-Grande Prairie Region, Alberta and British Columbia, Canada. *Quaternary International* 32: 21–32.

Churcher, C. S., and M. Wilson
1979 Quaternary Mammals from the Eastern Peace River District, Alberta. *Journal of Paleontology* 53: 71–76.

Driver, J. C.
1988 Late Pleistocene and Holocene Vertebrates and Palaeoenvironments from Charlie Lake Cave, Northeast British Columbia. *Canadian Journal of Earth Sciences* 25: 1545–1553.

1990 Bison Assemblages from the Sierra Blanca Region, Southeastern New Mexico. *Kiva* 55: 245–263.

1992 Identification, Classification and Zooarchaeology. *Circaea* 9: 35–47.

1998a Human Adaptation at the Pleistocene/Holocene Boundary in Western Canada, 11,000 to 9000 BP. *Quaternary International* 49/50: 141–150.

1998b Late Pleistocene Collared Lemming (*Dicrostonyx torquatus*) from Northeastern British Columbia. *Journal of Vertebrate Paleontology* 18: 816–818.

1999a Stratified Faunas from Charlie Lake Cave and the Peopling of the Western Interior of Canada. In *Zooarchaeology of the Pleistocene/Holcene Boundary,* edited by J. C. Driver, pp. 77–83. BAR International Series 800. British Archaeological Reports, Oxford.

1999b Raven Skeletons from Paleoindian Contexts, Charlie Lake Cave, British Columbia. *American Antiquity* 64: 289–298.

2001 Paleoecological and Archaeological Implications of the Charlie Lake Cave Fauna, British Columbia. In *People and Wildlife in Northern North America: Essays in Honor of R. Dale*

APPENDIX A: PHOTOGRAPHS OF TSE'K'WA

COLLECTION 1: STRUCTURE OF THE SITE

COLLECTION 2: EXCAVATIONS IN PROGRESS

COLLECTION 3: A SAMPLE OF STONE TOOLS AND ANIMAL BONES

COLLECTION 1: STRUCTURE OF THE SITE

Figure 1.01 Aerial View of the Charlie Lake Area

Tse’K’wa is located downhill and to the left of the white house in the centre of the photo. As can be seen, it is situated halfway down the side of the hill that slopes toward a small creek. A tiny portion of Charlie Lake can be seen in the background. *Photo credit: Jean Bussey*

Figure 1.02 Aerial Close-up of Tse'K'Wa

This view clearly shows the sandstone bedrock outcrop behind a small group of people who are standing next to the 1990/1991 excavation area (under the temporary roof of plastic). In front of the people is a large rock, known as the "parapet". This detached from the bedrock at the end of the last ice age and moved a few metres downhill, creating a gully between the back of the parapet and the bedrock from which it had detached. The small cave entrance is in the bedrock behind the group of people. *Photo credit: Jean Bussey*

Figure 1.03 End of the 1991 Excavations

This is a view of the site at the end of the 1991 season. The photographer is standing on the bedrock above the entrance to the cave. The deep hole in front of the photographer was excavated by archaeologists who removed all of the deposits that had accumulated between the bedrock and the "parapet". This has exposed the back face of the parapet, and the archaeologist is standing beside that rock face. The modern ground surface level can be seen to the right, under the temporary fence.

Figure 1.04 Cross Sections of the Deposit in the Gully

The archaeologists are removing the lowest layers of deposits in the gully. To the right is the bedrock and to the left is the back face of the parapet – the large boulder that fell away from the bedrock at the end of the last ice age. These two rock faces form either side of a gully. Straight ahead is the cross-section of the deposits that filled the gully over about the last 12,000 years. By keeping this side of the excavation vertical, the archaeologists have created a clean cut through all the layers, allowing them to draw and photograph the sequence of different deposits that have filled up the gully.

Figure 1.05 General View of the Gully and Cave

This photo was taken at the end of the 1990 field season. In the foreground is the large hole excavated by the archaeologists. You can also see the bedrock face against which deposits have accumulated, and the entrance to the small cave.

COLLECTION 2: EXCAVATIONS IN PROGRESS

Figure 2.01 1983 Excavations

In the 1983 season we excavated relatively small square holes to probe the deposits in the gully. The archaeologists are standing around one of the deepest excavations, looking down at the layer that produced the oldest material at the site.

Figure 2.02 View Into 1983 Excavations

And this is what the archaeologists in the previous photo are looking at. You can see very clearly the different layers in the side of the excavation. The archaeologist with the green hard hat is working on the layer that produced some of the early artifacts and bones. *Photo credit: Knut Fladmark*

Figure 2.03 Starting Work in 1990

At the end of the 1983 season all the excavation areas were backfilled to prevent untouched deposits from slumping. In 1990 the first job was to remove the backfill from the old excavation areas and determine where the new excavations would take place. Rather than dig small square holes, we decided to open up a single large hole. This was much safer because two sides of the excavation area would be solid rock, thus reducing the danger of cave-ins. It also allowed us to map the different layers more easily.

Figure 2.04 Excavating the Upper Layers

We constructed a roof to allow us to keep working in the rain. These archaeologists are excavating the uppermost layers, representing the last thousand years of the use of the site.

Figure 2.05 Upper Layers and Cave Entrance

In this view you can see the entrance to the cave, with excavations in the foreground that have removed some of the more recent layers. The square holes were excavated in 1983. The archaeologists are working around the square holes and removing the backfill as they dig down.

Figure 2.06 Screening

Much of the material from Tse'K'wa is very small and cannot be seen easily when excavating the layers of soil and other deposits. Therefore all of the sediments were screened through 3mm mesh, allowing archaeologists to pick out small bones and chips of stone.

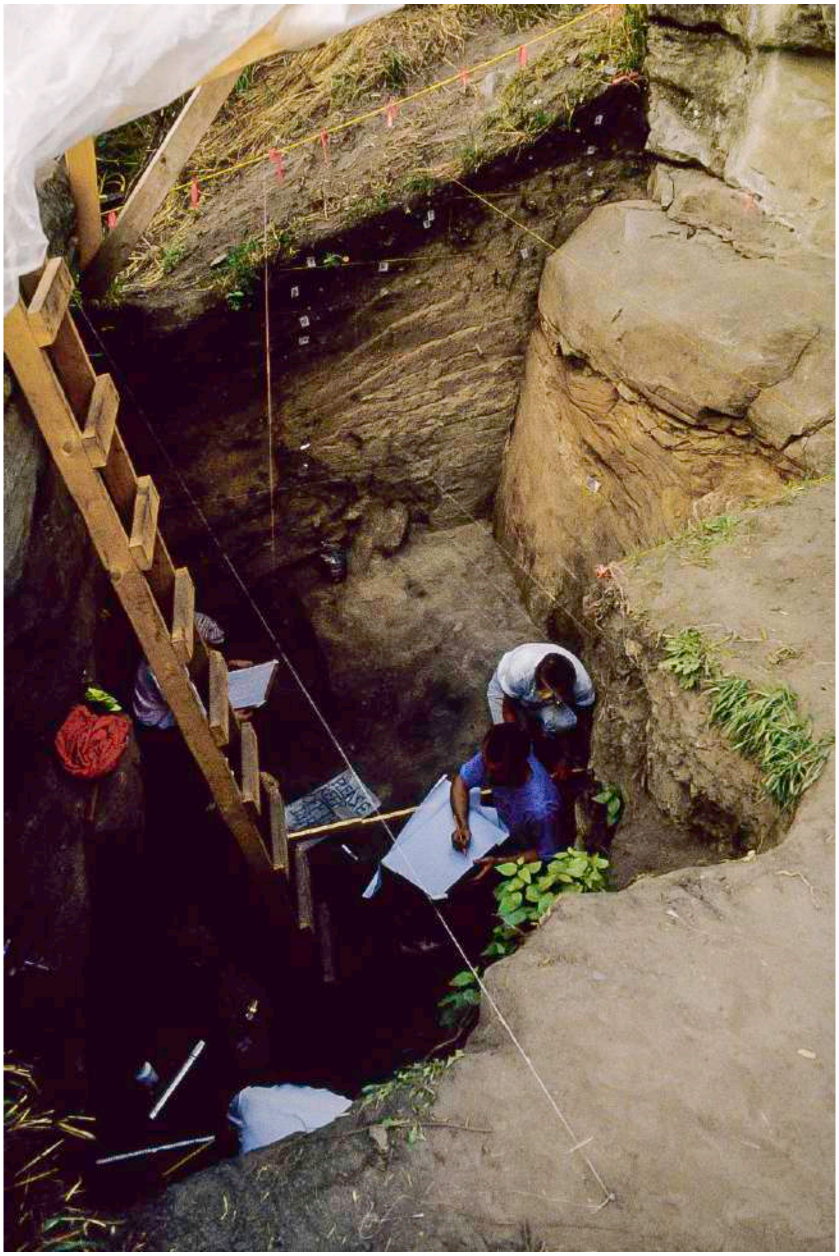
Figure 2.07 Mapping

We also made a detailed map of the site using standard surveying instruments

Figure 2.08 End of 1990 Season

By the end of the 1990 season we had excavated about half the depth of the deposits. We lined the excavation area with plastic and then backfilled it to protect it from winter weather.

Figure 2.09 Drawing Strata



Before we backfilled we made a record of the cross-section of the layers that we had dug through.

Figure 2.10 1991 Season

Returning to the site in 1991 we continued to excavate deeper. This photo was taken toward the end of the excavations. You can see that the distance between the rock walls got smaller as we went deeper, and also that we started to encounter big boulders that had been left on the floor of the gully when the parapet detached from the bedrock.

Figure 2.11 Working on the Lower Layers

Photo by Knut Fladmark. This is a typical scene of excavations towards the end of the 1991 season. We are working in a cramped space and spending a lot of time recording and mapping what we found.

Figure 2.12 Bison Bone

The lower layers contain the bones of an extinct species of bison. Here, the archaeologist is carefully excavating around a complete tibia – the lower hind leg bone. The smooth sandstone surface to the right of the photo is the back surface of the "parapet". We inspected these sandstone surfaces very carefully in the hope of finding artistic representations incised or painted on the surface, but nothing was found.

Figure 2.13 Bison Calf

Another area of the excavation revealed another bison tibia, but this much smaller bone is from a bison calf.

Figure 2.14 End of Excavations

This is the view of the site close to completion of excavations in 1991. The archaeologist is standing on the deepest point we reached in the excavations.

Figure 3.01 Fluted Spear Point

This spear point dates to about 10,500 BC and is important because it resembles many other spear points in North America that date to the end of the last ice age. In particular it is similar to artifacts found in Alberta and Montana, suggesting that some of the first people to enter the Peace River region after the ice age came from the southeast.

COLLECTION 3: A SAMPLE OF STONE TOOLS AND ANIMAL BONES

Figure 3.02 Fluted Spear Point

The spear point from Tse'K'wa on the right can be compared to similar artifacts found on ploughed fields in the area around Fort St. John.

Figure 3.03 Other Spear and Arrow Points

Photo by Knut Fladmark. As one goes through time, the shape of spear and arrow points changes. Here are some examples from later in the site's history.

Figure 3.04 More Stone Tools

These tools include some arrow or spear points and larger tools that were probably used as knives.

Figure 3.05 Large Chopping Tools

These larger tools were found exclusively with the large extinct bison bones in the early layers. We believe that they were made elsewhere and brought to the site for a special function – possible smashing through ligaments or breaking marrow bones open

Figure 3.06 Large Chopping Tools

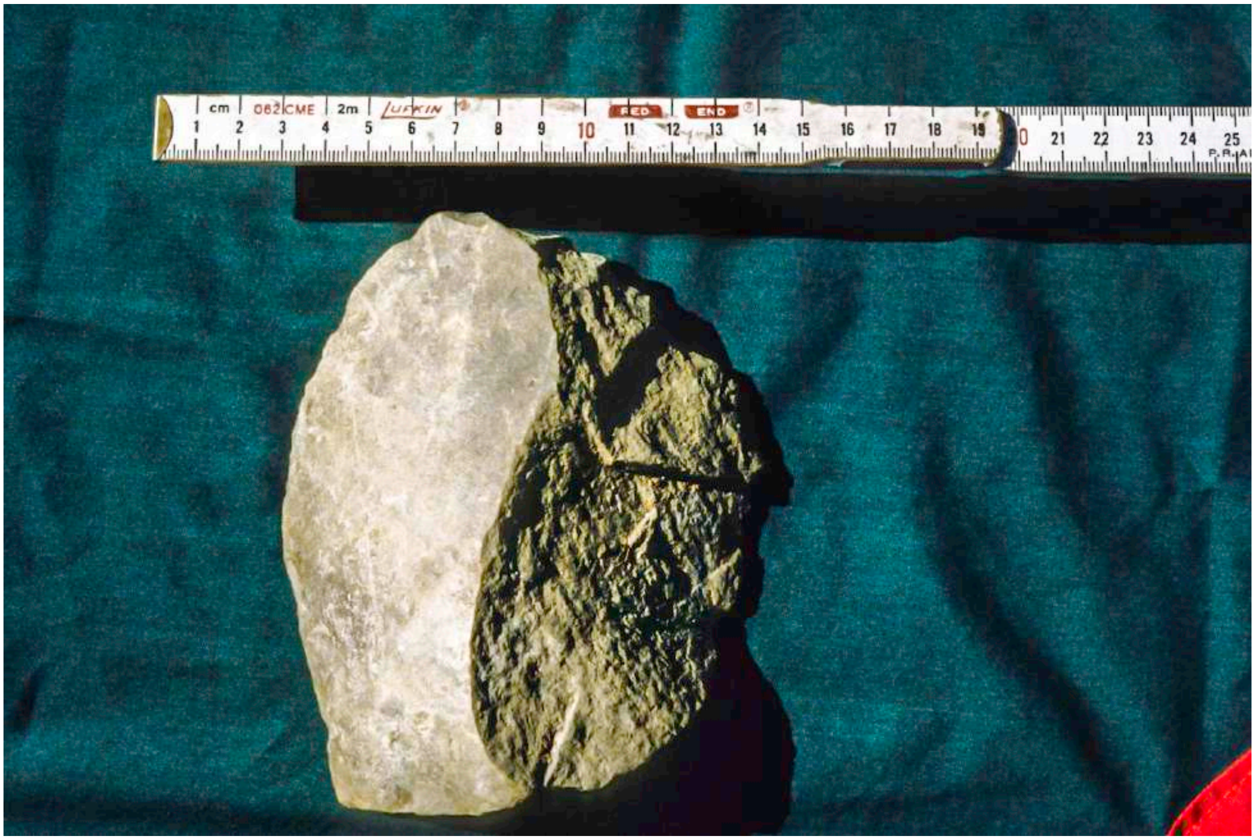


Figure 3.07 Large Chopping Tools

Figure 3.08 Small Animal Bones

Most of the bones found at the site were from small animals. This is a typical collection of small bones from the lower layers. Many of these can be identified quite precisely.

Figure 3.08 Lemming

Perhaps the most surprising animal identified so far is the collared lemming, whose teeth are shown here. These teeth have a highly distinctive shape that cannot be confused with any other species. Today this species is confined to the arctic regions, so its presence at Tse'K'wa is evidence of quite different environmental conditions at the end of the last ice age.

Figure 3.09 Bison Toes

One interesting feature of the bison bones from the early layers is that many of the bones could be fitted back together. This is the front foot of a bison, with almost all the bones present. Starting at the top you can see the lower end of the cannon bone, below which are two toes, ending in a cloven hoof. The little bones to the side are called sesamoids, and allow ligaments to pass smoothly over joints. The cannon bone bas broken in ancient times, probably by people. The holes in one of the toe bones were drilled to obtain samples for radiocarbon dating.

Figure 3.10 Old and Recent Bison

This photo illustrates how much bigger the extinct bison were. On the left is the tibia (shin bone) or a modern bison bull. On the right is the equivalent bone from Tse'K'wa. It is somewhat longer and much broader, suggesting that the live animal would have weighed a lot more than a big modern bull bison.

APPENDIX B: FURTHER READING

Vallieres, C (2004). *The Paleoindian Bison Assemblage from Charlie Lake Cave*. SFU Summit-Institutional Repository: Theses, Dissertations, and other Graduate Related Essays.

Handly, M. J (1994). *Lithic assemblage variability at Charlie Lake Cave (HbRf-39): a stratified rock shelter in northeastern British Columbia*. Peterborough, Ont: Trent University, Masters Thesis

BIBLIOGRAPHY

J.C. Driver. and C. Vallieres (2008). *The Palaeoindian Bison Assemblage from Charlie Lake Cave, British Columbia*. Canadian Journal of Archaeology 32(2): 239-257.

J.C. Driver (1988). *Late Pleistocene and Holocene Vertebrates and Palaeoenvironments from Charlie Lake Cave, Northeast British Columbia*. Canadian Journal of Earth Sciences, 25: 1545 – 1553.

J.C. Driver (1998). *Late Pleistocene collared lemming (Dicrostonyx torquatus) from northeastern British Columbia*. Journal of Vertebrate Paleontology 18(4): 816-818.

J.C. Driver (1999). *Raven skeletons from Paleoindian Contexts, Charlie Lake Cave, British Columbia*. American Antiquity 64(2): 289-298.

J.C. Driver (1999). *Stratified Faunas from Charlie Lake Cave and the Peopling of the Western Interior of Canada.* In Zooarchaeology of the Pleistocene/Holocene Boundary, edited by J.C. Driver, pp.77-83. British Archaeological Reports International Series 800, Oxford.

J.C. Driver (2001). *Paleoecological and Archaeological Implications of the Charlie Lake Cave Fauna, British Columbia, 10,500 to 9,500 B.P.* In People and Wildlife in Northern North America: Essays in Honour of R. Dale Guthrie, edited by S.C. Gerlach and M.S. Murray, pp.13-21. British Archaeological Reports International Series 944, Oxford.

J.C. Driver and K. Hobson (1992). *A 10,500 year sequence of bird remains from the southern boreal forest region of Western Canada*. Arctic 45(2): 105 – 110.

J.C. Driver, (1996). *The Prehistory of Charlie Lake Cave*. In Early Human Occupation in British Columbia edited by R.L. Carlson and L. Dalla Bona, 11-21. University of British Columbia Press, Vancouver.

J.C. Driver, (1996). *The Significance of the Fauna from the Charlie Lake Cave Site*. In Early Human Occupation in British Columbia edited by R.L. Carlson and L. Dalla Bona, 11-21. University of British Columbia Press, Vancouver.

J.C. Driver, M. Handly, K.R. Fladmark, D.E. Nelson, G.M. Sullivan and R.Preston (1996). *Stratigraphy, Radiocarbon Dating and Culture History of Charlie Lake Cave, British Columbia*. Arctic 49(3) : 265-277.

K. Fladmark, J.C. Driver, D. Alexander (1988). *The Paleoindian Component at Charlie Lake Cave (HbRf 39), British Columbia*. American Antiquity 53(2): 371-384.

Shapiro, B. and 26 others including J. Driver (2004). *Rise and fall of the Beringian steppe bison*. Science 306: 1561-1565.