Paleontological Resources of the Lillooet Land Resource Management Plan (LRMP) Area, British Columbia

Prepared by the British Columbia Paleontological Alliance

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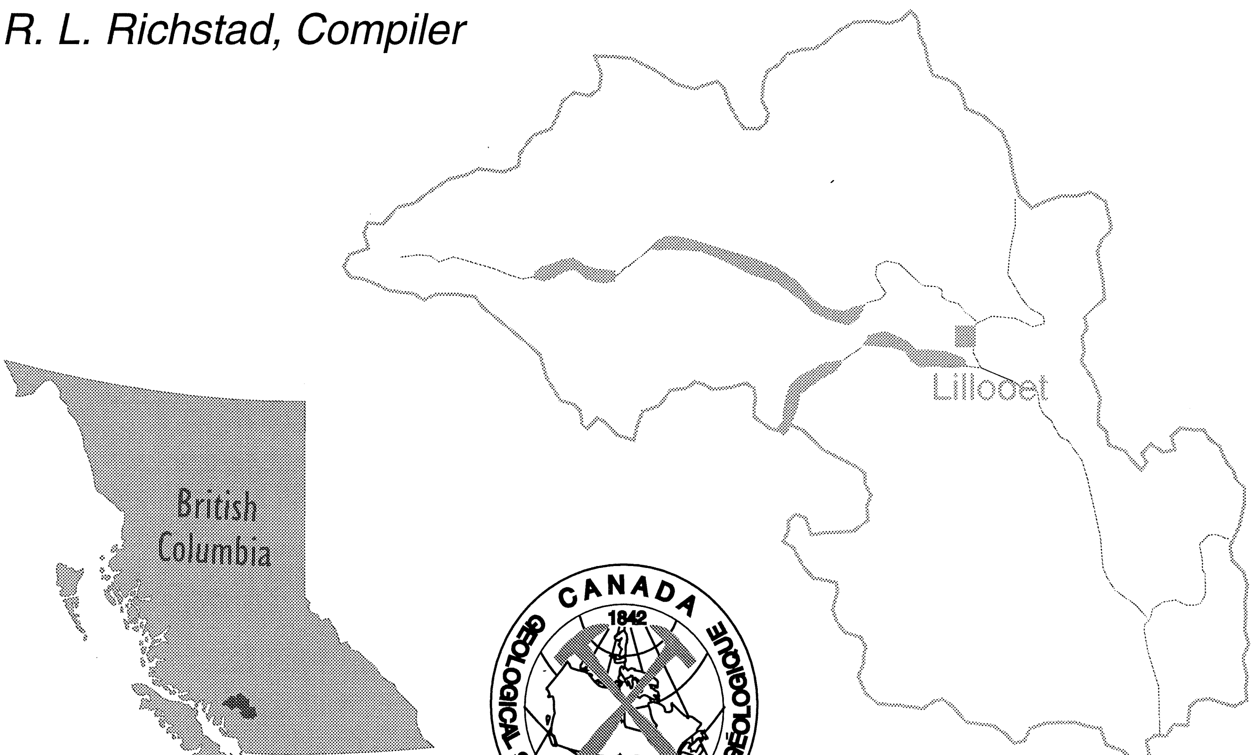

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SUMMARY

The British Columbia Paleontological Alliance (BCPA) is an organization of professional and amateur paleontologists of British Columbia, dedicated to advancing the science of paleontology in the province through education. The BCPA is a leading authority on paleontological resources in British Columbia, and includes representation from most of British Columbia's principal museums, universities, and government agencies that deal with paleontology. This report has been prepared by the BCPA, in association with the Geological Survey of Canada, for the Lillooet Land Resource Management Plan team, to enable it to make informed decisions about land designation issues relating to paleontological resources. The Geological Survey of Canada contributes a national and international paleontological expertise to the BCPA in helping to produce the assessment. The recommendations stated are those of the BCPA and are not those of the Geological Survey of Canada.

The Lillooet LRMP area comprises many different geologic units. Fossils are distributed sparsely in some of these units, more richly in others. Microfossil assemblages are most common in the rocks, macrofossils less so. Most fossil localities in the Lillooet LRMP area include fossil types and assemblages known from elsewhere in the Lillooet LRMP area, in British Columbia, or in Canada, and are therefore considered as not especially unique or significant. On this basis, it is the opinion of the BCPA that no specific fossil localities within the Lillooet LRMP area merit special protection status.

The Tyaughton Creek/Gun Creek/Relay Creek region of the Lillooet LRMP area includes a thick sequence of richly-fossiliferous Mesozoic strata that needs further study. Although the nature of fossil occurrences in this region does not dictate that the area be specially preserved, it is important that scientific collecting in this area continues. For this reason, should the region be considered for Provincial Park status, the BCPA urges that all lands within the park remain open for unrestricted scientific collecting of fossils by the professional and amateur paleontological community.

The BCPA also recommends that planners design and implement an educational exhibit for the general public highlighting the important role that fossils of the Marble Canyon Formation, specifically fusulinid foraminifers, have played in helping to interpret the plate tectonic history of western Canada. Roadside exposures within the present Marble Canyon Provincial Park lend themselves readily to such an exhibit and local landowners may be receptive to contributing to

the development of an educational display.

It is the further recommendation of the BCPA that all areas of the Lillooet LRMP area remain open to fossil collecting by the professional and amateur community as well, under the standards of the BCPA Code of Ethics. The BCPA recommends that no fossil sites presently known in the LRMP area be advertised in a manner which would promote over-collection or site destruction, but rather any collection should be done in a manner which is consistent with the BCPA Code of Ethics. Should new information come to light about fossil resources in the Lillooet LRMP area, local land-use planners are encouraged to consult with the BCPA to assess the scientific value of such sites and decide on appropriate action for special designation status.

PREFACE

The British Columbia Paleontological Alliance (BCPA) is a union of professional and amateur paleontologists from across the province, dedicated to advancing the science of paleontology, chiefly through education. Amateurs and professionals have organized together in regional societies which hold regular meetings and field trips. The Board of Directors of the BCPA (see Appendix A) consists of 2 directors from each of the 5 regional societies presently active in the province, plus representatives from university, government, and museum organizations actively engaged in professional paleontological research or education in the province. As the largest organization of professional and amateur paleontologists in the province, the membership of the BCPA represents a wide spectrum of paleontological expertise, much broader than any single agency in the province.

The BCPA is working actively to provide needed information to land-use planners and other government officials to help them make decisions regarding paleontological resources in British Columbia. In addition, it is a goal of the Geological Survey of Canada (GSC) to catalogue and inventory the paleontological resources of the Canadian Cordillera. This report is the fourth in a series resulting from this collaborative effort between the GSC and the BCPA. In order to disseminate the information widely, the reports have been published by the Geological Survey of Canada as Open File Reports. The recommendations made in the report are those of the BCPA and not the Geological Survey of Canada. The first report deals with paleontological resources of the Kamloops LRMP area and was produced in Fall, 1996 (Haggart et al., 1997a). The second covers paleontological resources of the Lakes District LRMP area and was produced in Winter, 1996/97 (Haggart et al., 1997b). The third report addresses paleontological resources of the Dawson Creek LRMP area and was produced in Spring, 1997 (Haggart et al., 1997c). The final published report covers resources of the Okanagan-Shuswap LRMP area (Haggart et al., 1998). The reports have been written in a format which assumes a limited but basic understanding of geology. Much of the summary information is similar in each of the reports; however, recommendations regarding paleontological resources are specific to each particular LRMP area. These recommendations reflect the views of the BCPA and not those of the Geological Survey of Canada.

This report has been prepared by the BCPA in response to a request from planners for needed information and advice on paleontological resources in the Lillooet LRMP area.

THE NATURE OF PALEONTOLOGICAL RESOURCES

Fossils constitute the remains of plants and animals that lived in the distant past and which have been subsequently petrified and preserved in the rock record. ***Paleontology*** is the scientific study of these fossils. In this report, we refer to ***paleontological resources***, also known as ***fossil resources***, as all those fossil materials which are present in the area of the report.

THE NATURE OF FOSSILS

One line of evidence that fossils represent ancient organisms is that they are usually found in hard rock, or lithified sediment, in contrast to human remains and artifacts, which are found in soft or unlithified sediments. However, not all rock types are fossiliferous. Fossils are most often found in a variety of sedimentary rocks, including sandstone, shale, conglomerate, and limestone. Fossils may also be preserved in metamorphic rocks, that is, those altered by the long-term effects of heat or pressure, but they are typically deformed and often unrecognizable. Fossils are not found in igneous rocks such as granite and volcanic rocks.

The fossil record shows that life on Earth has had a long and varied history. Life on our planet is considered to have evolved initially in the ocean environment, with the transition to land taking place much later in the Earth's history. The oldest direct evidence of biological organisms presently known consists of fossil bacteria, approximately 3 billion years in age. The first soft-bodied organisms, animals such as jellyfish and worms, probably evolved around 1 billion years ago. It was not until about 600 million years ago that the first shelled animals living in the oceans evolved, during the so-called "Cambrian Explosion." The first ancestors of ocean fishes subsequently evolved about 450 million years ago, and plants began to experiment with environments on the land at approximately the same time. All of this evolutionary history of life on the planet has been interpreted from analysis of the fossil record.

1. Distinction Between Paleontological and Archeological Resources

> *It is critical that resource planners understand that paleontological resources are distinct from archeological resources, and that different and unique criteria are used for determining where paleontological resources may occur in a region, as well as their scientific importance.*

Confusion often exists among the lay public as to the precise nature of paleontological, anthropological, and archeological resources. Physical anthropology studies the evolutionary history of humans through analysis of their fossil remains and is thus a subdiscipline of paleontology. Such fossil resources generally range in age from approximately 250,000 to 1.75 million years old, the approximate length of time that direct human ancestors have been present on Earth. Such human remains predate the arrival of human cultures in North and South America and thus, research in physical anthropology is focused in Africa, the Middle East, and Asia.

In contrast, scientists consider paleontology to be distinct from archeology, or the branch of science that studies human cultures through excavation and recovery of relics left by them. Archeological resources, for example, are the criteria by which the presence and activities of native cultures in British Columbia over the past 10,000 years or so have been established.

2. Types of Fossils

For the purposes of this report, we ascribe fossils to two basic types: microfossils and macrofossils. Microfossils are those fossil materials which are too small to be seen readily with the naked eye and which therefore require a microscope for detailed study. To study microfossils, the paleontologist collects bulk samples in the field and then uses physical or chemical methods to break down the rock enclosing the microfossils. The isolated microfossils are then mounted on a specimen slide for study under the microscope. Common types of microfossils include radiolarians, conodonts, foraminifers, ostracodes, ichthyoliths (fish teeth and bones), and pollen grains. Generally, microfossils are found in limestone and shale rocks and are usually abundant. They are, of course, not generally recognizable until extracted from the host rock.

Macrofossils, in contrast, are those fossil materials which can be seen readily and studied without a microscope. Examples of this group include bone and bone fragments, plant and leaf material, corals, and shells. Macrofossils can be found in all the sedimentary rock types listed above. They are located by the paleontologist principally by applying mechanical action, usually hammers, to break apart the rock at the outcrop, splitting it into smaller pieces until a specimen is found. In some instances, the paleontologist may bring bulk samples to the laboratory to break them down.

3. Occurrence and Preservation of Fossils

Macrofossils are generally less abundant than are microfossils. This is because of several factors, among them that microfossils are so much smaller than macrofossils, and many more of them can be preserved in the same area as a single macrofossil. In addition, the destructive forces which act to break down a formerly living animal or plant, such as biological decay, environmental weathering and chemical dissolution, work more effectively on larger objects.

Generally, macrofossils are found in rock outcrops where these destructive forces have been minimal since the death of the once-living organism. However, if a particular rock unit contains fossils at one locality, it is reasonable to conclude that the same unit will also contain fossils at other localities where such destructive factors have also been minimal. Any locality where the rock unit is exposed at the surface may potentially contain similar, or different, fossils. It is important, however, that the rock itself be exposed at the surface and not covered with soil or vegetation. For this reason, road-cuts from new road-building activity are a favourite study area for the paleontologist: they expose fresh rock which may contain fossils. In this way, new fossil localities are continually coming into existence in areas of development. Similarly, storms and heavy rain may erode rock in drainages and on cliffs, providing new exposures to survey for fossil materials. Most fossils therefore constitute a resource that is continually being recharged as erosion or development exposes new and different areas of fossiliferous rocks.

> *In this manner, paleontological resources are not generally considered to be unique. This places them in direct contrast with archeological resources, which are considered unique for a specific time and place. Land managers and planners must keep this critical distinction in mind when assessing paleontological resources in their areas.*

USES AND VALUES OF FOSSILS

Fossils are extremely valuable in a variety of ways. They are utilized by paleontologists and geologists to date the age of the rocks containing them, and to help construct geological maps of the Earth's surface. They can be used to help interpret the environments of the rocks containing them. And of course, they are critical to unravelling the history of life on our planet and the processes that have shaped the evolutionary history of organisms.

1. Age Dating of Rocks

It has been known for nearly two centuries that fossils are very useful for defining the age of geological rock units, and a basic background in geology is thus necessary to properly interpret fossils and their geologic context. Because the evolutionary history of life is irreversible, the succession of fossils in the rock record has been used by geologists as the basis of the geological time scale (Appendix C). Rocks that contain a particular fossil or fossil assemblage are thus considered to be *correlative*, or the same age as all other rocks around the globe that contain the same fossils. The value of most fossils as geological correlation tools is based on their relatively widespread distribution and their abundance. Correlation of rocks underpins the production of geologic maps and the elucidation of Earth history.

2. Paleogeography and Paleoenvironmental Reconstruction

Interpreting the environment of deposition of ancient sedimentary rocks is a key role of fossils, and one for which they are highly valued. By studying assemblages of fossils preserved in a sedimentary rock, the paleontologist can ascertain whether the rock formed in the ocean, in a lake, or even in a desert environment. Knowing the depth in the ocean at which marine rocks accumulated is often crucial in the search for oil and natural gas, and such fossil information is highly prized by the petroleum exploration industry. Fossil assemblages can tell us whether the ocean or land temperatures were cold or hot in past times, whether land masses were covered by luxuriant forests or barren deserts, and which land areas were once connected but have been torn apart through the migration of the Earth's tectonic plates.

3. History of Life on Earth

Of course, fossils are also of great value in deciphering the history of life on Earth. The development of life on our planet has often been characterized by great leaps in evolutionary advancement, when many new life forms evolved over relatively rapid intervals of geologic time. Our understanding of the processes by which this evolutionary development has taken place is based primarily on analysis of the fossil record, as well as observation of biological processes active in the world today.

The history of life on Earth is also one of times of great crisis, when large-scale extinction events have decimated our biological world. The precise causes of many such extinctions in the geological past will perhaps never be fully known, but there is certainly no question that our planet has experienced many periods when great numbers of the plants and animals living have become extinct over very short periods of time, never to be seen again. Fossils play a critical role in helping paleontologists assess the extent and rapidity of these past extinction events. Through understanding the nature and pace of past extinction events, it is clear that our planet is currently experiencing a period of extinction equal to, and probably significantly greater than, any recorded in the fossil record.

THE ROLE OF AMATEUR COLLECTING

Traditionally, scientific collecting of fossils has been undertaken primarily by professional paleontologists, those trained researchers pursuing the science as a full-time career. Professional paleontologists have great interest in adequately assessing each paleontological site and in collecting from the site in a rigorous scientific manner. Increasingly, however, the abilities of professionals to undertake field expeditions to collect fossils are being restricted as their employment and funding organizations cut back on the amount of monies allocated for paleontological research. This problem is particularly acute in Canada at the present time.

For this reason, many professional paleontologists rely increasingly on contributions from the amateur collecting community to supplement their field activities. In British Columbia, for example, amateur collectors have been responsible for locating the first Eocene bird fossil in the province, and probably from Canada, the first Eocene crayfish, many new Eocene insect finds, a Cretaceous elasmosaur, dinosaur and other vertebrate remains on Vancouver Island, and many new Jurassic and Cretaceous mollusk occurrences across the province. In addition, amateurs have located new localities for many known fossil types, greatly increasing the paleontologists' understanding of the geographic distribution of those fossils.

Most professional paleontologists in the province, including all professional members of the BCPA, encourage amateur collectors to make their finds known to the professional community. By doing so, professional paleontologists recognize that the maximum amount of information is made available for scientific study. Through the educational efforts of the BCPA, professionals work with the amateur community to ensure that amateur collecting is done in a rigorous and scientific manner. Professionals participate in field trips and demonstrations to show the amateur community how to collect fossils adequately, how to measure and describe the rocks containing the fossils, and how to curate their collections for long-term storage. In addition, the amateur collecting community follows a strict Code of Ethics (outlined in the BCPA Collecting Policy, Appendix B). The willingness of most collectors to provide their fossils for scientific study is to be commended.

Of course, not all amateur collectors will subscribe to the strict guidelines of the BCPA Collecting Policy. But this will be true whether such a policy exists or not. In fact, a very large number of amateurs *do* follow the guidelines and they *do* make their collections available for study. Most professionals are strongly concerned that, by restricting the access of amateurs to collect fossils, the free exchange of information that presently exists between the amateur and professional communities will evaporate. This is precisely the situation that has evolved in Alberta, where very restrictive legislation and a permit system have driven collecting underground. In spite of the existing legislation in Alberta, unmonitored fossil collecting continues in that province, but collaborative interactions with the scientific community have virtually ceased. For this reason, the BCPA strongly recommends that no limitations be placed on the rights of amateurs to collect fossils in all those areas not specifically designated in this report.

DESIGNATED FOSSIL SITES IN BRITISH COLUMBIA

In spite of the fact that most fossiliferous rocks in British Columbia contain fossils at numerous localities over their outcrop area, some rock units are known to contain only one or, at best, several fossil localities. Given that such fossil localities can be "one-of-a-kind" in a national or global sense, specific protection of such localities is often desirable. Several such fossil localities are already known to exist in British Columbia and they have been recognized previously for their unique paleontological materials. Chief among these are the Burgess Shale, Wapiti Lake, Puntledge River and Driftwood Canyon localities.

1. Burgess Shale

The Burgess Shale locality is found in Yoho National Park and is therefore administered federally through Parks Canada. This relatively small exposure of marine rocks is one of the few places in the world where soft-bodied Cambrian (530 million years old) fossil organisms have been preserved. It has been declared a World Heritage Site by UNESCO as a result of this uniqueness. The Burgess Shale locality is administered under National Park General Regulations with specific restrictions to access by a Superintendent's Order under Section 7. The order specifies two zones: Zone 1 allows access to researchers by permit only, with limited collecting allowed; Zone 2 allows licensed guided tours with no collecting allowed. A Mandate of Understanding places responsibility for research and management of the fossil beds with the Royal Ontario Museum, Toronto. Enforcement of regulations relies largely on National Park rangers and research staff (while on-site).

Contacts: Brian MacDonald, Department of Canadian Heritage, Vancouver
Paul Kutzer, Yoho National Park Administration, Field, B.C.

2. Wapiti Lake (Fossil Fish Lake)

This site is located in the Peace/Liard District and contains 240 million year-old marine vertebrates, including armoured fish and coelacanths, which are remarkably complete and well preserved. Fossil specimens from Wapiti Lake are found today in museums around the globe. The 127.5 hectare site was designated as Management Class 0 by the British Columbia Ministry of Forests in 1990, which excludes timber supply activities and notes high sensitivity features.

Specifically, the area was covered at that time under Land Act Map Reserve No. 908049, established by the Ministry of Crown Lands on behalf of the Ministry of Municipal Affairs, Recreation and Culture for a period of five years, renewable for subsequent 5-year periods. A renewal of map reserve status was approved in 1995. Scientific fossil collecting and commercial extracting activity have been undertaken at the site under this status and permits have been issued for these activities. Research permits have been issued through the BC Lands Office in Fort St. John, while at least some of the commercial ventures have been overseen by the Royal Tyrrell Museum. The Wapiti Lake site is in the Dawson Creek LRMP area and specific proposals for protection and management of the site were presented in the report prepared by the BCPA for that LRMP area (Haggart et al., 1997).

Contact: Jeff Beale, Ministry of Forests (Dawson Creek), Chair, Interagency Planning Team

3. Peace River Ichthyosaur Fossils

This site is located in the Peace River District along the west bank of Peace River at the mouth of Nabesche River, presently flooded by Williston Lake. The ichthyosaur fossils were found in the early part of the century in Triassic strata. In order to preserve these and other vertebrate fossils found at the site, the area was designated an "Historic Object" under the Historic Objects Preservation Act by Order-in-Council (#1475), December 8, 1930. Subsequent flooding by Williston Lake precludes any further paleontological collecting at the site, although other collecting opportunities probably exist in the adjacent area.

4. Peace River Dinosaur Tracks

The Dinosaur Tracks site is also located in the Peace River District, along the north bank of Peace River in Rocky Mountain Canyon, opposite the mouths of Johnson and Moose Bar creeks. This site has also been subsequently flooded. Extensive dinosaur tracks and some bones were found here in the 1920s, in Lower Cretaceous strata, and the area was designated an "Historic Object" under the Historic Objects Preservation Act by Order-in-Council (#637), May 16, 1930. An extensive salvage survey in the late 1970s, in advance of the rising waters behind Peace Canyon Dam, located many hundreds of specimens, most of which are reposited at the Tyrrell Museum, Drumheller, Alberta. Subsequent flooding by Dinosaur Lake precludes any further paleontological collecting in the area.

5. Puntledge River Paleontological Site

The Puntledge River shales, exposed on southeastern Vancouver Island, contain abundant, well preserved marine fossils, including some vertebrates, approximately 70 million years old. These shales crop out extensively on the east side of Vancouver Island and the adjacent Gulf Islands. In April, 1989, a small section of the river (10 x 30 metres) was designated, under the Heritage Conservation Act, as a BC Provincial Heritage Site by Order-in-Council (#547), in order to facilitate the excavation of the fossilized skeleton of an elasmosaur, an extinct marine reptile. More recently, additional significant elasmosaur and vertebrate remains have been found on other nearby rivers. In February, 1996, the Puntledge River site was proposed for Protected Area status, the extent of which will be dependent on negotiations with private landowners who hold a considerable portion of the property in question, and subject to the ability of funds to purchase lands at fair market value. Subsequent management strategies have not yet been determined.

Contact: Lyn Barnett, Land Use Coordination Office, Ministry of Environment, Lands and Parks, Victoria

6. Driftwood Canyon

This site in the Skeena District consists of a small canyon containing well preserved, lacustrine plant, insect and fish fossils, approximately 40 million years old. Outcrops of similar Eocene strata are found extensively throughout the Smithers region, and also near Horsefly and throughout a large part of south-central British Columbia, in the Princeton/Kamloops region. Originally established as a Class A Provincial Park in 1967, Driftwood Canyon was recommended for reclassification as a Recreational Area in 1978 in order to allow public fossil collecting. The Driftwood Canyon locality was thus the first, and to date the only, site in the province with its special status conferred not due to the uniqueness of its fossils or their preservation, but rather to allow general collecting of fossils. Active promotion of the fossil beds as a local recreational attraction by the Smithers Chamber of Commerce has subsequently generated extensive excavation of the site, resulting in serious undercutting of the cliff face forming the major outcrop. This safety hazard, coupled with a request for protection from the Royal British Columbia Museum, have resulted in a recent initiative to phase out public collecting through a campaign of education and information.

Contact: Ken Zimmer, Acting District Manager, BC Parks, Smithers, B.C.

GEOLOGY OF THE LILLOOET LRMP AREA

Gabrielse et al. (1991) noted that the geological architecture of the Canadian Cordillera can be described in terms of tectonic assemblages, terranes, and morphogeological belts. Each tectonic assemblage is unique, reflecting it's own depositional history, place of origin and subsequent changes as it accreted to the continent of North America during the Mesozoic and Cenozoic time periods (see Appendix C). This accretion and subsequent disruption through plate tectonic processes has led to the development of the five morphogeological belts of the province (Figure 1a). These belts are (from east to west): the Foreland Belt; the Omineca Belt; the Intermontane Belt; the Coast Belt; and the Insular Belt. The Lillooet LRMP area straddles two of these belts - the western two-thirds of the LRMP area resides in the Coast Belt while the eastern third lies in the Intermontane Belt (Figure 1b). Each of these two regions is particularly unique geologically and as such they are discussed individually.

1. The Intermontane Belt

That part of the Lillooet LRMP that lies east of the Fraser and Yalakom rivers is found in the Intermontane Belt. In this region, the older rocks of the Intermontane Belt are correlated with the Quesnellia and Cache Creek terranes, and are overlain by Jurassic and Cretaceous sedimentary and volcanic rocks. Limited exposures of Quesnellia terrane are found in the southeasternmost part of the Lillooet LRMP area. Rocks of this terrane consist of Upper Triassic and Lower Jurassic volcanic arc strata, volcanic-derived sedimentary rocks, and contemporaneous intrusive rocks, all overlain by younger Jurassic volcanic arc-derived clastic strata. The most common sedimentary rock types are thinly interbedded homogenous argillite, laminated argillite and siltstone, in places silicified. Turbiditic sandstones are common, as well as massive sandstones with rip-up clasts from volcanic sources. In the Lillooet LRMP area, fossils from rocks of Quesnellia terrane are uncommon; elsewhere, carbonate strata of the terrane yield abundant crinoidal debris, as well as conodonts, fusulinids and other foraminifers, and local brachiopods and corals.

Perhaps the most fossiliferous strata of the Intermontane Belt are found in the Cache Creek terrane. This terrane consists of oceanic sediments of Mississippian to Early Jurassic age. Particularly spectacular within the terrane are the limestone beds of the Marble Canyon

Intrusive Rocks (No Fossils)

ETf, ETg, mTgc: *Tertiary plutonic rocks*

LKg, mKg: *Cretaceous plutonic rocks*

EJgC: *Jurassic plutonic rocks*

Pd: *Permian plutonic rocks*

Primarily Sedimentary Rocks (Fossils common)

PTK, PTs: *Early Tertiary volcanic and sedimentary rocks, including French Bar Formation*

KS: *Lower to Upper Cretaceous Taylor Creek and Jackass Mountain groups*

JKR: *Upper Jurassic to Lower Cretaceous Relay Mountain Group*

JL: *Lower Jurassic Tyaughton Group*

PJB: *Permian to Jurassic Bridge River Complex oceanic crust and sediments*

Primarily Volcanic Rocks (Fossils rare)

TQG, NTP: *Upper Tertiary/Quaternary volcanics*

UKM: *Upper Cretaceous volcanics*

UTrC, Ltrd: *Upper Triassic Cadwallader Group volcanics with minor marine to non-marine clastic, carbonate strata; mafic volcanics*

Puo, Puos: *Devonian-Triassic Shulaps Group oceanic volcanics*

Metamorphic Rocks (No Fossils)

n *Metamorphic rocks of uncertain age*

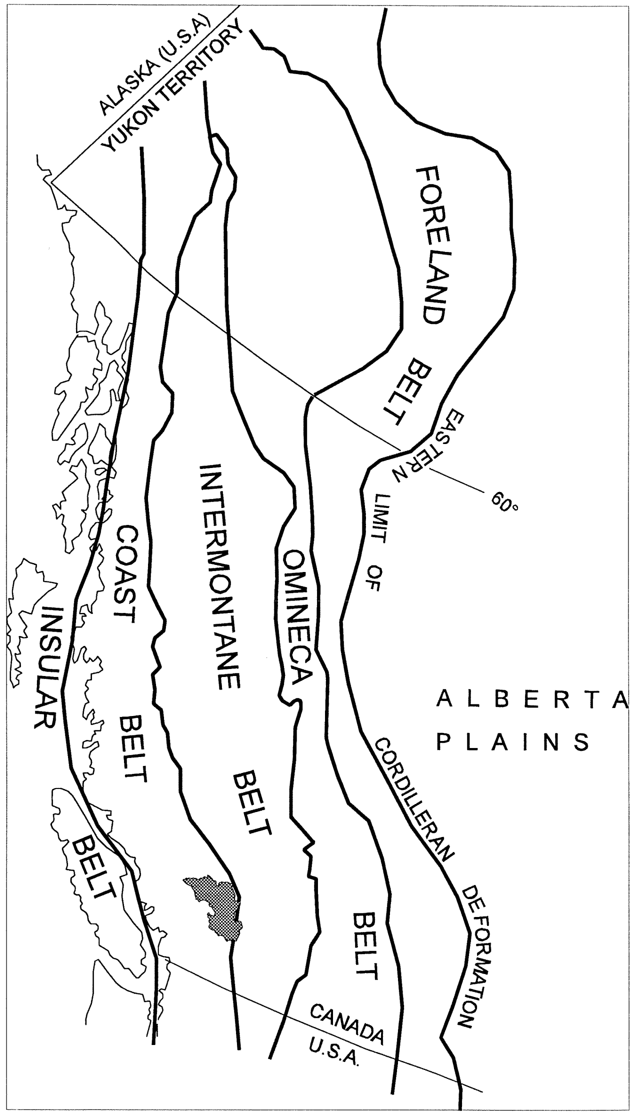
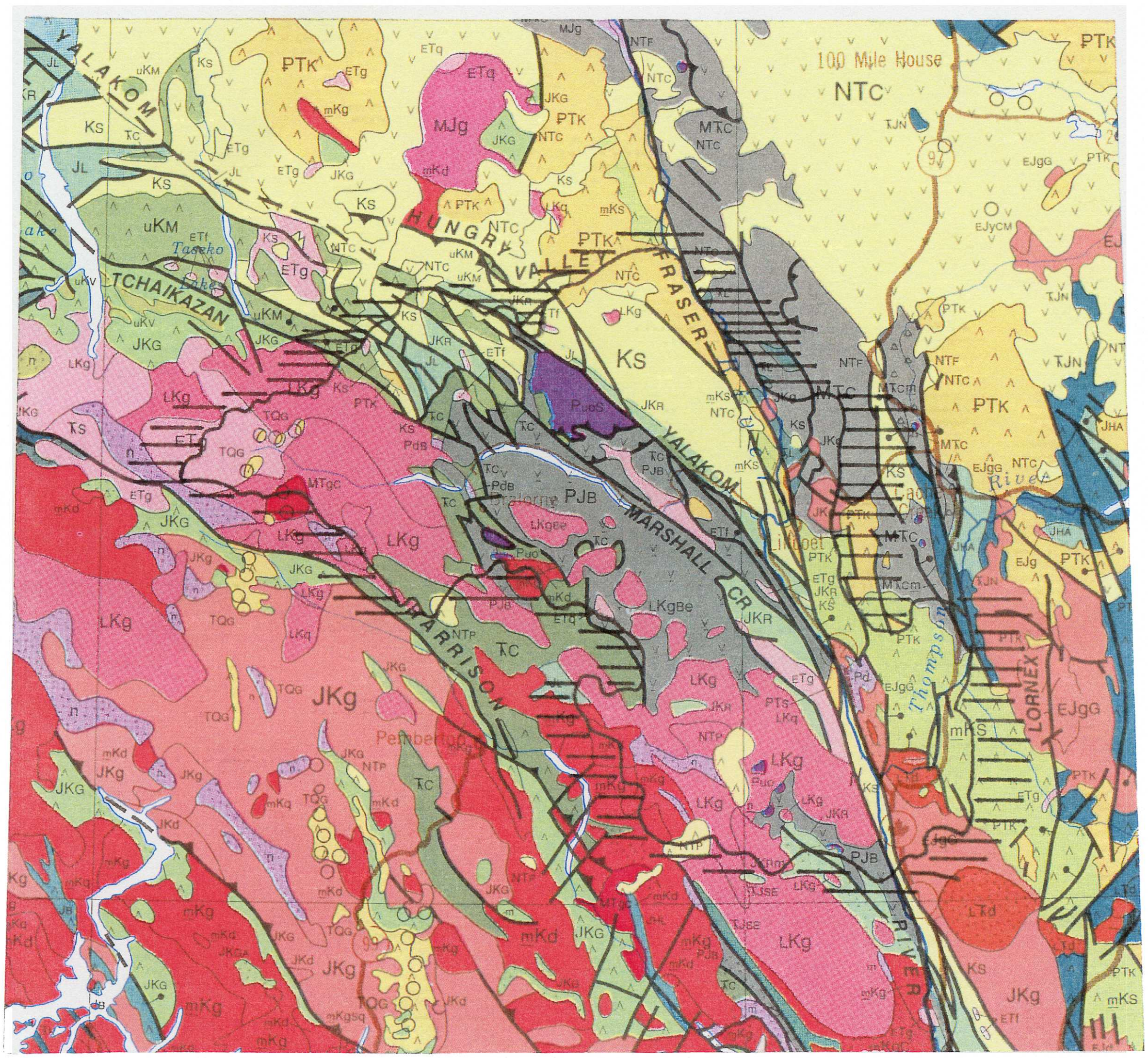


Figure 1a. Morphogeological belts of the Canadian Cordillera. Shading indicates area of Lillooet LRMP.

Figure 1b. (At right; legend above). Generalized geology of the Lillooet LRMP area (hachured lines denote LRMP boundary) (from Wheeler and McFeely, 1991).

Formation, rich with fusulinid foraminifers and a few corals and bivalves. Such macrofossil types are atypical of the Cache Creek terrane, however; most of the oceanic sediments of the terrane are depauperate in macrofossils, but rich in microfossils such as conodonts and radiolarians.


100 Mile House
YALAKOM
HUNGRY VALLEY
FRASER
TCHAIKAZAN
YALAKOM
MARSHALL CR
HARRISON
LORNEX
Thompson
Bralorne
Pemberton
Lillooet
NTc
PTK
MJg
Ks
PJB
LKg
JKg
EJgG

Overlying the Quesnellia and Cache Creek terranes are a variety of Jurassic and Cretaceous sedimentary strata, derived extensively from volcanic sources. These strata include the Spences Bridge and Kingsvale sedimentary groups, thick sandstone and shale sequences which are moderately fossiliferous with mollusks, including ammonoid cephalopods, bivalves, and some gastropods.

Early Tertiary volcanic and sedimentary rocks, including the French Bar Formation, locally overlie older deposits in the Intermontane Belt, and they have produced a variety of plant macrofossil specimens from interbedded siltstones, shales, and tuffs. Such strata accumulated in characteristic fault-controlled basins throughout the Intermontane Belt (Yorath, 1991), and locally include Eocene freshwater lacustrine fossils (Wilson, 1977).

2. The Coast Belt

Rocks of the Coast Belt are distinctly different from those of the Intermontane Belt. In general, the belt is characterized by more rugged relief than the Intermontane Belt and much of this relief is attributed to the more erosion-resistant intrusive rocks which comprise large parts of the belt. The intrusive rocks include various types of granite, granodiorite, or diorite, and range in age from Triassic through Tertiary. These rocks formed from hot magmas which cooled at great depths within the earth's crust and were subsequently exposed at the surface through erosion. Since they originate at deep levels within the crust, and from molten magmas, intrusive rocks do not contain any fossils.

Significant occurrences of sedimentary strata are found within the Coast Belt, however. Rocks of the Bridge River terrane are widespread and consist of Permian to Jurassic oceanic crust and sediments (including Hurley Formation, Fergusson Group) which were amalgamated with the continental crust in late Mesozoic time. Because of their origin in mid-ocean settings, rocks of the Bridge River terrane are very poorly fossiliferous in macrofossils. They include locally common microfossils, however, in particular radiolarians, and these fossils have been instrumental in unravelling the age of these complexly-deformed rocks.

Minor outcrops of Late Triassic and Jurassic oceanic crust and sedimentary strata in the southern part of the LRMP area are assigned to the Shuksan terrane. These rocks have been mostly metamorphosed and do not contain any significant fossil occurrences.

The Methow terrane is another significant package of rocks and includes poorly fossiliferous Triassic to Jurassic basalt and ocean arc volcanic rocks, overlain by Upper Jurassic to Upper Cretaceous sedimentary deposits of the Relay Mountain Group and additional volcanics. The sandstones and shales of the Relay Mountain Group are locally rich in macrofauna, including ammonoid cephalopods and bivalves, and these rocks in the Lillooet area have contributed significantly in the past to interpreting the sequence of marine life in western Canada during the Mesozoic era.

More-deformed, but locally fossiliferous strata are found within the Cadwallader Terrane, generally exposed north and west of the Methow terrane. This terrane includes the Upper Triassic Cadwallader Group of volcanic rocks, with minor interstratified marine to non-marine clastic and carbonate strata. Cadwallader Group sedimentary strata are poorly fossiliferous but have yielded corals, brachiopods, bivalves and ammonoid cephalopods. The upper part of the terrane includes the Lower Jurassic Tyaughton Group and Upper Jurassic and Lower Cretaceous Eldorado and Relay Mountain groups. These sedimentary and volcanic sequences contain thick accumulations of fossiliferous sandstone, shale and conglomerate.

Lower to Upper Cretaceous strata of the Taylor Creek and Jackass Mountain groups are found overlying the older terrane rocks of the Coast Belt. These sedimentary sequences are also locally rich in mollusk fossils, including ammonoid cephalopods, scaphopods, bivalves and gastropods.

Quaternary glacial deposits are found locally throughout much of the Lillooet LRMP region, but are confined primarily to valleys, where both glacial (ice-derived) and fluvial-glacial (water-derived) sediments are common. Deposits vary from sorted, coarse gravels, sand and silts to unsorted tills. Due to the extent of coverage of Quaternary deposits, they have not been included on the map of Figure 1. Although Pleistocene fossils are known from Quaternary deposits of areas adjacent to the Lillooet LRMP area, none have so far been recognized in the Lillooet region.

PALEONTOLOGICAL SITE ASSESSMENT PROCESS

The BCPA's Committee on Fossil Collecting and Regulation Policy was asked by members of the Lillooet LRMP team to assess the paleontological importance of all known sites within the Plan study area. In discussions with Lillooet LRMP team personnel, the Committee stipulated that the BCPA would only deal with assessing which fossil sites in the study area are scientifically unique or of unusual value, such that special protection is merited in our view. The BCPA also agreed to suggest options for managing any sites it so proposed. Other multiple criteria upon which site management selection might be based, such as recreational potential, scenic attraction, commercial activity, etc., were specifically excluded from the BCPA assessment mandate. The BCPA is not prepared to assess such additional factors in total and, if such analysis is desired by the LRMP team, an independent agency should undertake this effort. The BCPA can provide a listing of consulting paleontologists who can be contacted for such services.

The initial step in the assessment process was to compile published information about fossil localities in the LRMP area. This was undertaken by studying the geological and paleontological literature sources at the Library of the Geological Survey of Canada's Vancouver office, as well as compiling lists of fossil information from the unpublished database files of the Geological Survey of Canada. Concurrently, university and museum researchers who have undertaken studies of British Columbia fossils, particularly those of the Lillooet LRMP area, were solicited for their opinions on the quality and significance of paleontological sites in the LRMP area. These researchers include Dr. Jim Basinger (University of Saskatchewan, Saskatoon), Dr. L.V. Hills (University of Calgary), Dr. Steven R. Manchester (University of Florida, Gainesville), Dr. Elizabeth McIver (University of Saskatchewan, Saskatoon), Dr. Michael J. Orchard (Geological Survey of Canada, Vancouver), Dr. Terry Poulton (Chief Paleontologist, Geological Survey of Canada, Calgary), Dr. Ruth Stockey (University of Alberta, Edmonton), Dr. Howard Tipper (Geological Survey of Canada, Vancouver), Dr. E. T. Tozer (Geological Survey of Canada, Vancouver), Wesley C. Wehr (University of Washington, Seattle) and Dr. Mark V.H. Wilson (University of Alberta, Edmonton).

After the literature search and researcher enquiries was completed, the BCPA Board of Directors met in February to discuss in detail the scientific merit of all identified localities in the Lillooet LRMP region. The recommendations of this report are those formulated at that Board meeting.

RECOMMENDATIONS

As noted above, microfossil localities are widespread within the Lillooet LRMP area, macrofossil localities less so. Most macrofossil localities in the LRMP area contain commonly occurring invertebrate fossil remains, including ammonoid cephalopods, bivalves, brachiopods, corals, plants, and echinoderms. The few Tertiary localities found in the LRMP area are rich in plant macrofossils. All of these fossil types are often found by local collectors, and they provide the nucleus for recreational fossil collecting.

1. Tyaughton Creek Region

Perhaps the most important area for future paleontological research in the Lillooet LRMP area is the large region of the Chilcotin Ranges encompassing the drainage basins and dividing ridges of Tyaughton Creek, Gun Creek, and Relay Creek, an area mostly inaccessible by motor vehicle at present. Rich macro- and microfossil collections made from this area in the past have demonstrated that a very complete section of strata spanning the Upper Triassic through the Lower Cretaceous is preserved here, perhaps one of the most complete sections spanning this interval anywhere in Canada. Further biostratigraphic research should be undertaken on the rocks in this area, in particular the Jurassic and Lower Cretaceous sequences. However, stratigraphic paleontologists who have worked in this particular area note that extensive additional fossil collecting will be critical to this research and fossil collecting should therefore not be restricted in any manner, except for commercial purposes. If local planners are considering inclusion of the Tyaughton Creek region within a new or expanded provincial park, the BCPA proposes that this area be placed in a special Scientific Reserve within the park, in order that unrestricted scientific collecting by the professional and amateur community can continue within it.

2. Marble Canyon

The Marble Canyon area includes outcrops of fossiliferous limestone assigned to the Marble Canyon Formation and locally rich with fusulinid foraminifers of Permian age. Fusulinids are large, unicellular marine organisms that went extinct at the end of the Permian period, and they are characteristically found in rocks formed at low latitudes of the Permian oceans elsewhere around the world. Their occurrence today at relatively high latitudes in British Columbia has thus been used to document that these rocks have travelled great distances from their point of origin to their present location. The fossils are dramatic evidence of the important role that plate tectonic processes have played in forming and shaping our continents. Fortunately, the rocks and fossils of the Marble Canyon Formation have been studied thoroughly over the past two decades, and the fossils occur in relatively large numbers; there is thus no risk of losing important information by continued small-scale collecting of these localities. Due to the global significance of these rock exposures and their fossils, the Marble Canyon Formation will be a site visited by the international scientific community during the 1999 Carboniferous Congress to be held in Calgary, Alberta.

The rocks and fossils of the Marble Canyon Formation lend themselves readily to use as an educational tool for portraying the important role that geology plays in our daily lives. The BCPA thus strongly urges local planners to consider creating an information site in the Marble Canyon region which will display these fossils, and interpret their occurrence in terms of plate tectonic processes. Local landowners may recognize positive public relations value in sponsoring such an information site, and can perhaps be persuaded to contribute towards such a display. Such an information site should ideally be located in the Marble Canyon Provincial Park.

3. Other Areas

The professional paleontologists consulted in the preparation of the Lillooet and other LRMP reports are in agreement that all other fossil localities in the Lillooet LRMP area provide useful information about the distribution of fossil species in the province, but none of these localities should be considered especially unique or significant. For these reasons, the BCPA concludes that there are no other known paleontological sites in the area of the Lillooet LRMP area for which special land-use designation should be established at present. We reiterate our belief that scientific fossil collecting under the conditions of the BCPA Code of Ethics should continue at all localities in the Lillooet LRMP area.

It is our further recommendation that no fossil sites known in the Lillooet LRMP area be advertised to promote collecting by the general public in a manner which might lead to site destruction, or be contrary to the BCPA Code of Ethics. It is our view that fossil collecting should be undertaken by persons interested enough to seek out information on localities from established organizations. This approach should facilitate public education about fossil resources and encourage responsible collecting within the framework of the Collecting Policy established by the BCPA.

It is possible that continued scientific fossil collecting may generate new fossil discoveries that merit special designation. Should the BCPA should become aware of any specific information about fossils of especially significant scientific importance or uniqueness in the Lillooet LRMP area, it will immediately convey this information to local planners for special-status consideration. Such status might include various restrictions on collecting at the site(s), as outlined in the BCPA Policy on Fossil Collecting and Regulation (Appendix B).

The BCPA has prepared this report on a voluntary basis, in the interest of providing summary information to local land-use planners. Should planners require more detailed study of specific fossil sites, they should contract for such assessment with a consulting paleontologist; the BCPA can provide a listing of consulting paleontologists in British Columbia, if requested.

ACKNOWLEDGMENTS

We sincerely thank the Lillooet LRMP planning team, in particular Terry Macdonald and Mike Hanry, for supporting this initiative and providing advice on land status designations. In addition, all those persons who contributed their scientific expertise to helping the BCPA produce its assessment of the fossil resources of the Lillooet region have our warm appreciation. Steve Irwin, of the Geological Survey of Canada, is also thanked for providing access to unpublished database files. Careful reviews of the Open File manuscript by Steve Irwin and Glenn Woodsworth are greatly appreciated.

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APPENDIX A

BRITISH COLUMBIA PALEONTOLOGICAL ALLIANCE

Board of Directors

February 21, 1998

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APPENDIX B

BRITISH COLUMBIA PALEONTOLOGICAL ALLIANCE POLICY ON FOSSIL COLLECTING AND REGULATION

Adopted February 24, 1996

The British Columbia Paleontological Alliance (BCPA) is a union of professional and amateur paleontologists working to advance the science of paleontology in the province through fostering public awareness, scientific collecting and education, and by promoting communication between all those interested in fossils. It is the position of the BCPA and its component regional societies that fossils comprise a critical record of past life forms and, therefore, fossils have important scientific, heritage and educational values. Any collecting of fossils must be made with due consideration of these factors.

General Scientific Collecting

Fossil collecting activities, by both professionals and amateurs, should be undertaken in a responsible manner, that is, suitable for subsequent scientific study and where collected materials receive proper curation, as described in the following BCPA Standards and Ethics for Scientific Collecting. Fossil collecting undertaken according to these standards provides a valuable record of British Columbia's paleontological resources and should be encouraged.

Standards and Ethics for Scientific Collecting

Determine the status of the land prior to collecting. Ensure that appropriate permission and permits have been obtained from landowners or governmental authorities before venturing to a fossil site. Leave each site as found with respect to gates, fences or constructions on the property.

Practice sound environmental etiquette. Ensure that the size of field groups, as well as collecting methods employed, minimize the impact of collection on the outcrop.

Take appropriate safety precautions while collecting and carry a first aid kit in each field group.

Collectors must record and maintain documentation of all relevant geographic and stratigraphic information for each fossil in their collections. Every effort should be made to ensure that this information is accessible to interested professional researchers.

Fossil collections must be properly curated. Each specimen should normally have a unique identifying number related to a documented fossil locality. Specimens should be stored in a manner consistent with their long-term preservation. Important specimens should be housed in a recognized paleontological repository.

Sale of fossils for personal or corporate profit by any member of the Alliance is unacceptable.

Members who fail to adhere to these standards may have their membership in the Alliance revoked.

Paleontological Reserves

A few fossil localities in British Columbia are of outstanding scientific importance (e.g. Burgess Shale and Wapiti Lake, both presently protected) and merit specific protection and regulation as Paleontological Reserves. Measures of the importance of a Paleontological Reserve include, but are not limited to: uniqueness of the fossils found there (either individual specimens or associations of fossil types); unusual preservation of fossils; large, moderately-complete vertebrate remains; etc. It is the opinion of the BCPA that recommendations proposing such a locality, and the nature and extent of management of such sites, should be made to legislators by the BCPA in consultation with other professionals having specific knowledge relevant to the proposed locality.

General scientific collecting is not permitted in Paleontological Reserves. Locality protection should be flexible, to allow for periodic revision of the status, and should be designed so as not to hinder valid scientific research at the locality.

The BCPA will seek to work directly with provincial ministries and legislators to help develop a process whereby Paleontological Reserves can be designated promptly and with the input of the BCPA.

Paleontological Research Sites

The BCPA recognizes that valid scientific research may require that some fossil sites remain undisturbed for the duration of the study. Such sites are to be designated Paleontological Research Sites (PRS). Researchers may apply to the BCPA for PRS status. Research sites would be established typically for periods of six months to two or more years, depending on the nature of the research. Collecting by BCPA members will be prohibited for the duration of the

Paleontological Research Site designation. At the conclusion of the assigned study period, the site will revert to normal status unless the researcher demonstrates to the satisfaction of the BCPA that it should be further protected.

The BCPA will seek to work directly with provincial ministries and legislators to help develop a process whereby Paleontological Research Sites can be designated promptly and with the input of the BCPA.

Out-of-Province Paleontologists

Out-of-province paleontologists should not be restricted or hindered from fossil collecting, provided they follow adequate collecting and curatorial procedures, as outlined in the above Standards and Ethics for Scientific Collecting. Out-of-province paleontologists should inform the BCPA of their research program prior to initiation of their collecting program. Type specimens and general collections of fossils must be housed in appropriate institutions designated for such storage. In particular instances, the BCPA may request out-of-province paleontologists to deposit a representative suite of specimens in a British Columbia museum, or recognized institutional collection.

Commercial Collecting

The BCPA is opposed to commercial extraction of fossils by its member organizations or individuals. Any commercial fossil extraction activity should be regulated by the province and should require permits and/or licenses, with some sort of associated fee. The BCPA anticipates that its advice will be sought and followed by regulators in assessing each permit application for suitability.

The BCPA will seek to work directly with provincial ministries and legislators to help develop a method whereby guidelines for Commercial Fossil Collecting Standards and a Commercial Permit Application Process are established.

APPENDIX C

THE GEOLOGICAL TIME SCALE

ERA		PERIOD	CHARACTERISTIC LIFE	CANADIAN OROGENIES	TOTAL ESTIMATED TIME IN YEARS
CENOZOIC		RECENT	Man		
		PLEISTOCENE	Mammals and modern plants		2,000,000
	TERTIARY	PLIOCENE			5,000,000
		MIOCENE			25,000,000
		OLIGOCENE			38,000,000
		EOCENE			55,000,000
		PALEOCENE	Reptiles and gymnosperms	Laramide	65,000,000
MESOZOIC		CRETACEOUS		Columbian	140,000,000
		JURASSIC		Nassian Inklinian	210,000,000
		TRIASSIC	Amphibians and lycopods	Tahltanian Appalacian	250,000,000
PALÆOZOIC		PERMIAN			
	CARBONIFEROUS	PENNSYLVANIAN			
		MISSISSIPPIAN			
		DEVONIAN	Fishes	Caribooan Ellesmerian Acadian	345,000,000
		SILURIAN			440,000,000
		ORDOVICIAN	Higher invertebrates	Taconic	
		CAMBRIAN			
PRECAMBRIAN	PROTEROZOIC	HADRYNIAN	Primitive invertebrates and algae		540,000,000
		HELIKIAN	Stromatolites	Grenville	945,000,000
				Elsonian	1,370,000,000
		APHEBIAN	Algae and other?	Hudsonian	1,735,000,000
	ARCHÆAN		?	Kenoran	2,490,000,000
					3,900,000,000

APPENDIX D

PALEONTOLOGICAL RESOURCES OF THE LILLOOET LRMP AREA

The first step in the assessment process entailed compiling all fossil localities in the Lillooet LRMP area discussed in the geological literature. Library resources at the Vancouver office of the Geological Survey of Canada were utilized for this purpose. Compilation information included locality, stratigraphic horizon, fossils collected and identified, age of strata, and the source of the reference. Information on 76 macrofossil and 4 microfossil localities was obtained in this way. In addition, the database files of the Geological Survey of Canada office in Vancouver were searched and produced information on additional 87 macrofossil and 467 microfossil localities, mostly unpublished. No attempt was made to update taxonomic identifications given in literature or database sources. The studied microfossil locality data include a variety of fossil types, principally conodonts, fusulinids and other foraminifers, radiolarians, and ichthyoliths. Given the abundance and widespread distribution of microfossils, these localities are not considered of especial significance and microfossil data are not presented in the following summary.

The following is a summary listing of the more common macrofossils found in the fossiliferous geological units of the Lillooet LRMP area, starting with the older rocks. The precise locations of fossil sites have been withheld from this report to protect the sites from over-collecting. This information is available to planning agents through the office of the Geological Survey of Canada in Vancouver.

PERMIAN
Marble Canyon Formation
Fusulinid foraminifers

- *Conodonofusinella* sp.
- *Glomospira* sp.
- *Gyroporella* sp.
- ?*Neoschwagerina* sp.
- *Schwagerina acris*
- *Schwagerina* sp.
- *Tetrataxis* sp.
- *Texturalaria* sp.
- *Verbeekina* sp.
- ?*Verbeekina* sp.
- *Yabeina columbiana*
- *Yabeina minuta*

Yabeina sp.

Algae, unidentified

Corals

?*Waagenophyllum* sp.

Unidentified corals

Echinoid, unidentified

Mollusks, unidentified

Bryozoans, unidentified

Age: Late Permian

TRIASSIC

Cadwallader Group

Brachiopods

Terebratula suttonensis (Clapp and Shimer)

Bivalves

Megalodon canadensis n. sp.

Myophoria sp.

Pleuromya pearsonensis n. sp.

Corals

Isastrea whiteavesi Clapp and Shimer

Calamophyllia suttonensis Clapp and Shimer

Calamophyllia dawsoni Clapp and Shimer

Montlivaltia cf. *gosaviensis* Frech

Turcicula mccanni Shimer

Age: Late Triassic (Norian)

Cache Creek Complex

Scleractinian corals, colonial and solitary

Conodont microfossils

Age: Early to Middle Triassic or younger

Unnamed Strata

Ammonoids

Juvavites sp.

Bivalves

Halobia sp.

Corals

Age: Late Triassic (Early Norian)

TRIASSIC TO JURASSIC

Bridge River Complex

Radiolarian microfossils

Conodont microfossils

Age: Middle Triassic to Early Jurassic

Tyaughton Group

Ammonoids

Arniotites sp.
Asteroceras sp.
Echioceras sp.
Haugia (?) sp.
Metophioceras sp.
Phylloceras (?) sp.
Schlotheimia sp.

Bivalves

Cassinella beyrichi Bittner
Monotis subcircularis (Gabb)
Myophoria sp.

Age: Late Triassic to Early Jurassic

Unnamed Strata

Ammonoids

Atractites (s. lato) sp. indet.
Charmasseiceras sp. indet.
Choristoceras cf. *C. marshi* Hauer
Psiloceras canadense Frebold

Belemnoids, indeterminate

Bivalves

Meleagrinella sp.
Myophoria suttonensis
Modiola cf. *strigillata*
Indeterminate bivalves

Age: Latest Triassic to earliest Jurassic (Rhaetian to Pliensbachian)

JURASSIC

Unnamed Strata

Ammonoids

Charmasseiceras marmoreum (Oppel)
Discamphiceras (?) *tipperi* Frebold
Eolytoceras tasekoi Frebold
Eolytoceras sp. indet.
Paracaloceras cf. *P. coregonense* (Sowerby)
P. multicostatum Frebold
P. rursicostatum Frebold
Paracaloceras sp. indet.
Phylloceras sensu lato sp.
Psiloceras canadense Frebold

P. occidentale Frebold
Psiloceras ex aff. *P. planorbis* (Sowerby)
Psiloceras (Curviceras) columbiae Frebold
Psiloceras sp. indet

Age: Early Jurassic (Hettangian)

Unnamed Strata

Ammonoids

Agassiceras cf. *scipionianum* d'Orbigny
Arietites sp.
Asteroceras cf. *stellare* Sowerby
Coroniceras bisulcatum Bruguière
Coroniceras cf. *bisulcatum* Bruguière
Psiloceras sp.
Schlotheimia (Scamnoceras) cf. *acuticosta* Buckman
Schlotheimia (?) sp.
Vermiceras scylla Reynès
Vermiceras latisulcatum Quenstedt

Bivalves, unidentified

Gastropods, unidentified

Age: Early Jurassic

Unnamed Strata

Ammonoids

Lytoceras ? sp.
Pseudogrammoceras ? sp.
Pseudolioceras ? sp.
Tmetoceras sp.

Bivalves

Ostrea sp.
Pecten sp.

Belemnoids

Belemnites sp.

Brachiopods

"Rhynchonella" sp.

Age: Late Early Jurassic to early Middle Jurassic

Unnamed Strata

Ammonoids

Erycitoides howelli (White)
Erycitoides sp. aff. *E. howelli* (White)
Erycitoides kialagvikensis (White)
Erycitoides (?) sp.
Planammatoceras (?) sp.
Phylloceras sp.

Pleydellia (?) sp. cf. *P. argentina* Maubeuge and Lambert
Pseudolioceras sp. cf. *P. whiteavesi* (White)
Pseudolioceras (?) sp.
Pseudolioceras (?) or *Ludwigia* (?) sp.
Tmetoceras flexicostatum Westermann
Tmetoceras kirki Westermann
Tmetoceras sp. cf. *T. scissum* (Benecke)
Tmetoceras sp.
Zurcheria (?) sp.

Cephalopod arm hooks (?)

Bivalves
Inoceramus sp.
Ostreiid
Oxytoma (?) sp.
Pleuromya sp.

Belemnoids

Gastropods, unidentified

Rhynchonellid (?) brachiopods, unidentified

Age: Middle Jurassic (Aalenian)

Unnamed Strata

Ammonoids
Chondroceras marshalli (McLearn)
Erycites aff. *E. howelli* (White)
Erycites kialagvikensis (White)
Holcophylloceras cf. *H. costisparsum* Imlay
Oedania ? sp. indet.
Stematoceras sp. indet
Stephanoceras (Skirroceras) cf. *S. kirschneri* Imlay
Stephanoceras sp. indet.
Tmetoceras cf. *T. scissum* (Benecke)
Witchellia ? sp. indet.

Age: Middle Jurassic (Bajocian)

Unnamed Strata

Bivalves
Buchia mosquensis (von Buch)

Age: Late Jurassic (Middle to ?Late Kimmeridgian)

JURASSIC TO CRETACEOUS

'Eldorado Group'

Ammonoids
"*Acanthoceras*" sp.
Anacardioceras sp.

Olcostephanus sp.

Bivalves

Buchia spp.

Inoceramus sp.

Pleuromya sp.

Belemnoids

Belemnites sp.

Age: Late Jurassic to Early Cretaceous

Relay Mountain Group

Ammonoids

Ammonoid, gen. and sp. indet.

Argentiniceras sp. cf. *noduliferum* (Steuer)

Dichotomites cf. *giganteus* (Imlay)

Perisphinctid, poorly preserved

Phylloceras sp. cf. *knoxvillense* Stanton

Phylloceratid ammonoid, gen. et sp. indet.

Protothurmannia n. sp. B of Jeletzky (1984)

Belemnoids

Acroteuthis (Boreioteuthis) cf. *impressa* (Gabb)

Cylindroteuthis (Cylindroteuthis) ? sp. indet. (poor fragmentary casts only)

Onychites sp. indet. (belemnite arm hook)

Bivalves

Buchia cf. *blanfordiana* (Stoliczka) of Jeletzky 1965

Buchia concentrica (Sowerby) s. lato

Buchia cf. *concentrica* (Sowerby) s. lato

Buchia concentrica var. *erringtoni* (Gabb) (fairly common)

Buchia crassicollis Keyserling

Buchia fischeriana (d'Orbigny) (small to medium size forms)

Buchia inflata (Toula)

Buchia lahuseni (Pavlow) var. *tenuicollis* (Pavlow)

Buchia cf. *lindstroemi* (Sokolov)

cf. *Buchia mosquensis* (von Buch) s. lato (rare and poorly preserved)

Buchia okensis (Pavlow) (late form; a single specimen)

Buchia ex aff. *okensis* (Pavlow)

Buchia pacifica Jeletzky 1965 (prevalent)

Buchia n. sp. aff. *piochii* of Jeletzky 1968 (relatively rare)

Buchia russiensis (Pavlow) s. lato (common)

Buchia russiensis (Pavlow) var. *taimyrensis* Zakharov

Buchia teniustriata (Lahusen)

Buchia cf. *tenuistriata* (Lahusen) (rare)

Buchia cf. *terebratuloides* Lahusen

Buchia tolmatschowi (Sokolov) (rare)

Buchia uncitoides (Pavlow)

Buchia uncitoides var. *acutistriata* (Crickmay) (common)

Buchia uncitoides var. *spasskensoides* (Crickmay)
Buchia ex gr. *uncitoides-pacifica*
Buchia sp., transitional to *B.* cf. *blanfordiana*
Buchia sp. indet.
Inoceramus (s. lato) sp. indet. (fragments)
Pleuromya sp. indet.

Age: Late Jurassic to Early Cretaceous (Oxfordian to Barremian)

JURASSIC OR CRETACEOUS

Unknown Strata

Echinoderms
- Crinoid columns

Bryozoan remains

Algal plant remains
- *Pachytheca* sp.

Gastropods, unidentified

Indeterminate molluscs (few)

Age: Jurassic or Cretaceous [possibly Triassic?]

CRETACEOUS

Jackass Mountain Group

Ammonoids
- *Anagaudryceras* cf. *sacya* (Forbes)
- *Anagaudryceras* ? sp. indet.
- *Ancyloceras (Helicancylus)* cf. *aequicostatum* Gabb
- *Brewericeras* (=*Leconteites*) *deansi* (Whiteaves)
- *Brewericeras* (=*Leconteites*) *lecontei whiteavesi* Jones, Murphy and Packard
- *Eotetragonites* sp. indet.
- *Shasticrioceras* sp.

Belemnoids
- *Acroteuthis* ? sp. cf. *A. shastensis* Anderson
- *Acroteuthis (Boreioteuthis)* ex gr. *impressa* (Gabb)
- *Acroteuthis* sp. indet.
- *Hibolites* ? sp.

Bivalves
- *Astarte*? sp. indet
- *Aucellina gryphaeoides* (J. de C. Sowerby)
- *Buchia* sp. indet.
- *Inoceramus* n. sp. aff. *neocomiensis* (d'Orbigny)
- *Mytilus* sp. indet.
- *Nemodon* ? sp.
- *Ostrea* sp. indet.
- *Pecten* (*Entolium*) sp. indet.

Pecten sp.
Phyllopachyceras infundibulum (d'Orbigny)
Pleuromya vancouverensis Whiteaves
Pleuromya sp.
Quoiecchia ex gr. *aliciae* Crickmay
Toxoceratoides? n. sp. of Jeletzky
Trigonia sp. (*Quadratae* section)
Trigonia sp. (*Scabrae* section)
Trigonia spp.
Yaadia cf. *lewisagassizi* Crickmay

Gastropods
Pseudomelania ? sp. indet
"Pterocera"? sp. indet.

Brachiopods
'Terebratella' cf. *whiteavia* Anderson

Plants
Cladophlebis virginiensis Fontaine
Cladophlebis virginiensis Fontaine forma *acuta*
Cladophlebis sp.
Coniopteris heterophylla ? Fontaine
Coniopteris sp.
Elatides curvifolia (Dunker)
Elatides dicksoniana (Heer)
Gleichenites nordenskioldi (Heer) emend Seward
Nilssonia sp.
Ptilophyllum speciosum (Heer)
Pterophyllum concinnum Heer
Podozamites sp.
Ruffordia ? *goepperti* ? Seward
Sagenopteris sp.
Sphenopteris latiloba ? Fontaine

Age: Early Cretaceous (Valanginian to Albian)

Taylor Creek Group

Ammonoids
Cleoniceras (Grycia) perezianum (Whiteaves)
Desmoceras (Pseudouhligella) sp. indet. juven.
Marshallites sp. indet. juven.
Pseudhelicoceras? sp.
Tropaeum? sp. indet.

Nautiloid
Cymatoceras sp.

Bivalves
Acila (s. lato) sp. indet.
Indogrammatodon sp. indet.

Inoceramus cf. *anglicus* Woods
Inoceramus cf. *concentricus* (Parkinson)
Lima (s. lato) sp. indet.
Pecten (Entolium) sp. indet.
Pecten (Syncyclonema) sp. indet.
Trigoniid?, indeterminate

Gastropods
Leda (s. lato) sp. indet.

Scaphopod
Dentalium (s. lato) sp. indet.

Indeterminate sponge

Age: Jurassic to early Late Cretaceous (mostly Albian to Cenomanian)

Kingsvale Group

Plants
Araliaephyllum sp.
Celastrophyllum (celastrinites?) (*acutidens*)
Ciccites sp.
Cinnamomoides ovalis (Dawson)
Ficus ovatifolia? Berry
Juglandites sp.
Menispermites
cf. *Myrtophyllum boreale* or cf. *Magnoliaephyllum* sp.
Platanus sp.
Rhamnites sp.
Sapindopsis variabilis Fontaine
Trochodendroides potomacensis (Ward)
Trochodendroids (cercidiphyllum?) (cf. *potomacensis*)

Age: Early Cretaceous (Albian)

Kingsvale Group?

Non-marine Unionidae or Sphaeriidae bivalves

Age: Early Cretaceous

Unnamed Strata

Bivalves
Buchia cf. *crassicolis* Keyserling var. *americana* Sokolow
Buchia sp. ex gr. *crassicolis* Keyserling
Buchia sp. ex aff. *crassicolis* Keyserling
Buchia pacifica
Buchia tolmatschowi
Buchia sp. indet.

Age: Early Cretaceous (Valanginian to Hauterivian).

Unnamed Strata

Plants

Laurophyllum sp.

Age: Early Cretaceous (Albian)

TERTIARY

French Bar Formation

Plants

Alnus sp. cf. *A. cremastogynoides* Berry
Carpinus grandis Unger
Cinnamomum sp. cf. *affine* Lg.
Hamamelis ? *clarus* Hollick
?*Laurophyllum* sp. cf. *L. laraminum* (DN) Bell
Metasequoia occidentalis (Newberry) Chaney
? *Sequoia nordenskioldi* Heer
?*Salix* sp. cf. *S. wyomingensis* Kn. and Cock
Tetracera sp. cf. *T. castaneafolia* Mac G

Age: Early Tertiary (Late Eocene or Oligocene?)