KAKWA RECREATION AREA: NORTHEASTERN BRITISH COLUMBIA GEOLOGY AND RESOURCE POTENTIAL (93H/15, 16, 93I/1, 2)

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KEYWORDS: Regional geology, Kakwa Recreation Area, resource assessment, stratigraphy, coal, dimension stone, phosphate, lead-zinc, barite, mineral potential.

INTRODUCTION

The Kakwa Recreation Area encompasses approximately 128 000 hectares (1280 km^2) of wilderness land immediately west of the Alberta border and approximately 70 kilometres north of the town of McBride, British Columbia, at latitude 54°00′ north, longitude 120°20′ west (Figure 1-6-1). It is the northernmost part of a contiguous, northwest-trending belt of parks and wilderness areas that includes Yoho National Park and Mount Robson Provincial Park in British Columbia, and Banff and Jasper National Parks and Willmore Wilderness Area in Alberta. The area is quite remote and access is generally on horseback, on foot, or by helicopter or float plane. An old logging road, along the McGregor River valley, leads to the southern and western edge of the recreation area and an extension leads into the area; however, wash-outs along this road have made it impassable to vehicles. Trails suitable for dirt bikes and all-terrain vehicles lead into the northeastern part of the area from Sherman Meadows, in Alberta.

Relief in Kakwa is considerable, with elevations ranging from less than 915 metres (3000 feet) in the Jarvis Creek valley, along the western edge of the area, to over 3050 metres (10 000 feet) at Mount Ida (3190 m) and Mount Sir Alexander (3275 m). Much of the terrain is very steep and cliffs are common. There are large icefields near Mount

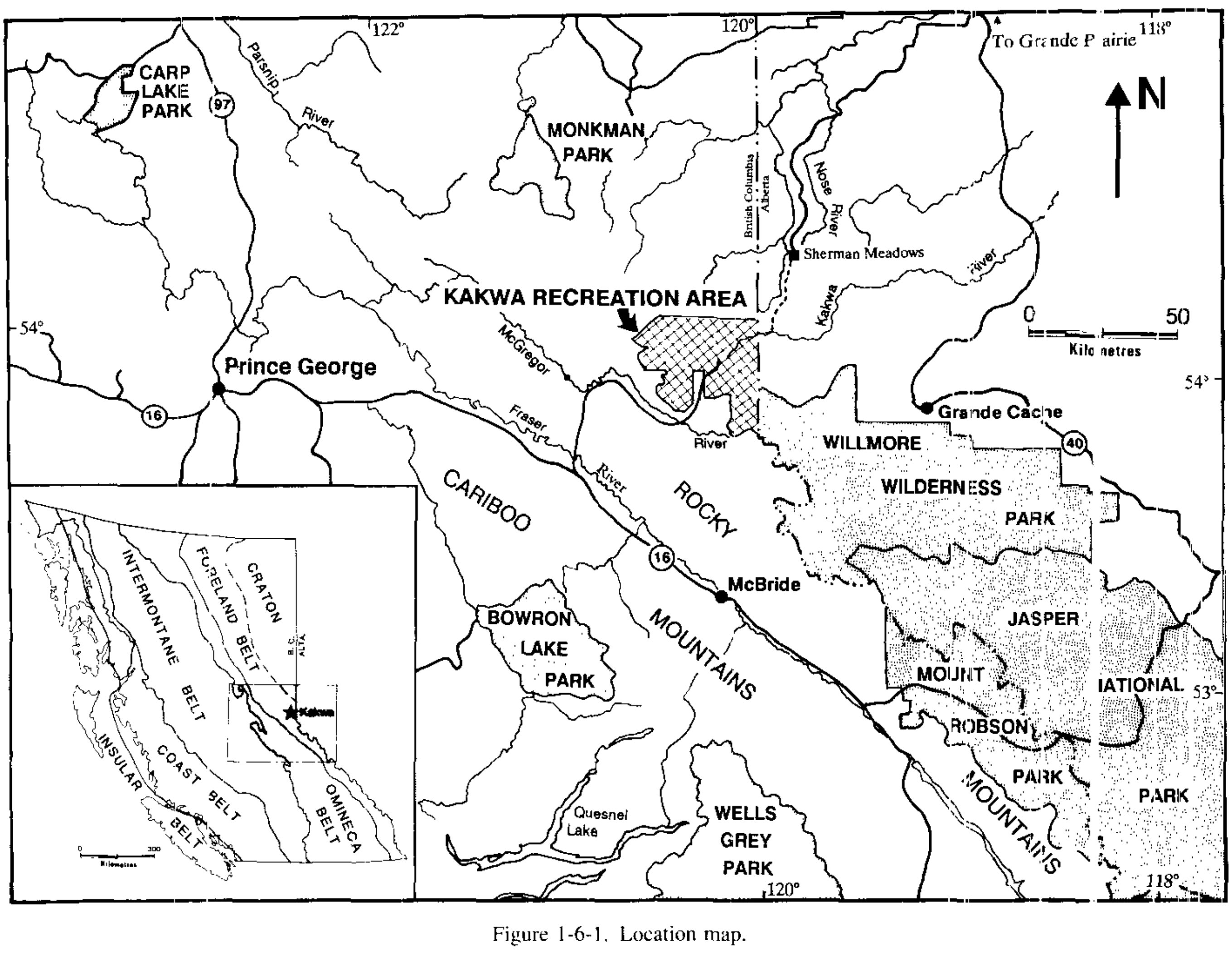
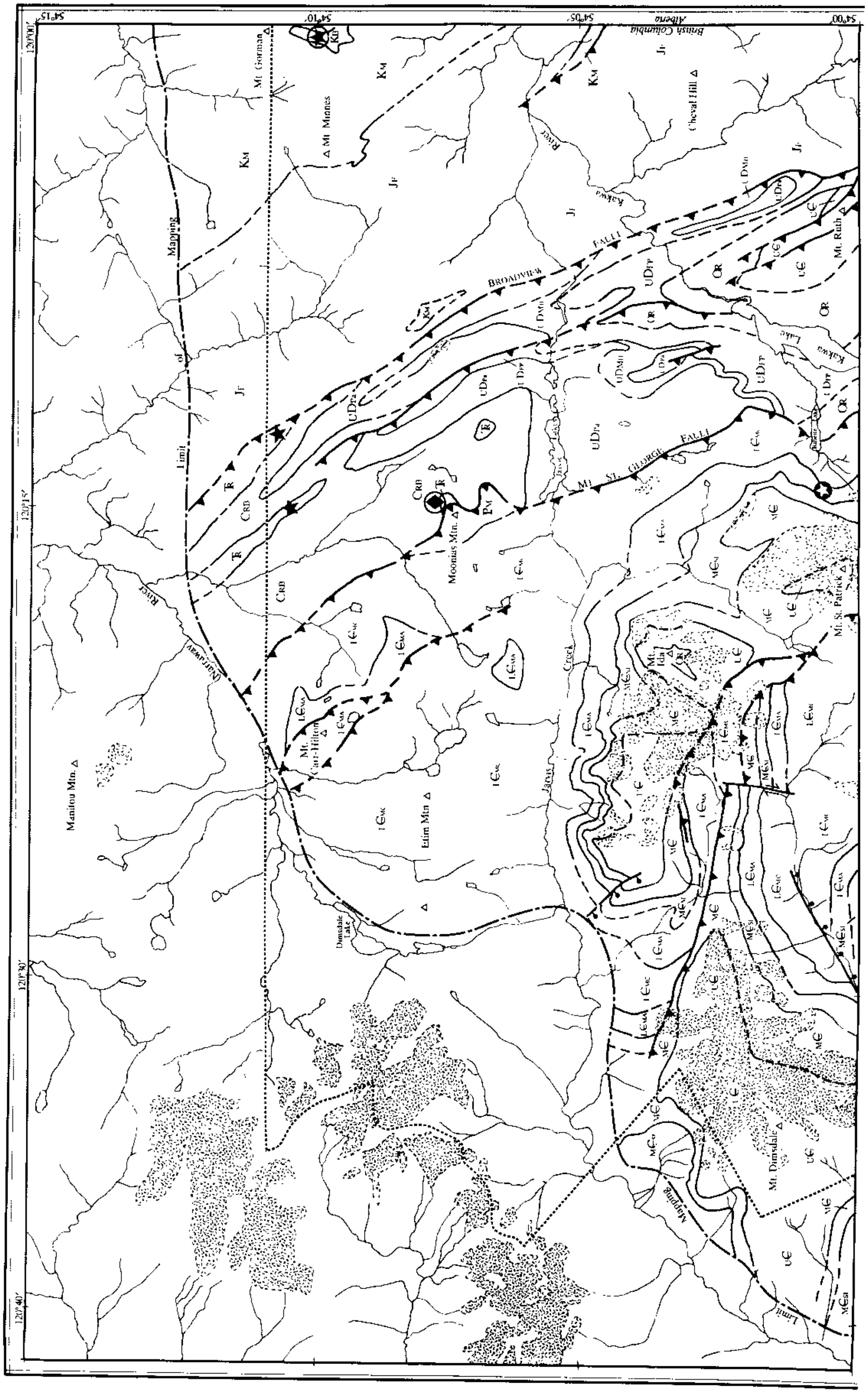


Figure 1-6-1. Location map.


Mt. Gorman
Mt. Minnes
Cheval Hill
British Columbia
Alberta
Kakwa River
Broadview Fault
Mt. St. George Fault
Mt. Ruth
Kakwa Lake
Moonias Mtn.
Mt. St. Patrick
Mt. Ida
Mt. Hart-Hillem
Narraway River
Limit of Mapping
Manitou Mtn.
Eim Mtn.
Jarvis Creek
Dimsdale Lake
Mt. Dimsdale
54°15'
54°10'
54°05'
54°00'
120°00'
120°15'
120°30'
120°40'

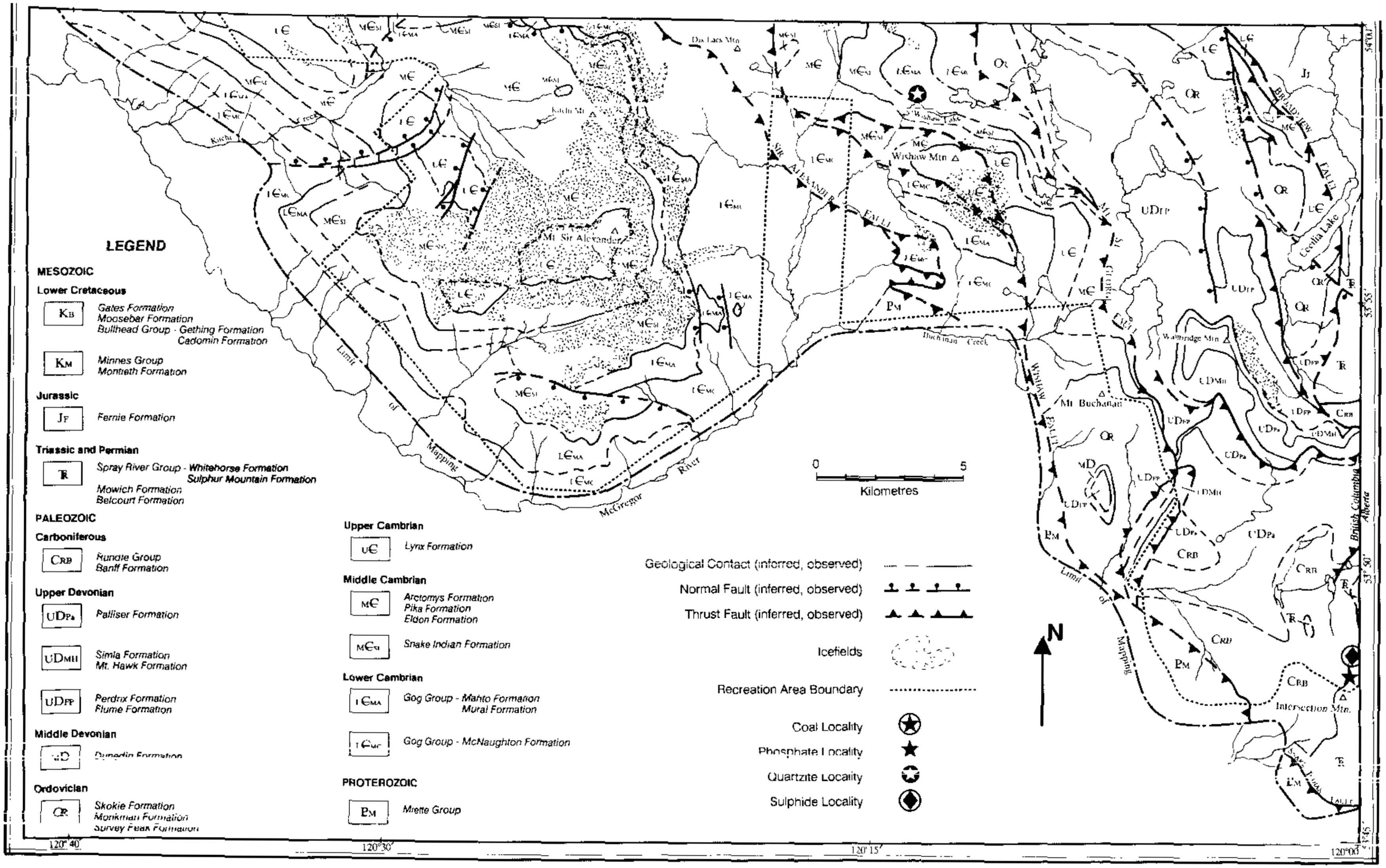


Figure 1-6-2. Generalized geology, Kakwa Recreation Area; compiled from mapping by J. Pell, J.L. Hammack, B. Fletcher and W.D. Harris, 1991 and from McMechan, 1986 and McMechan and Thompson, 1985.

Ida, Mount Sir Alexander and Mount Dimsdale and along the northwestern boundary of the recreation area.

There has been very little exploration work in Kakwa, in part due to its remoteness. There are coal leases in the northeastern part of the region and some oil and gas permits were also held there in the early 1980s. Quartzite, near the centre of the region, has been examined for its potential as a building stone. A lead-zinc-barite showing is located a few kilometres north of the recreation area and a gypsum prospect a short distance to the southeast. Although there has been limited activity, the geology indicates that a number of potentially economic commodities could exist within the boundaries of the recreation area, including coal, phosphate, gypsum, lead, zinc, barite and dimension stone. Kakwa Recreation Area is currently under consideration for upgrade to Class "A" park status and, prior to its reclassification, the mineral potential of the area must be evaluated, which is the focus of this project.

GEOLOGICAL SETTING

Kakwa lies within the Foreland tectonostratigraphic division of the Canadian Cordillera and is underlain by a sequence of carbonate and clastic sedimentary rocks ranging from Late Precambrian to Early Cretaceous in age. Folds and southwest-dipping, northeasterly directed thrust faults are the dominant structures in the region. Major thrust sheets contain strata which generally young to the northeast. Previous work in the area includes regional mapping by Campbell, Mountjoy and Young (1973), McMechan (1986), McMechan and Thompson (1985) and Taylor and Stott (1979).

STRATIGRAPHY

UPPER PROTEROZOIC (HADRYNIAN)

Rocks of the Hadrynian Miette Group are exposed in the hangingwall of the Mount St. George fault in the Moonias Mountain area; the Snake Indian and Wishaw faults near Intersection Mountain; and the Mount Sir Alexander and Wishaw faults south of Wishaw Mountain (Figure 1-6-2). Only the upper parts of this unit are exposed within the study area and detailed observations were possible only in the Moonias Mountain and Intersection Mountain areas.

At Moonias Mountain two lithologic units were observed. The lowest comprises a relatively resistant, thickly bedded, medium brown weathering quartzite-granule to pebble conglomerate, quartz wacke and medium grey quartz arenite, interbedded with brown and grey-weathering argillite and minor light grey quartz arenite. Minimum thickness for this unit is 300 metres. The conglomerate is composed of well-rounded quartzite pebbles supported by a matrix of medium-grained, poorly sorted quartz wacke. This lower unit is overlain by in excess of 200 metres of thinly bedded, dark brown-grey argillite with thin silty interbeds. Silty beds are locally crosslaminated and show graded bedding. One thick unit within the argillite has abundant tan-weathering dolostone breccia blocks of probable olistostromal origin. These blocks are up to 6 metres in diameter and stand out in relief against the more recessive argillite.

In the Intersection Mountain area, rocks of the Miette Group include a well-bedded, cliff-forming unit consisting of medium orange-brown-weathering, dark grey, calcareous quartzite-granule conglomerate and quartz wacke with interbedded medium to dark grey phyllite. This unit is underlain by a thick, poorly exposed, dark grey phyllite.

LOWER PALEOZOIC

Lower Paleozoic strata underlie a significant proportion of Kakwa Recreation Area (Figure 1-6-2) and comprise a conformable sequence that disconformably overlies Proterozoic rocks. The Lower Cambrian Gog Group, which forms the base of this succession, consists of the McNaughton, Mural and Mahto formations (Table 1-6-1). The McNaughton Formation is a resistant, rusty to dark-weathering unit that forms a thick and fairly monotonous sequence dominated by medium to thick-bedded light grey quartzites. These quartzites are often laminated or crosslaminated; thin black shale layers and granule to pebble-conglomerate beds are present locally. In some areas crosslaminations are stained pinkish, giving the rock an attractive banded appearance. In the area south and west of Wishaw Mountain, black siltstones and argillites are interbedded with the quartzites and locally form units tens of metres thick that contain thin quartzite interbeds. The McNaughton Formation is largely devoid of fossils; however, trace fossils such as worm tubes *(Scolithus)* and meandering patterns on bedding planes, suggestive of worm trails, occur in the upper parts of the unit. In the Kakwa area, the McNaughton Formation is estimated to be approximately 1500 metres thick (McMechan, 1990; Slind and Perkins, 1966).

The Mural Formation is a reddish brown, recessive unit predominantly consisting of silty and sandy dolostones, dolomitic quartzites, shales and minor limestone. Its contact with the underlying McNaughton Formation is gradational and consists of a zone of interbedded light grey quartzites, dolomitic quartzites and dolostones. The Mural Formation begins where dolomitic rocks dominate over quartzites. Orange to tan dolostones, dolomitic quartzites and grey quartzites characterize the lower part of the formation, while grey and greenish grey shales, grey crystalline limestones, dolostones and lesser amounts of quartzite are more common in the upper part. Dolomitic quartzite beds often grade up-section into sandy dolostones. *Scolithus* worm tubes are common in the sandy layers (Plate 1-6-1). This formation is 225 to 300 metres thick in the Kakwa region.

The Mahto Formation is a grey to maroon, resistant unit, overlying the recessive Mural Formation. In the Kakwa area it is approximately 300 to 350 metres thick. It consists of light grey to creamy beige, pink and maroon, medium to thick-bedded quartzites with minor amounts of interbedded brown and dark grey sandy shales, dolomitic quartzites and siltstones. As with the other units of the Gog Group, fossils are restricted to *Scolithus* worm tubes. Quartzites are generally fine to coarse grained and, locally, granule-conglomerate layers are present. Colours of the quartzites vary from solid greys, pinks and maroons to very attractive, intricately swirled and banded patterns in shades of maroon, pink and creamy white (Plate 1-6-2).

TABLE 1-6-1
TABLE OF FORMATIONS

LOWER CRETACEOUS		
Gates Fm:	(>110 m)	sandstone, carbonaceous shale, coal
(Middle and Torrens River members, in descending order)		
Moosebar Fm:	(35-50 m)	shale, minor sandstone
BULLHEAD GROUP		
Gething Fm:	(25-80 m)	sandstone, siltstone, coal
Cadomin Fm:	(±25 m)	conglomerate
	unconformity	
MINNES GROUP		
Gorman Creek Fm:	(650-1000 m)	sandstone, siltstone, minor coal
UPPER JURASSIC AND LOWER CRETACEOUS		
Monteith Fm:	(200-400 m)	sandstone, siltstone, shale
JURASSIC		
Fernie Fm:	(250-900 m)	shale, silty sandstone, siltstone
	unconformity	
TRIASSIC		
SPRAY RIVER GROUP		
Whitehorse Fm:	(130-400 m)	dolostone, limestone, evaporites
(Winnifred, Brewster and Starlight evaporite members, in descending order)		
Sulphur Mountain Fm:	(405-475 m)	siltstone, silty limestone
(Llama, Whistler and Vega-Phroso members, in descending order)		
	unconformity	
PERMIAN		
Mowich Fm:	(±10 m)	sandstone, conglomerate at base
Belcourt Fm:	(>10 m)	limestone, conglomerate at base
	unconformity	
UPPER CARBONIFEROUS		
Hanington Fm:	(0-5 m)	limestone w/basal pebble conglomerate
	unconformity	
LOWER CARBONIFEROUS		
RUNDLE GROUP:	(±400 m)	limestone, dolostone
(Mt. Head, Turner Valley, Shunda & Pekisko formations, in descending order)		
UPPER DEVONIAN AND LOWER CARBONIFEROUS		
Exshaw & Banff fms:	(180-260 m)	shale, minor limestone
	unconformity	
UPPER DEVONIAN		
Palliser Fm:	(±530 m)	limestone (fossil-poor)
	unconformity	
Simla Fm:	(60-70 m)	limestone, biostromal
Mount Hawk Fm:	(90-140 m)	limestone, fossiliferous
Perdrix Fm:	(85-470 m)	laminated shale
Flume Fm:	(75-145 m)	limestone, stromatoporoid biostrome
	unconformity	
MIDDLE DEVONIAN		
Dunedin Fm*:	(±60 m)	limestone, siltstone, conglomerate
	unconformity	
MIDDLE ORDOVICIAN		
Unnamed unit*:	(>75 m)	dolostone, quartzite and limestone
Skoki Fm:	(110-380 m)	dolostone, minor limestone
LOWER ORDOVICIAN		
Monkman quartzite:	(30-75 m)	quartzite, dolomitic quartzite
Survey Peak Fm:	(450-600 m)	silty dolostone, limestone, shale
UPPER CAMBRIAN		
Lynx Fm:	(600-800 m)	limestone, dolostone, calc-argillite
MIDDLE CAMBRIAN		
Arctomys Fm:	(50-100 m)	red shale, silty shale, dolostone
Pika Fm:	(80-100 m)	limestone, dolostone
Eldon Fm:	(350-375 m)	limestone, dolostone
Snake Indian Fm:	(±400 m)	limestone, red shale, siltstone
LOWER CAMBRIAN		
GOG GROUP		
Mahto Fm:	(300-350 m)	maroon, pink, grey quartzite, dolostone
Mural Fm:	(225-300 m)	dolostone, quartzite, limestone, shale
McNaughton Fm:	(±1500 m)	quartzite, granule conglomerate
	unconformity	
UPPER PROTEROZOIC		
MIETTE GROUP		
Upper Miette:	(>300 m)	argillite, sandstone, conglomerate

* Mt. Buchanan area only

Plate 1-6-1. Subvertical *Scolithus* worm tubes in Lower Cambrian quartzites within the Mural Formation. Section viewed is perpendicular to bedding.

Plate 1-6-2. Intricately swirled colour-banding patterns in Lower Cambrian Mahto Formation quartzites. Banding parallels solution fronts. Symbol indicates bedding orientation.

The Middle Cambrian Snake Indian Formation is a recessive to ribbed-weathering unit with colourful banding in shades of tan, red, green and grey, and overlies the Mahto Formation quartzites (Plate 1-6-3). The lower part of the formation is more recessive and tan weathering; it consists of thin-bedded red, green and grey shales, with tan-coloured dolostone, silty limestone layers and minor sandstone interbeds. The upper part of the formation is ribbed weathering, with thick resistant grey limestone units separated by recessive bands of brightly coloured shales and thinly interbedded dolostones. The limestones are variably thin to thick bedded, wavy bedded to nodular and commonly show evidence of bioturbation, with dolomitized burrows. The top of the formation is marked by the last thick, recessive, brightly coloured shale and dolostone (Mountjoy and Aitken, 1978). In the Kakwa area, this formation is approximately 400 metres thick.

Massive, cliff-forming, dark grey limestones of the Eldon Formation overlie the Snake Indian shales and carbonates (Plate 1-6-3). These limestones vary from thin bedded and nodular to thick bedded and often are bioturbated, with dolomitized worm burrows and beds a common feature (Plate 1-6-4). The dominant lithology is lime mudstone, however, oolitic grainstones also occur locally. The Eldon Formation is approximately 350 to 375 metres thick in the Kakwa area and is overlain by approximately 80 to 100 metres of ribbed-weathering strata of the Pika Formation.

In much of the area, the base of the Pika Formation is placed at the base of a yellow-orange dolostone unit between the massive Eldon limestones and the overlying, wavy, thin to medium-bedded lime mudstones. These limestones are commonly bioturbated, locally contain dolomitized worm burrows and are sometimes interbedded with thin grey shales. In the Mount Sir Alexander area, the Pika Formation consists of two distinctive units. The lower unit comprises an orange to buff-weathering, recessive sequence of medium grey lime mudstone, that commonly contains dolomitized laminae and worm burrows. The top of the lower sequence is marked by approximately 5 metres of interbedded grey-brown to orange-brown argillite and grades into an upper, massive, more resistant unit comprising medium to light grey, laminated lime mudstones that are locally oolitic and display lode casts, graded beds and crosslaminations.

The top of the Middle Cambrian sequence is marked by the Arctomys Formation, a distinctive, red-weathering recessive unit, 50 to 100 metres thick. It comprises blood-red and minor amounts of dark green dolomitic shale and silty shale and thin bedded, tan-weathering dolostone. Mud cracks, salt crystal casts and ripple marks are common.

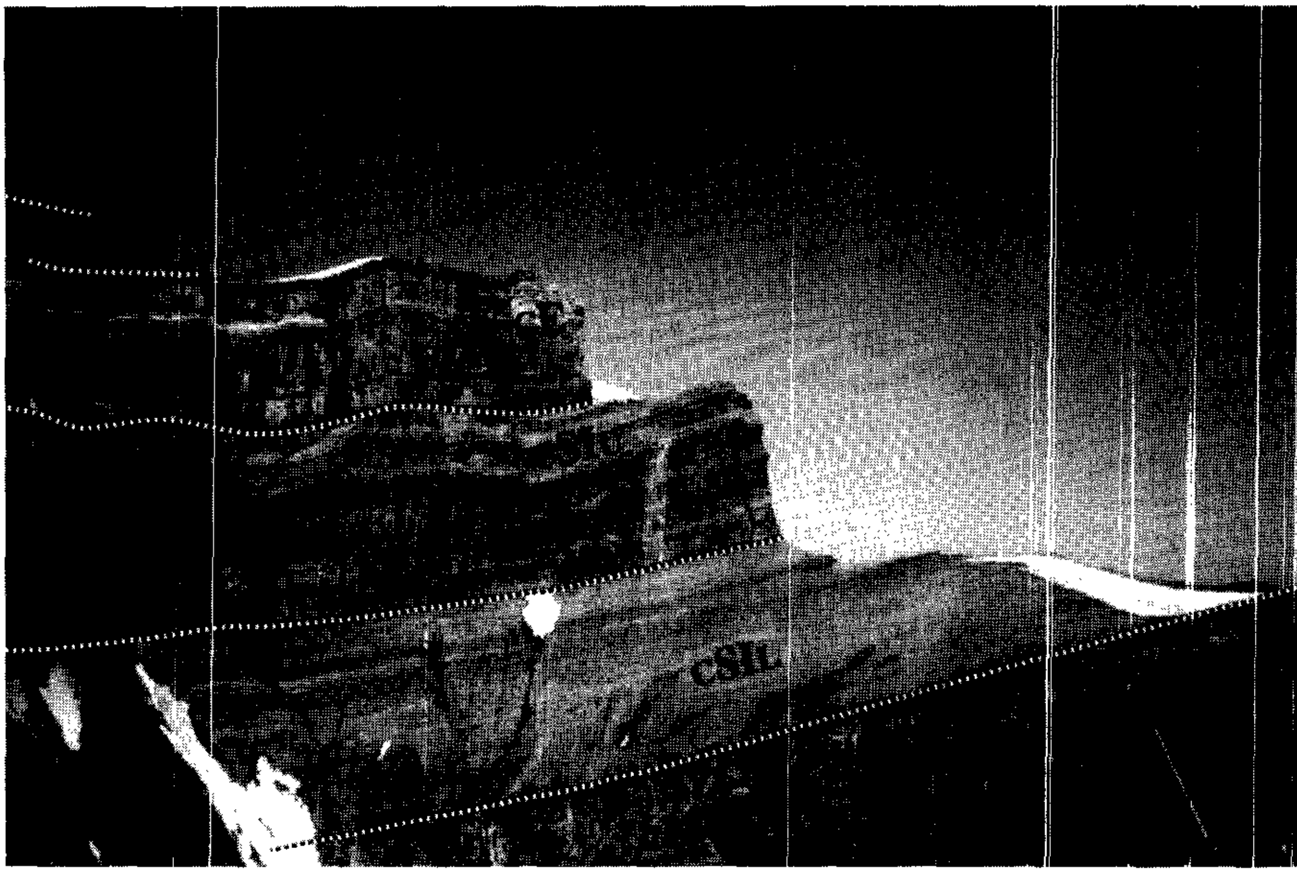


Plate 1-6-3. The exposed Cambrian section on the east flank of Mount St. Patrick, as viewed from the southeast. The lowest unit exposed is the massive, cliff-forming Lower Cambrian Mahto Formation (cMh) which is overlain by the recessive Middle Cambrian lower Snake Indian Formation (cSIl). The colour-banded and slightly ribbed-weathering upper Snake Indian formation (cSIu) forms the next cliff step and is overlain by a cliff-forming ledge of the Middle Cambrian Eldon Formation (cE). Recessive strata of the Middle Cambrian Pika and Arctomys formations (cPA) form the next step and the uppermost ledge, seen only in the far upper left corner of the photograph, is cliff-forming Upper Cambrian Lynx Formation (cLx).

The Upper Cambrian Lynx Formation is a resistant, cliff-forming unit that crops out at the peaks of most of the highest mountains in the area and is characterized by well-defined buff and grey colour-banding and bedding (Plate 1-6-5). It conformably overlies recessive shales of the Arctomys Formation and is estimated to be 600 to 800 metres thick (McMechan, 1986). The lower part of this formation consists of medium-bedded, buff, grey and locally orange-weathering, very fine grained dolostones with interbeds of fine to coarse-grained quartz arenites and sandy dolostones, light grey siltstones and minor, medium-bedded, grey limestones. The sandstones are often crossbedded and may contain dolostone chips (Plate 1-6-6). The dolostones are locally stromatolitic and characterized by sedimentary structures such as layers of flat-pebble conglomerate, burrows, lode casts, slump folds and disrupted bedding. Beds containing nodules of white chert are also present locally. The upper part of the Lynx Formation is dominated by limestone. Its base is marked by 50 to 100 metres of relatively recessive, greenish grey to grey-weathering calcareous argillite with limestone nodules. This is overlain by tan to grey-weathering, wavy bedded to nodular, argillaceous or silty limestones with thin to thick beds of more resistant grey limestone.

The Lower Ordovician Survey Peak Formation is a resistant unit that conformably overlies Upper Cambrian strata. It is 450 to 600 metres thick and has approximately 30 to 70 metres of recessive, light greenish grey to silvery weathering, strongly cleaved, calcareous shale and shaley limestone with interbeds of limey flat-pebble conglomerate at its base. Burrows and feeding traces on bedding planes are locally very common. The remainder of the unit comprises resistant, buff to orange-weathering, silty dolostones, dolomitic siltstones and blue-grey-weathering limestones. Grey argillite partings are common in this part of the sequence and flat-pebble conglomerates are present locally. The siltstones and dolostones are wavy bedded and have a very rough weathered surface, with more resistant, whispy laminae. They are interbedded with silty, thin-bedded to massive limestones that are generally nodular to wavy bedded and can be partially dolomitized. Both the dolostones and limestones locally show evidence of bioturbation, containing burrows and feeding trails that are sometimes silicified. Some layers are rich in fossil debris; brachiopod and trilobite fragments are common.

The Survey Peak Formation is overlain by the Lower Ordovician Monkman Quartzite Formation. The Monkman is a resistant, light grey weathering marker unit that aver-

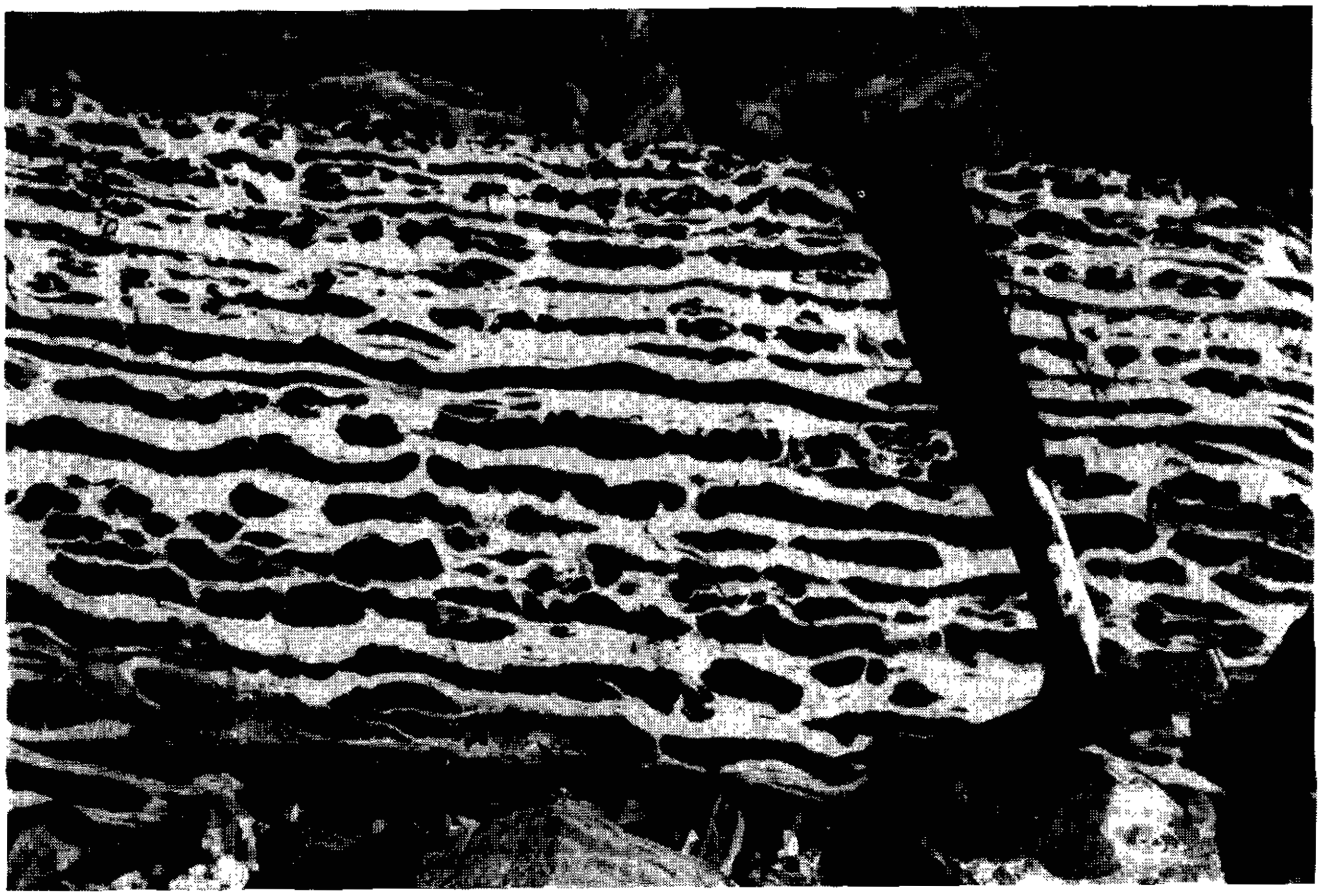


Plate 1-6-4. Dolomitized layers and worm burrows (light grey) are commonly found within thin-bedded Eldon Formation lime mudstone units (darker grey).

ages between 30 and 100 metres thick and comprises fine to medium-grained, thin-bedded to massive, light grey to buff-weathering quartzites and dolomitic quartzites. Crossbedding, ripple crosslaminations and burrows are common features.

Middle Ordovician strata, assigned to the Skoki Formation, overlie the Monkman quartzites. The Skoki is a resistant, tan-weathering formation characterized by monotonous, medium to thick-bedded, finely crystalline dolostones. For the most part, the dolostones are rather featureless, however, locally they can contain oncolites, stromatolites, intraclasts, mud cracks and rare chert nodules. Minor amounts of wavy bedded to nodular limestone are present in this formation and gastropods are found locally. Thick-bedded, crosslaminated, sandy dolomite horizons can also occur.

The youngest Lower Paleozoic rocks observed in the Kakwa area are an unnamed unit composed of medium-bedded to massive dolomitic quartz arenite and dolostone. This unit was mapped in the Mount Buchanan area where it conformably overlies the Skoki Formation (Figure 1-6-2). Medium-bedded to massive, medium to light grey, fine-grained dolomitic quartz arenite predominates and has a distinctive medium yellow-tan to buff-orange weathered surface. This sandstone is locally interbedded with medium-bedded, medium to light grey and orange-weathering, finely crystalline dolostone. True thickness could not be determined but is not less than 75 metres.

Middle Paleozoic

The middle Paleozoic sequence in the Kakwa area is dominated by carbonate rocks exposed in a thrust sheet which is bounded on the east by the Broadview fault and on the west by the Mount St. George and Wishaw faults (Figure 1-6-2).

The lowest unit in the middle Paleozoic package is the the Middle Devonian Dunedin Formation which disconformably overlies Ordovician strata. It is exposed at only one location within the study area, approximately 3 kilometres south of Mount Buchanan (Figure 1-6-2) where it is estimated to be approximately 60 metres thick (McMechan and Thompson, 1985). It is characterized by two distinct lithologies, an upper, resistant limestone-dominated package and a lower, less resistant sequence dominated by clastic rocks. The upper package consists of thick-bedded, medium grey and yellow-buff-weathering, medium grey lime mudstones and wackestones with minor interbeds of medium orange-brown weathering, light grey, fine-grained quartz arenite and siltstone. The lower clastic sequence

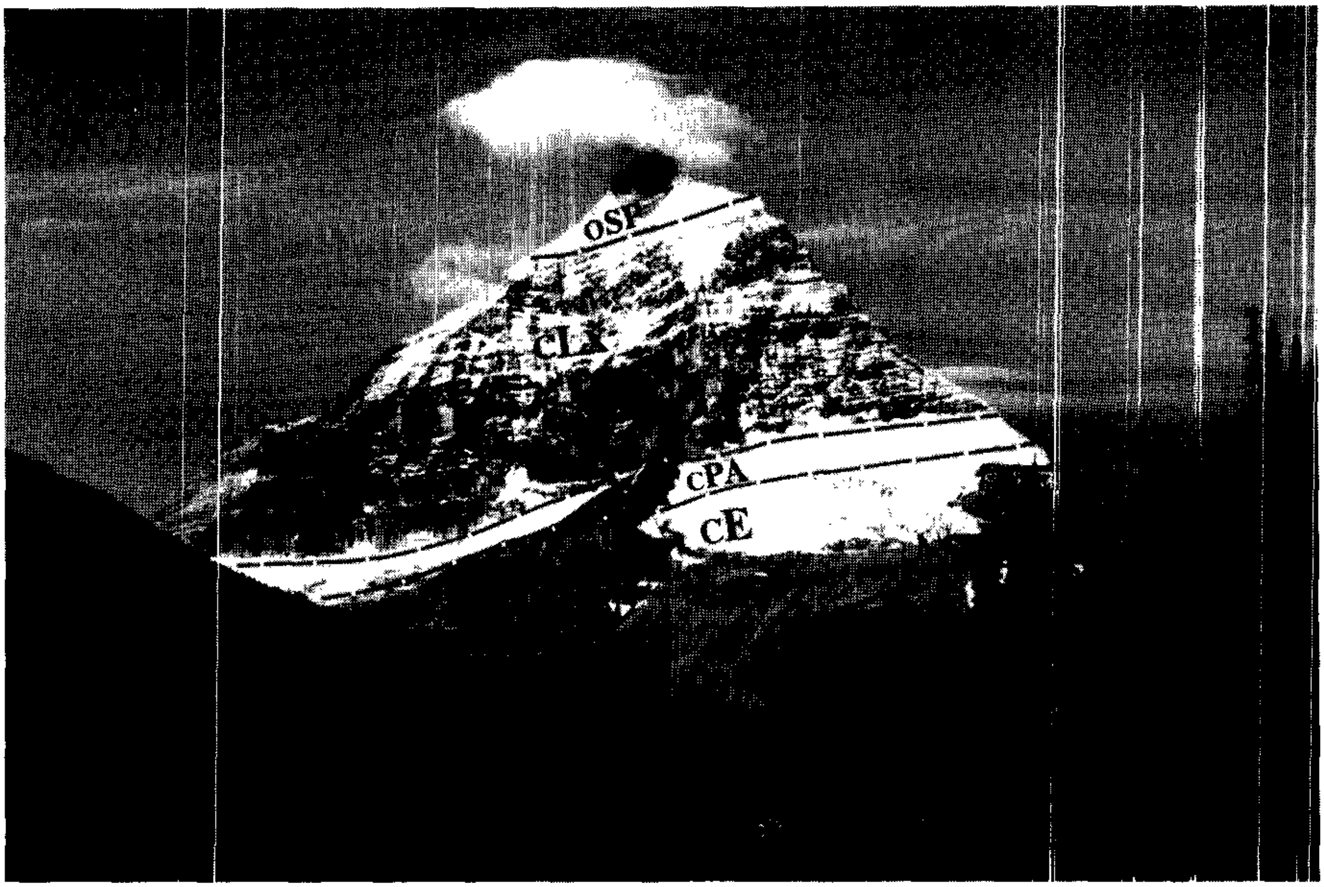


Plate 1-6-5. The Cambrian and Ordovician section exposed at Mount Ida, as viewed from Jarvis Lakes. The main cliff-forming unit, that comprises the bulk of the mountain, is the Upper Cambrian Lynx Formation (cLx); it is overlain by more recessive strata of the Ordovician Survey Peak Formation (oSP), which cap the mountain. Recessive strata of the Middle Cambrian Arctomys and Pika formations (cPA) that underlie Lynx strata, are poorly exposed, outcropping on the small spur between the two icefields. The Middle Cambrian Eldon Formation (cE) forms the lowest cliffs, immediately above the scree slope.

consists of medium orange-brown weathering, fine to coarse-grained, light grey quartz arenite and siltstone. Elsewhere, the Dunedin Formation includes a basal quartz-pebble conglomerate (McMechan and Thompson; 1985), however, this was not observed in the study area.

Upper Devonian Fairholme Group strata unconformably overlie the Dunedin Formation. The Fairholme Group comprises the Flume, Perdrix, Mount Hawk and Simla formations of Frasnian age (Table 1-6-1). The Flume Formation is generally 75 to 85 metres thick, however, in the Mount Buchanan area it is in excess of 145 metres (Geldsetzer, 1982). Where the whole sequence is exposed, as in the area east of Mount Buchanan, the Flume Formation consists of a thin quartzose sandstone unit overlain by a thin unit of red and green calcareous shales followed by a stromatoporoid biostrome which is sharply overlain by shaley limestones. The biostrome, which can be in excess of 100 metres thick, generally consists of medium to thick-bedded, grey to buff to chocolate-brown weathering limestones and patchily interspersed dolostones. Large, mound-shaped stromatoporoids in apparent life position; smaller, detached specimens; fenestral stromatoporoids and corals were all noted (Plate 1-6-7). Fossils are locally silicified. The overlying shaley limestones generally form a dark grey weathering, relatively recessive, thin-bedded to nodular unit that becomes increasingly shaley up-section. They commonly contain abundant corals and crinoids and extremely abundant brachiopods; locally, they weather to form brachiopod gravels.

The Perdrix Formation has a gradational contact with the underlying Flume Formation. It is characterized by greyish green to black shales with thin, calcareous interbeds that are recessive and generally very poorly exposed. Thickness of the Perdrix Formation is estimated at between 185 and 470 metres (Geldsetzer, 1982); lack of good exposure, and faulting, make true thickness estimations difficult.

The Mount Hawk Formation conformably overlies the Perdrix shales and consists of cliff-forming grey limestones, often with a ribbed weathering pattern. In the Kakwa area, it is characterized by thick ledges of massive limestone with intervening zones of thin-bedded to nodular limestone and shaley limestone. This formation is invariably very fossiliferous; however, weathered surfaces are locally coated with a crust of light grey lime, which obscures their fossiliferous nature. Gastropods, rugosan and colonial corals are the dominant macrofossils; brachiopods were also noted

Plate 1-6-6. Lime mudstone chips in a crossbedded dolomitic sandstone bed from the lower part of the Lynx Formation.

locally. The nodular limestone units predominantly consist of skeletal mudstones and wackestones; skeletal wackestones and grainstones comprise the more massive beds. In the Kakwa area, the Mount Hawk Formation is 90 to 140 metres thick (Geldsetzer, 1982).

The Simla Formation conformably overlies the Mount Hawk and averages 60 to 70 metres in thickness. It comprises a sequence of massive, thick-bedded, resistant, light grey limestones, interbedded with lesser, thin-bedded limestones. Grainstones are the dominant lithology (Geldsetzer, 1982). Like the Mount Hawk Formation, Simla limestones are very fossiliferous, with colonial corals, bryozoans and crinoids the dominant organisms. Brachiopods occur locally and gastropods were noted in a few places. In some locations, light grey, limy encrustations obscure the fossiliferous nature of these rocks; in other areas, silicification enhances the fossils. Thin bands and nodules of black chert occur in some sections. In the Kakwa area, lithological similarities between the Simla and Mount Hawk formations often make recognition of the contact difficult and it is often easier to distinguish the units from a distance due to the lighter weathering colour of the Simla limestones.

The Palliser Formation, of Famennian age, consists of a thick succession of monotonous limestones which disconformably overlie the Simla Formation. In the Kakwa area, this formation is approximately 530 metres thick. Its base is marked by a thin, brown-weathering fossil "hash" layer containing whole and fragmented gastropods, brachiopods and crinoids. The lower part of the formation consists of recessive to ribbed-weathering, thin, wavy bedded to nodular lime mudstones, with some medium-bedded limestone ledges which grade upwards from grainstones to mudstones (Geldsetzer, 1982). These strata are often mottled light grey, dark grey and buff weathering. Rare oolitic beds (oolitic shoals) containing lime-mud intraclasts are present locally. Fossils are uncommon, with only rare brachiopods and scleractinian corals being noted near the base of the formation. Locally, flat-pebble conglomerate beds, with a reddish, iron oxide coating, are also present.

The upper part of the Palliser Formation consists of more resistant, thin to medium-bedded, grey to grey-brown mottled limestones. Its base is defined by approximately 10 metres of black and grey, rhythmically laminated lime mudstones, which are in sharp contact with underlying lower Palliser lithologies. This marker unit is overlain by thin-bedded lime mudstones and shaley limestones that give way, up-section, to monotonous, medium-bedded lime mudstones and pelletal grainstones. Macrofossils are rare in this part of the section, with brachiopods and crinoid osscicles occasionally present; trace fossil markings are common

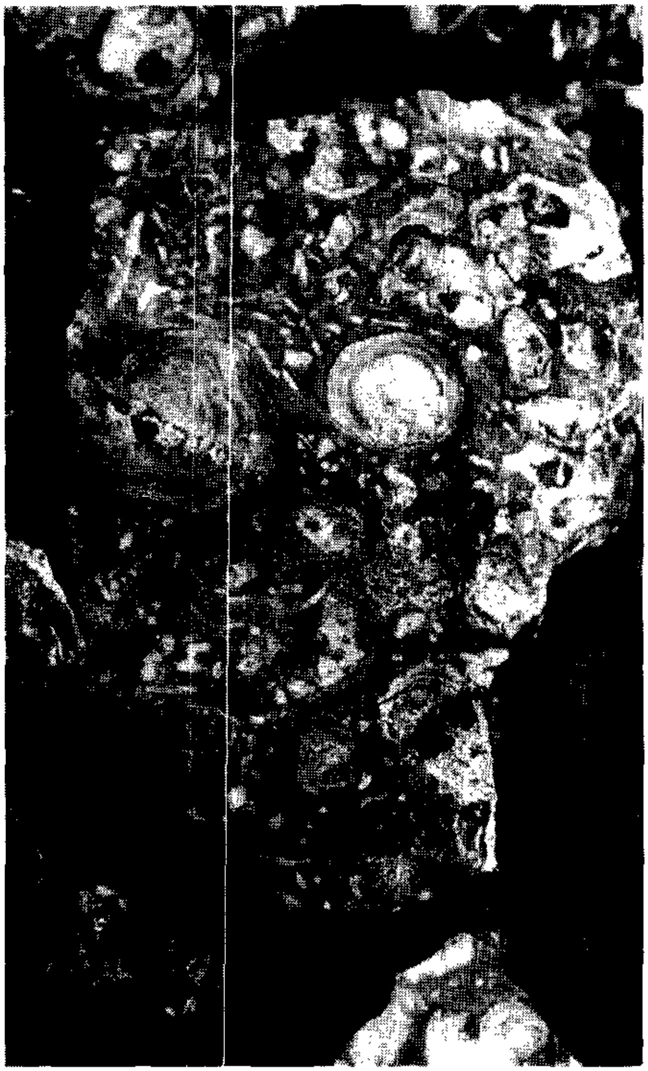


Plate 1-6-7. Detached and fragmented stromatoporoids in the Upper Devonian (Frasnian) Flume Formation.

on bedding planes in the lower part of this section. Nodules of black chert also occur locally.

Upper Paleozoic

The Upper Paleozoic sequence comprises a basal clastic, shale-dominated package, overlain by a thick sequence of carbonate rocks, capped by thin sandstones and chert-pebble conglomerates. Terrigenous clastic rocks of the Banff and Exshaw formations, which are predominantly Lower Carboniferous in age, form the base of this sequence and unconformably overlie the Palliser Formation. These units, which cannot be subdivided in the Kakwa area, are recessive and poorly exposed. They consist predominantly of black shales with thin interbeds of lime wackestone and grainstone and minor sandstone; carbonate content of this unit increases up-section until carbonate rocks dominate and the strata are assigned to the Rundle Group. A thickness of 180 to 260 metres has been estimated for the combined Banff and Exshaw formations (McMechan, 1986).

Two carbonate units of Carboniferous age are present within the study area; the widespread Lower Carboniferous Rundle Group, and the thin, discontinuous, Upper Carboniferous Hanington Formation. The latter is typically absent due either to nondeposition or erosion as part of a widespread sub-Permian disconformity. The only known occurrence of the Hanington Formation within the study area is at the type section, approximately 3 kilometres east of Moonias Mountain (Bamber and Macqueen, 1979; Figure 1-6-2). Rundle Group rocks crop out in the southeastern and north-central parts of the recreation area (the Intersection Mountain area and northeast of Moonias Mountain; Figure 1-6-2) and reach a thickness of approximately 400 metres.

The Rundle Group is subdivided into four formations in this area. From oldest to youngest, they are the Pekisko, Shunda, Turner Valley and Mount Head formations. The Pekisko, Shunda and Turner Valley formations are very similar in character. All are variably thin to thick bedded, light to medium grey weathering and consist of medium grey skeletal grainstones, wackestones and packstones with minor lime mudstone. Crinoidal debris is the most abundant skeletal constituent. Chert nodules are typically absent, however, they are locally abundant. The overlying Mount Head Formation is predominantly composed of light grey weathering, light to dark grey, fine-grained dolostone which is locally petroliferous. Chert nodules and chert beds are very common. Macrofossils are common in all of the formations of the Rundle Group. The most common types include rugosan, scleractinian and lithostrotion corals: brachiopods, gastropods and echinoderms are also present.

Rocks of the Hanington Formation disconformably overlie those of the Rundle Group. At the type section, this unit consists of medium to thick-bedded, partially dolomitized skeletal wackestone, packstone and lime mudstone. Chert nodules and layers are locally common and a thin bed of chert-granule to pebble conglomerate is found at its base. The unit is 5 metres thick, and is lithologically very similar to the overlying Belcourt Formation of Permian age. Division has been made primarily on the basis of microfossil interpretation which has established an Upper Carboniferous age for this formation (Bamber and Macqueen, 1979).

Permian strata disconformably overlie rocks of the Lower Carboniferous Rundle Group and the Upper Carboniferous Hanington Formation. Two lithologically unique units characterize the Permian of the area, the Upper Permian Mowich Formation sandstones and the Lower Permian Belcourt Formation gritty limestones and conglomerates. The Belcourt Formation appears to be absent over much of the study area, but where exposed it is separated from the overlying Mowich Formation by a mid-Permian disconformity (Bamber and Macqueen, 1979).

Belcourt Formation rocks were observed at one locality, approximately 3 kilometres east of Moonias Mountain (Figure 1-6-2). Here, thick-bedded medium grey weathering chert-pebble conglomerate with a carbonate matrix is interbedded with, and grades into, thick-bedded, medium grey weathering gritty lime mudstone, clean lime mudstone, skeletal packstone and wackestone. Finely crystalline dolostone predominates toward the top of the unit. Chert pebbles are dark to light grey in colour and are well rounded. Gastropods and brachiopods are locally abundant. The true thickness of this unit could not be established, but is not less than 10 metres.

The Mowich Formation is by far the more extensive of the two units within the study area. It is a light brown-buff weathering, light to medium grey, medium to fine-grained quartz arenite. Outcrops are commonly lichen covered, giving the rocks a dark grey to black appearance. The unit is typically less than 10 metres thick, and is most easily distinguished by its dark colour and its unmistakable stratigraphic position between the thick succession of massive grey carbonates of the Rundle Group and the thick orange to brown-weathering siltstone sequence of the Triassic Sulphur Mountain Formation.

Mesozoic

Triassic Spray River Group strata (Sulphur Mountain and Whitehorse formations), which crop out in the northern and eastern regions of Kakwa Recreation Area (Figure 1-6-2), unconformably overlie Permian rocks. The older Sulphur Mountain Formation is a moderately resistant unit that weathers a characteristic dark reddish brown to brownish orange colour. It has been subdivided into the Vega-Phroso, Whistler and Llama members, in ascending order. In the Kakwa area, the Vega-Phroso siltstone member is approximately 245 to 270 metres thick and comprises a shaley to flaggy weathering sequence of dolomitic and calcareous siltstone, fine-grained sandstone, silty limestone and shale (Gibson, 1975). It is quite platey near the base and becomes increasingly flaggy up-section. Ammonites are relatively common; pelecypods were also noted in some sections and, in one location, moderately well preserved fish fossils were found (Pell and Hammack, 1992, this volume). The Whistler Member, where present, is generally 10 to 20 metres thick and consists of dark grey to black-weathering siltstone, silty limestone, silty shale, dolostone, phosphorite and phosphatic pebble conglomerate (Gibson, 1975). Ammonites, pelecypods, and locally brachiopods, occur in this member and are commonly phosphatic. The Llama Member is characterized by relatively resistant, orange-brown-weathering, thin to thick-bedded dolomitic quartz siltstones, silty limestones and dolostones that contain pelecypods and rare ammonite fossils, and locally, reptile bones. Where it occurs, it is approximately 150 to 185 metres thick.

The Whitehorse Formation conformably overlies the Sulphur Mountain Formation and is a variable sequence of recessive to moderately resistant, buff to light grey to yellowish grey weathering dolostones, limestones and sandstones, with minor amounts of siltstone, intraformational conglomerate and evaporite. Regionally, it can be divided into the Starlight evaporite member, the Brewster limestone member and the Winnifred Member with cumulative thicknesses of between 130 and 400 metres (Gibson, 1972, 1975). Limited exposure in the Kakwa area makes subdivision of the Whitehorse Formation difficult. The most common lithologies encountered were very porous, sugary, buff

Plate 1-6-8. Disharmonic chevron folds in Lower Cretaceous Minnes Formation strata, north of Mount Minnes.

grainstones, buff and grey fossiliferous grainstones, massive, light grey weathering quartz wacke and medium-crystalline dolostones that often had a very strongly petroliferous odor when broken. Chert layers and lenses and intraformational breccia horizons were also observed.

The Jurassic Fernie Formation is a recessive, poorly exposed unit with an estimated thickness of 250 to 900 metres that, on a regional scale, unconformably overlies carbonate rocks of the Triassic Whitehorse Formation (McMechan, 1986). In the Kakwa area, it crops out east of the Broadview fault (Figure 1-6-2) and is always in fault contact with older strata. The lower part of the Fernie Formation consists of dark grey and black shale with minor sandstone; very thin to thin-bedded, greyish brown weathering siltstone, silty sandstone and shale with local, more resistant silty sandstone units in the upper part of the formation.

The Upper Jurassic to Lower Cretaceous Monteith Formation conformably overlies Fernie Formation strata. It is a resistant, light greyish brown to yellowish brown weathering marker unit, approximately 200 to 400 metres thick, that predominantly consists of very fine grained laminated sandstones. Wood fragments and crinoids with star-shaped stems *(Pentacrinites?)* are locally present in these sandstones.

The Gorman Creek Formation of the Lower Cretaceous Minnes Group (also referred to as the Nikanassin Formation) conformably overlies Monteith Formation sandstones in the northeastern part of the Kakwa area. It comprises a thick, orange-brown, ribbed-weathering succession of interlayered sandstone, siltstone, mudstone and carbonaceous shale. Thin coal beds, averaging 30 to 50 centimetres in thickness, are common in the upper part of this formation. Sandstones are generally buff weathering, fine to coarse grained, carbonaceous and often display ripple crosslaminations or crossbedding. Dark chert grains are common constituents of the sandstones. The thickness of this formation is estimated at 650 to 1000 metres (McMechan, 1986).

Conglomerates and sandstones of the Lower Cretaceous Bullhead Group (Cadomin and Gething formations) unconformably overlie Minnes Group strata east of Mount Minnes (Figure 1-6-1). The Cadomin Formation is a cliff-forming unit, approximately 25 metres thick, that comprises clast-supported, multilithic conglomerates with pebble to cobble-sized clasts in a sandy matrix. The Gething Formation conformably overlies the Cadomin conglomerates and consists of a ribbed-weathering sequence of orange-brown crosslaminated sandstones, carbonaceous siltstones and carbonaceous shales. In the Kakwa area it is 45 to 50 metres thick and its top is marked by a fairly thick (2.5 to 3 m) coal seam (Pribyl, 1979).

The Moosebar Formation conformably overlies Gething strata. It is a recessive unit, 35 to 55 metres thick, that is comprised of grey to tan-weathering shales with thin, rusty weathering siltstone interbeds. In the Kakwa area, it is conformably overlain by approximately 110 metres of Lower Cretaceous Gates Formation strata, which comprise the youngest sediments in the region. The Torrens River Member of the Gates Formation comprises approximately 12 metres of thin to thick-bedded, crosslaminated sandstones and is overlain by a ribbed-weathering succession of fine to coarse-grained carbonaceous sandstones, siltstones and shales assigned to the "Middle" Gates Member. Three moderately thick coal seams (ranging from 2 to 6 m) are present within this unit (Pribyl, 1979).

STRUCTURE

The Kakwa area can be broadly divided into three structural domains with differing structural styles. The eastern domain includes the area underlain by Jurassic and Cretaceous strata, east of the Broadview fault (Figure 1-6-2). The rocks in this region are relatively incompetent; shales and thin-bedded sandstones are the dominant lithologies. Folds are predominantly chevron style with short wavelengths, small amplitudes and highly variable axial planes (Plate 1-6-8). They tend to be disharmonic. Axial traces of the folds trend southeasterly and are subparallel to the bounding faults.

The central domain is bounded by the Broadview fault to the east and, to the west, by the Wishaw fault in the vicinity of, and south of Mount Buchanan and by the Mount St. George fault to the north of Mount Buchanan (Figure 1-6-2). Numerous minor thrusts occur within this major sheet; in most cases they are not more than 10 kilometres in strike length and are either splays off the major bounding faults or terminate along strike with displacement transferred into folds. In the southern part of the area, south of Wallbridge Mountain, northerly directed thrusts with east-west strikes cross the main structural grain. Two northwest-trending, west-side-down normal faults, with strike lengths in excess of 5 kilometres, are also present within the central domain. Normal faults post-date the thrusts and many of the thrusts are either offset or truncated by them.

The central block is predominantly underlain by Middle and Upper Paleozoic strata; some Ordovician rocks are present near the centre of the belt and Triassic units crop out in the north and south. The units carried within this thrust sheet are dominated by carbonates and most are fairly competent; however, intervening, thick incompetent (shaley) units also occur within the sequence. Map-scale folds, with northwest-trending axial traces are present within this domain and are fairly continuous along strike. They are generally quite tight and vary in orientation from upright to overturned, both along their axial trace and in cross-section (Plate 1-6-9). Some smaller scale folds are also present. They are not continuous along strike and are clearly conical in nature. With folds of all scales, disharmony occurs between competent and incompetent units.

The western domain lies west of Wishaw fault in the vicinity of, and south of Mount Buchanan and west of the Mount St. George fault, north of Mount Buchanan. A structurally complex zone of small thrust slivers and overturned folds occupies the region north of Mount Buchanan, between where the Mount St. George and Wishaw faults are clearly the eastern bounding structures of this package (Figure 1-6-2). The southern and western boundary of this domain is defined by the Snake Indian - Back Range fault system (McMechan, 1986), which lies outside the area mapped.

This domain is underlain by Cambrian quartzites and carbonate rocks that are predominantly medium to thick

Plate 1-6-9. Upright to overturned folds in Upper Devonian strata, northeast of Kakwa Lake. The recessive Perdrix Formation (dPx) is exposed at the base of the cliffs and is overlain by the cliff-forming Mount Hawk and Simla formations (dSMh) that cannot be easily differentiated in this section. The Palliser Formation (dP) is exposed at the top of the ridge; a slightly more recessive unit at the base of the Palliser forms a slight step above the Simla and Mount Hawk strata.

bedded and quite competent. Proterozoic Miette Group strata are exposed, in a number of locations, in the immediate hangingwall of the east-bounding faults. The dominant structures in this part of the area are open folds and broad warps with east or southeast-trending axial traces and northerly directed thrusts with east to east-southeast traces. Normal faults are also prominent within this block, particularly in the southwestern area, near Mount Sir Alexander. Most strike westerly and southwesterly. Small drag folds are often associated with the normal faults. The east-west structural trends within this domain are anomalous on a regional scale.

ECONOMIC GEOLOGY

COAL

Coal licenses are held in the northeastern corner of Kakwa Recreation Area, covering the ridge south of Mount Gorman. This area is underlain by a shallow, south-dipping sequence of Lower Cretaceous strata that contains four significant coal seams. The lowest seam is reportedly 2.4 to 3 metres thick and occurs at the top of the Gething Formation. The overlying Gates Formation, the top of which has been eroded, hosts three seams that were trenched in the late 1970s and are reported to be 1.8 to 2.7, 3.6 to 6, and 5.5 to 6 metres thick, respectively (Pribyl, 1979). The coal-bearing strata cap the ridge and the seams, which contain an estimated 4 to 4.5 million tonnes of coal, could be exploited at stripping ratios of between 1:1 and 15:1 (Pribyl, 1979).

Coal seams also occur within the Lower Cretaceous Minnes Formation in the Mount Minnes and Mount Gorman areas, in the northeastern part of the Kakwa area. Several seams are present, particularly in the upper part of this formation; however, they are generally less than 1 metre thick and not of serious economic interest under current conditions.

DIMENSION STONE

Quartzites of the Lower Cambrian Mahto Formation, that crop out in the centre of Kakwa Recreation Area near Babette and Wishaw lakes, were examined in the late 1970s and early 1980s for their potential use as dimension stone.

At that time, roads were extended to the prospects from existing logging roads in the McGregor River valley. At Babette Lake the strata were drilled, while at Wishaw Lake an attempt was made to quarry test blocks. The only mineral claims currently held within the recreation area cover these stone prospects.

The Mahto Formation, at the Babette Lake prospect, consists of fine to medium-grained, locally crossbedded quartzites that vary from creamy white to dark maroon in colour; some beds are uniform in colour, while others have quite attractive colour banding. Some of the colour banding is parallel to sedimentary laminations and crosslaminae and may reflect a depositional feature, however, much of the banding appears to be unrelated to original sedimentary features and forms intricately swirled patterns that may be related to solution fronts (Plate 1-6-2). Beds slightly more than a metre thick are common. Large blocks, in the 1 to 2 cubic metre size range, are found in talus beneath cliff outcrops. At Wishaw Lake, the Mahto quartzites are creamy white or beige to light pink in colour; most of the colour banding at this location is parallel to laminations and crosslaminations. Bedding thicknesses range from 50 centimetres to just over a metre; beds up to 2 metres thick are reported (Hora, 1984). Quarried blocks, 2 to 2.5 cubic metres in size, are present on site, however, there are no blocks in the size range preferred by industry (1.4x1.6x3 m) on site at this time.

When cut into slabs and polished, the quartzite from these prospects has a colour and textural qualities comparable to high-quality, commercially exploited marble and strength comparable to high-quality granite (Hora, 1984). Due to the extreme hardness of this material, however, it is more difficult and hence, more expensive to finish than either marble or granite. Also of concern, is the variable porosity of these quartzites. In some places, the rock is well cemented and has low porosity, while in others it is quite porous, stains easily and would not produce an acceptable product unless treated with some type of sealant coating to reduce staining. The distribution of porous, and therefore, less desirable material within these prospects has not been documented (Z.D. Hora, personal communication, 1991).

Phosphate

Phosphorite beds are found within the Whistler Member of the Triassic Sulphur Mountain Formation at three locations around Kakwa. In the northern part of the area mapped, near the boundary of the recreation area, phosphatic rocks occur near the core of a syncline in the Sulphur Mountain Formation (Figure 1-6-2). At this location, the phosphatic horizon is 10 to 15 centimetres thick and is exposed in a rubbly outcrop associated with calcareous siltstones and silty limestones. The phosphorite is dark grey or bluish to white weathering, with a dark brown to black fresh surface. It has a gritty texture, a petroliferous odor and contains abundant ammonite and pelecypod fossils. Purple fluorite is present as veinlet infillings and fracture coatings. Grab samples of these phosphorites contained 21 to 23 per cent P_2O_5 (Samples 1097A and B, Table 1-6-2).

To the east of this occurrence, on the east limb of the adjacent anticline, phosphatic rocks again outcrop. At this

TABLE 1-6-2
ANALYSES OF TRIASSIC PHOSPHORITES

Sample	Sample Type/ Thickness	P_2O_5 %	Lithology	Location
1079A	Grab/Bulk	23.12	Fossiliferous P_2O_5	North Ridge-West
1079B	Grab	21.77	P_2O_5 w/fossils & fluorite	North Ridge-West
1091A	Grab	10.97	Phosphatic shale	North Ridge-East
1091B	Grab	8.04	Impure P_2O_5, silty w/fossils	North Ridge-East
1094A	12 cm	22.58	Nodular P_2O_5 w/fossils	North Ridge-East
1094B	18 cm	9.40	Phosphatic shale	North Ridge-East
1251A	Grab	18.70	Nodular phosphate	Intersection Mt.
1251B	Grab	20.06	P_2O_5 w/fossils & fluorite	Intersection Mt.

P_2O_5 analyzed by gravimetric assay method

locality, approximately 12 centimetres of phosphate rock overlies thin to medium-bedded, grey argillaceous limestone and calcareous siltstone. The phosphorite horizon is black to dark brown in colour, has a nodular texture and contains abundant ammonite fossils. It is overlain by 90 centimetres of grey, silty limestone, which is, in turn, overlain by 18 centimetres of phosphatic shale and siltstone. Sixteen centimetres of very fissile black shales overlie the phosphatic shale and the sequence is capped by more grey limestones. The lower nodular and fossil-rich phosphate horizon is moderately high grade, containing approximately 22 per cent P_2O_5, while the upper horizon of phosphatic shales and siltstones contains between 8 and 11 per cent P_2O_5 (Samples 1091 and 1094, Table 1-6-2). The entire phosphatic interval is only 1.2 metres thick in this area and limestones comprise a greater proportion of it than do phosphorites and phosphatic shales.

A third phosphate occurrence was found in the southeastern corner of Kakwa Recreation Area, near Intersection Mountain. It outcrops on a cliff face and is estimated to be no more than a metre in thickness. Nodular and fossiliferous phosphorites with fluorite-coated fracture surfaces were found in talus beneath the outcrops. Grab samples from this area contain between 18 and 20 per cent P_2O_5 (Samples 1251A and B, Table 1-6-2).

Carbonate-hosted Vein and Replacement Showings

Vein and replacement showings in carbonate rocks, although not common in the Kakwa area, were discovered in six locations. Southeast of Mount Ida, an orange-weathering, irregular dolomitized zone is exposed in light grey limestones near the top of the Middle Cambrian Snake Indian Formation. Coarse-grained dolomite occurs in veins and solution-collapse breccia infillings within the dolomitized rocks. Small shear zones, dominantly consisting of fine-grained calcite, are also present in this area. To the west of Mount Ida, an irregular zone of altered and recrystallized dolomite, cut by coarse-grained dolomite veins, occurs within limestones of the Middle Cambrian Eldon Formation. No evidence of potentially economic commodities, such as lead, zinc or magnesite was found in either area (Table 1-6-3), although correlative strata in southeastern British Columbia are known to host economic deposits in similar environments (Grieve and Höy, 198 ; Simandl and Hancock, 1991).

In the southern part of the area, southeast of Mount Buchanan, coarse-grained dolomite occurs in veins and open-space fillings in a brecciated zone within Ordovician Skoki dolostones. East-northeast of Mount Buchanan coarse-grained calcite veins containing minor amounts of barite cut irregularly dolomitized zones in Upper Devonian Mount Hawk limestones. These veins are narrow and appear to be barren; they are not particularly widespread (Table 1-6-3).

Barite veins and replacement zones, over a metre wide, were found in Rundle Group carbonate rocks at two locations, near the upper part of the unit. One site is in the northernmost part of the area mapped, approximately 2 kilometres north of the recreation area boundary and the other is near Moonias Mountain, north of Jarvis Lakes. In both localities, the veins consist predominantly of coarse-grained white barite; at the northern location carbonate inclusions and rusty vugs are common within the vein. Samples collected from these veins did not contain appreciable amounts of base metals (Table 1-6-3); however, the rusty material from the northern locality could not be adequately sampled and in both cases the material analyzed was predominantly pure barite. The Belcourt zinc prospect, located approximately 6 kilometres north of the recreation area, occurs in the same stratigraphic position and also consists of barite veins with patchily distributed zinc mineralization. This showing is reported to contain up to 2 per cent zinc (Lenters, 1980); grab samples of gossanous material and altered dolomitic wallrock, collected during a brief visit to the showing, contain 0.35 and 0.65 per cent zinc, respectively, while baritic vein material does not contain appreciable zinc values (Table 1-6-3).

Quartzite-Hosted Vein Showings

Quartz veins containing pyrite or associated with pyritic alteration halos were found in Lower Cambrian quartzites at two locations. A few kilometres south of Mount Ida, pyritic quartz veins associated with rusty, pyritic alteration halos cut McNaughton Formation strata. North of Kitchi Mountain, irregular quartz-pyrite veins, with alteration halos that locally contain 50 to 70 per cent pyrite occur within the Mahto Formation. No gold or base metals were noted in the limited samples collected from these veins (Table 1-6-3) even though veins in similar rocks, south of Jasper, are known to carry gold (Shaw and Morton, 1990).

Stratiform Sulphides

Apparently stratiform massive sulphide mineralization was found in fine-grained sandstones of the Permian Mowich Formation at two locations. Near Moonias Mountain, approximately 3.5 kilometres north of Jarvis Lakes, beds of pyrite 1 to 3 centimetres thick were discovered. In the southern part of the area, near Intersection Mountain, a gossanous zone, approximately 6 metres thick and 20 metres in strike length, occurs in what should be Mowich strata. In the same area, pieces of dark, bituminous sandstone containing up to 40 per cent pyrite were found in float beneath Mowich outcrops. Samples of pyrite-rich sandstones contain anomalous concentrations of zinc, up to 0.7 per cent (Table 1-6-3). Zinc mineralization in Permian sandstones has also been reported from the Belcourt showing, a few kilometres north of Kakwa (Lenters, 1980).

TABLE 1-6-3
CHEMICAL ANALYSES OF VEIN, REPLACEMENT AND STRATIFORM OCCURRENCES

SAMPLE	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	Fe %	DOMINANT MINERALS	LOCATION
Carbonate-hosted vein-replacement showings in Rundle Group strata								
1071	na	<0.2	2	<2	13	0.04	barite	North Ridge
2028	na	<0.2	<1	<2	12	0.04	barite	2.5 k N of Jarvis Lakes
BEL1	na	4.2	30	40	6462	1.24	dolomite	6 k N of Kakwa Rec. Area
BEL2	na	<0.2	<1	33	3549	>10.00	goethite	6 k N of Kakwa Rec. Area
BEL3	na	0.2	2	<2	43	0.32	barite	6 k N of Kakwa Rec. Area
Carbonate-hosted vein-replacement showings in other units								
1124A	na	<0.2	2	<2	<1	0.70	dolomite	4 k SE of Mt. Ida
1124B	na	<0.2	3	4	<1	0.75	calcite	4 k SE of Mt. Ida
1160	na	<0.2	2	<2	<1	0.30	dolomite	6 k W of Mt. Ida
1186A	na	0.2	2	<2	<1	0.10	calcite	3 k ENE of Mt. Buchanan
1186B	na	<0.2	1	<2	<1	0.02	barite	3 k ENE of Mt. Buchanan
2124	na	<0.2	2	4	<1	0.94	dolomite	3 k SE of Mt. Buchanan
Quartzite-hosted vein-replacement showings								
1100	6	<0.2	4	7	21	3.71	qz/py	3 k S of Mt. Ida
2078	6	<0.2	5	12	5	>10.00	pyrite	2 k N of Kitchi Mt.
Stratiform mineralization								
1252	6	<0.2	25	15	7190	5.98	pyrite	3.5 k N of Jarvis Lakes
1253	<5	<0.2	8	8	717	6.90	pyrite	Intersection Mountain
2164	<5	<0.2	6	13	1890	>10.00	goethite	Intersection Mountain

na = not analyzed; Au analyzed by fire assay with atomic absorption finish; all other elements analyzed by inductively coupled plasma technique, using HNO_3-HCl hot extraction.

DISCUSSION AND CONCLUSIONS

The Kakwa Recreation Area is underlain by strata which range in age from Late Precambrian to Early Cretaceous. The area can be divided into three domains with distinct stratigraphy and structural styles, bounded by major thrust faults. The eastern domain is underlain by Mesozoic rocks, predominantly shales and thin-bedded sandstones, and characterized by small, disharmonic chevron folds. The central domain predominantly contains middle and upper Paleozoic carbonate rocks with thick intervening shale units. Map-scale folds, which are common in this domain, are generally tight, upright to overturned structures that display some degree of disharmony between carbonate and shale-dominated sequences. Minor thrusts and normal faults are also present in this domain. The western domain contains thick-bedded lower Paleozoic quartzites and carbonate rocks and is characterized by broad open folds, small thrusts and abundant normal faults. Easterly structural trends are common in this domain, whereas the other two domains are dominated by northwesterly trends, more typical of the regional structures. The difference in structural styles between the three domains is largely controlled by the differences in competency and competency contrasts of the rock units. The east-west structural trends in the western domain represent a regional anomaly that may, in part, be related to the original shape of the sedimentary basin, where an anomalously thick section of Cambrian rocks was deposited on the south flank of the Peace River arch (McMechan, 1990).

A number of commodities of potential economic interest occur within Kakwa Recreation Area, including coal, phosphate, dimension stone, barite and zinc. Four thick coal seams occur in an erosional remnant of Lower Cretaceous strata that caps a small ridge in the northeastern corner of the area. The seams are up to 6 metres thick; however, they are of limited extent and constitute a fairly small tonnage of recoverable reserves. The phosphorite occurrences that were found within the recreation area, although worthy of note, are far too thin to be of economic interest at the present time. Approximately 50 kilometres to the north, in the Wapiti Lake area, phosphatic strata in the Sulphur Mountain Formation are reportedly up to 3.2 metres thick (Butrenchuk, in preparation; Legun and Elkins, 1986), which suggests that this interval does have potential and should not be overlooked.

Quartzite strata near the centre of the recreation area have been examined for their potential use in the building stone industry. They are very attractive rocks with colourful maroon, pink and cream banding and laminations; when cut and polished they produce a product comparable in appearance to commercially exploited marbles and in strength, to good quality granite. There are a number of problems with this stone, in some areas the rock is very porous and easily takes a permanent stain. If the showings were to be quarried, the porosity distribution would have to be mapped out and only the well-cemented material used, or the porous material coated with a sealant to reduce potential staining problems, which would increase costs. It is also doubtful whether large blocks of the size preferred by industry can be produced from the prospective sites. In some cases, smaller blocks might be utilized but again, this would result in increased costs. Distance to existing fabricating plants is another concern: trucking costs from the Kakwa area would be extremely high and a significant amount of road improvement would be necessary prior to shipping any material.

Zinc and barite showings occur near the upper contact of the Carboniferous Rundle Group and in the overlying Permian Mowich Formation in a number of locations within and immediately north of Kakwa. The barite occurs in veins and replacement zones approximately 1 metre wide within Rundle Group carbonate rocks; it is coarse grained and white in colour. In some areas, particularly to the north of the area, the barite veins cut extremely altered hostrocks and contain rusty vugs or gossanous (sulphide-rich?) inclusions with anomalous zinc contents. Apparently stratiform sulphide mineralization occurs locally in the Permian sandstones that overlie the Rundle Group. These stratiform sulphides carry some zinc and may be related to the same system that produced the barite veins. The rocks straddling the Carboniferous-Permian boundary have some potential and should be prospected in more detail.

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