Alberta Research Council
Open File Report 1964-1

GEOLOGY OF THE MALIGNE VALLEY
JASPER NATIONAL PARK
ALBERTA

by

M. A. Roed

Research Council of Alberta
Edmonton, Alberta
October, 1964

Alberta
RESEARCH COUNCIL

INTRODUCTION

Nowhere in Jasper Park is the array of geological features so vividly displayed as in Maligne Lake Valley and in the lower part of the Maligne River Valley (the two together are referred to as Maligne Valley in this report). The Maligne Valley is over 36 miles long, is 1 to 4 miles wide in places and heads in the largest ice-field in the Front Ranges of the Canadian Rockies, in the Brazeau Icefield. The entire valley has been heavily glaciated by valley glaciers in the not too distant past and is, in fact, a classical example of a glaciated U-shaped valley. As will be explained, the shape of the valley is largely due to the work of the glaciers in the Pleistocene Period or the Ice-Age.

Maligne Lake is the largest lake in Jasper Park, being about 14 miles long and 1 mile wide. It is reported to be very deep near the south end of the valley but no official records of soundings are available. The valley in which the lake lies was carved and excavated by valley glaciers and the lake has been dammed at its northern end by an end moraine deposited by the last glacier which flowed down the valley towards the Athabasca River. The glacial deposits and landforms forming the end moraine are excellent examples of glacial deposition and will be discussed and illustrated more fully in another part of this report.

The highest peak in the area is Mount Brazeau (11,386 feet) which stands southeast of Maligne Lake at the head of the Brazeau Icefield. It is barely visible behind the towering massif of Monkhead (10,535 feet). In general, the highest mountains are at the south end of the lake and are composed of strata that are of Cambrian, Ordovician and Devonian ages — rocks that were deposited between 600 million and 350 million years ago.

Northward from the high peaks at the south end of the lake, the valley sides are different in form and composition. The east side of the valley is made of steeply dipping limestone beds of Devonian to Mississippian age which form the spectacular range of sawtooth mountains called the Colin Range which is part of the Queen Elizabeth Ranges. On the west side of the valley and in sharp contrast to the east side is the Maligne Range composed of Cambrian and Precambrian quartzite and shales. These mountains owe their more subdued outline to the glaciers which moved over them and rounded them to their present form.

The Maligne River, arising at Maligne Pass (6,800 feet), flows into the northern part of Maligne Lake. At the northern end of the lake, the river flows out of the lake in a narrow channel to Medicine Lake. There is no visible northern outlet from Medicine Lake because the Maligne River flows underground (except during flood) for 9 miles before reappearing in its remarkable canyon which is about 180 feet in depth. The water flowing in the river bed between Medicine Lake and Maligne Canyon is derived from the adjacent mountainsides.

Not only is the Maligne Valley a U-shaped valley, but it is also a hanging tributary valley as a result of deepening or widening of the Athabasca Valley by glacial erosion at a faster rate than the tributary Maligne Valley. This process leaves the tributary at its junction with the main valley "hanging" above the main valley.

Geologic History of the Maligne Valley

The Maligne Valley as it is today was possibly cut and doubtless substantially deepened largely in Pleistocene time, probably within the last 100,000 years. However, the rocks in which the valley is excavated and the major structural features of the area are much older and represent events dating back to more than 500 million years ago.

The oldest rocks in the valley are of Precambrian age and belong to the Miette Group. These consist of somewhat altered or metamorphosed sandstones, quartzites and shales. The Miette rocks outcrop over a wide area of the Maligne Range, from the Maligne River above Maligne Lake northwestward to the town of Jasper. These beds are of a generally recessive nature and thus form lower, more rounded mountain ridges than do the later carbonate rocks of the Paleozoic Era.

The earliest Paleozoic rocks, those of Cambrian age, 500 to 600 million years old, overlie the Miette strata and also form most of the spectacular cliffs and mountains around the south half of Maligne Lake. The oldest rock unit, the Gog Formation, consists largely of sandstones with some conglomerate beds, and is about 4,000 feet thick. These rocks weather to reddish-brown rubbly blocks, as on the lower slopes of the Maligne Mountains west of Medicine Lake and on the unnamed peak just north of the north end of Maligne Lake.

Other Cambrian rock units in the Maligne Valley - in ascending order, the Titkana, Pika, Arctomys and Lynx Formations - consist mainly of shales and limestones, some 5,000 feet thick. The limestone units tend to form cliffs whilst the shale units

FIGURE 1 - TABLE OF FORMATIONS

ERA	PERIOD OR EPOCH	GROUP OR FORMATION (Map Unit)	LITHOLOGY	THICKNESS (Feet)
MESOZOIC	Lower Cretaceous	Luscar Fm	Sandstone, fine grained; greenish grey siltstone; shale; coal.	2,000±
		Cadomin Fm	Conglomerate, chert & quartzite.	10 to 30
		Disconformity		
	Lower Cretaceous and Jurassic	Nikanassin Fm	Sandstone; siltstone; silty mudstone dark grey.	1,000 to 2,000
	Jurassic	Fernie Group	Shale, black and dark grey, concretionary; all members present.	700 to 900
		Disconformity		
	Triassic	Whitehorse Fm	Carbonate, light grey breccias, red mudstone, gypsum.	100 to 1,500
		Sulphur Mountain Fm	Siltstone, dark brown grey; thin bedded silty mudstone.	600 to 1,000
		Disconformity ?		
PALAEOZOIC	Permian and/or Pennsylvanian	Rocky Mountain Fm	Massive grey chert; cherty brown sandstone.	0 to 220
		Disconformity		
	Mississippian	Rundle Group: Mt. Head Fm	Dolomite, dense, cherty, medium bedded.	250 to 400
		Rundle Group: Turner Valley Fm	Dolomite, brown, porous, coarse grained.	150 to 400
		Rundle Group: Shunda Fm	Limestone, dark grey, fine grained, thin bedded.	200 to 360
		Rundle Group: Pekisko Fm	Limestone, light grey, crinoidal, coarse grained, thick bedded.	115 to 300
		Banff Fm	Limestone and calcareous shale, dark brown, thin bedded.	500 to 760
		Disconformity		
	Devonian	Palliser Fm	Limestone, dark grey, massive, fine crystalline, dolomitic.	700 to 900
		Sassenach Fm	Sandstone, fine grained; siltstone, silty shale, silty carbonates.	100 to 600
		Fairholme Group: Mount Hawk Fm	Limestone, brown grey, argillaceous; and brown calcareous shale.	250 to 700
		Fairholme Group: Perdrix Fm	Shale, black, fissile, thin limestone interbeds.	200 to 350
		Fairholme Group: Maligne & Flume Fms	Limestone, dark grey, thin-bedded, argillaceous, Limestone, dark brown, cherty, with stromatoporoids.	150 to 250
		Unconformity		
	Lower Ordovician	Sarbach Fm	Carbonates, cliff-forming.	0 to 800
		Chushina Fm	Limestone; calcareous shale; greenish-grey intraformational conglomerate.	0 to 700
	Upper Cambrian	Lynx Fm	Carbonates, silty, thin-bedded, argillaceous; intraformational conglomerate.	1,000 to 2,400
	Middle Cambrian	Arctomys Fm	Shale, silty, red and green; siltstone, brown.	600 to 800
		Pika Fm	Limestone, calcareous; shale, thin-bedded.	500 to 700
		Titkana Fm	Limestone, dark grey, massive dolomitic.	500 to 800
		Shale Unit	Shale, green and red; argillaceous limestone. Limestone, dark grey, resistant.	1,400 to 1,800
	Lower Cambrian	Gog Fm	Sandstone, light grey; quartz, cross-bedded, fine to coarse grained, massive.	4,000
?-		Disconformity ?		
P-Є		Miette Group	Shale & phyllite, grey; sandstone, conglomeratic, poorly sorted; carbonate, arenaceous, with algal (?) markings	5,500+

From Mountjoy (1964), Edmonton Geol. Soc. Guidebook are recessive and form benches, as on Monkhead and Llysfran Peak at the south end of Maligne Lake. Of these rocks, the Pika Formation is particularly distinctive, as it consists of red, brown and green shaly rocks and weathers as a colorful band; as for example, on Mount Mary Vaux and around Coronet Creek.

The Cambrian carbonate rocks were laid down in a shallow sea, as were the overlying Ordovician strata which consist of 1,500 feet of limestones. The lower rock unit, the Chushina Formation, forms a bench in part, whereas the upper unit, the Sarbach Formation, typically forms an 800 foot high cliff, as on the flank of Maligne Mountain above Mount Paul and on the southwest side of Samson Narrows.

A break exists in the succession above the Ordovician rocks and any beds laid down in late Ordovician or in Silurian time have been eroded away when the region was raised above sea level in early Devonian time.

The next rocks represented in the succession are of late Devonian age - the Fairholme Group, some 375 million years old. These rocks consist of marine limestones and shales, and contain massive fossilised reef bodies in places; they form rubbly slopes to moderate cliffs on the west flank of Maligne Mountain and on the north ridges leading to Mounts Unwin and Charlton. Overlying the Fairholme Group is the Palliser Formation, a light-coloured massive limestone bed almost 1000 feet thick which forms massive cliffs and high peaks. Samson Peak is formed by the Palliser limestones, as is the long sawtooth ridge crest of the Colin Range, extending northwestward along the northeast side of Medicine Lake and to the Athabasca Valley.

Almost 2,000 feet of Mississippian marine carbonate rocks lie above the Devonian strata. The lower unit - the Banff Formation - tends to be dark, shaly and recessive, whereas the upper unit - the Rundle Group - is light-colored and cliff-forming, similar in character to the Palliser Formation. Mississippian rocks form Leah Peak and extend northward from there to Medicine Lake. Much of the ridge which flanks between Medicine Lake and Roche Bonhomme consists of Mississippian carbonates.

A thin chert and sandstone unit - the Rocky Mountain Formation - up to 200 feet thick, lies above the Mississippian beds. This unit represents the Pennsylvanian and the Permian - a time interval of almost 100 million years or almost the same as that of the 4000-foot thick Mississippian and Devonian limestone succession; thus doubtless some breaks in the stratal sequence exist at this level. The Rocky Mountain strata represent near-shore sediments and probably during Pennsylvanian and Permian time this region lay both slightly above and slightly below sea level.

The distinctive, dark-brown weathering rubbly siltstones of the Triassic Sulphur Mountain Formation lie on the whitish cherty sandstones of the Rocky Mountain unit. These form the bare rounded crests and western flank of the ridge extending northwestward from Leah Peak and outcrop in patches around the north end of Maligne Lake. No Jurassic or Cretaceous rocks are now represented in the Maligne Valley, although some may have been laid down in the region during these times. The major representation of Cretaceous time is in the structural features of the region. The Laramide orogeny of this time resulted in folding and major thrust faulting in the rock of the Maligne Valley region. The main thrust fault in the area is the Pyramid Thrust - a low angle fault that is located in the forested slopes southwest of the Maligne River below Medicine Lake and southwest of Medicine Lake and which in this area carries Precambrian and Cambrian rocks onto Mississippian limestones. In the area just northwest of Maligne Lake the fault crosses the Maligne River to carry rubbly Cambrian Gog quartzites and onto the reddish-brown weathering Triassic siltstones and then swings back to follow the southwest side of Maligne Lake and then the Maligne River Valley. Several other faults of a minor nature exist in the mountains around Maligne Lake. Much more notable in this area are the folds induced in the rocks by the mountain-building movements. Tight angular folds within particular rock beds are visible on the slopes below Mount Charlton and on the north side of Monkhead the rocks become vertical in a spectacular downfold.

The overall steep tilting and southwesterly dip of most of the succession was also induced by the mountain-building movements. This feature has had a major controlling influence on the subsequent development of the physiography of the area as both mountain ranges and major valleys lie generally parallel to the strike of the rocks and the major faults: - southeast to northwest.

Pleistocene History of Maligne Valley

Uplift of the area of the Rocky Mountains took place in early Tertiary time. The first evidence of extensive erosion of rock of the area is in Oligocene time. (The gravels capping the Cypress Hills in southeastern Alberta are remnants from this uplift.) Apparently most of Alberta and the Rocky Mountains were eroded to a near-level plain following this uplift. Subsequently two more uplifts of considerable magnitude took place, the last one of which may still be active at present.

Uplift of a landmass induces streams to incise into the underlying rocks. If the uplift is rapid or of great magnitude the streams and rivers incise themselves only vertically, producing valleys having a characteristic V-shape regardless of their size. The Grand Canyon, for example, is only a very large V-shape valley. If the erosion persists, the larger streams after reaching the base level of erosion begin to erode laterally and thus widen their valleys. The Athabasca River was in the first stages of valley widening in late Tertiary time, but most of its tributaries, including the stream which flowed and eroded most of the Maligne Valley, in pre-glacial time were still V-shaped.

The position of streams and their valleys is very often determined by the structure and consistency of the bedrock, it being much easier for a stream to establish a valley in soft or broken rocks than in massive hard formations. Consequently in mountainous regions, as in the Rocky Mountains, most of the streams are located over fault zones, within fold axes and along the strike of soft beds. The pre-glacial Maligne River, which excavated most of the valley, is located in part over relatively softer rocks of Mesozoic age and also adjacent to a major fault zone.

Pleistocene Period

A drastic drop in temperature signified the onset of the glacial age or the Pleistocene period. This started about 1,000,000 years ago. At least four times, the average temperature dropped significantly below that of the present day and these were the times of glacial advances or glacial stages. The interglacial stages had temperatures similar to those of today. Only a record of the last glacial stage — The Wisconsin — is available in the Rocky Mountains. It may be assumed, however, that because the Rocky Mountains are high in elevation and as most of the mountains elsewhere in the world in similar latitudes and of similar elevations were glaciated several times, they did not escape pre-Wisconsin glaciations.

The buildup of ice in the Rocky Mountains during Wisconsin time was of a large magnitude. The ice attained considerable thicknesses, to such an extent, in fact, that only the highest peaks protruded above the ice mass. After reaching its maximum thickness the ice retreated or melted away, with fluctuations. In other words, the glacier would retreat to a certain point, then advance a few miles and then again retreat.

In the high mountains south of Maligne Lake there are still small remnant glaciers present. From these locations and from others which do not have any glaciers at present, the ice flowed down the Maligne Valley and joined the main glacier flowing eastwards in the Athabasca River valley.

Hills or mountains which were entirely overrun by the glacier now have a rounded appearance, as the Bald Hills, for example. Other mountains which protruded above the glacier were not rounded but were undercut laterally and at present they have a very rugged and steep appearance.

Cirques are spoon-shaped hollows on sides of mountains produced by the action of glaciers. They are the seats from which glaciers originate. Essentially, cirque erosion is signified by an extremely rapid headward cutting of rock, producing steep walls. Where two cirques encroach on a mountain and meet, the sharp knife-edge ridge thus produced is called an arête. Where three or more cirques meet together, the resulting pyramid-shaped mountain produced is called a matterhorn or simply a horn. Arêtes and horns may be seen on most of the mountains surrounding the Maligne Valley. A col is a rounded arête which has been glaciated or it is a saddle on a mountain. Cols are present on most of the high mountains in the area.

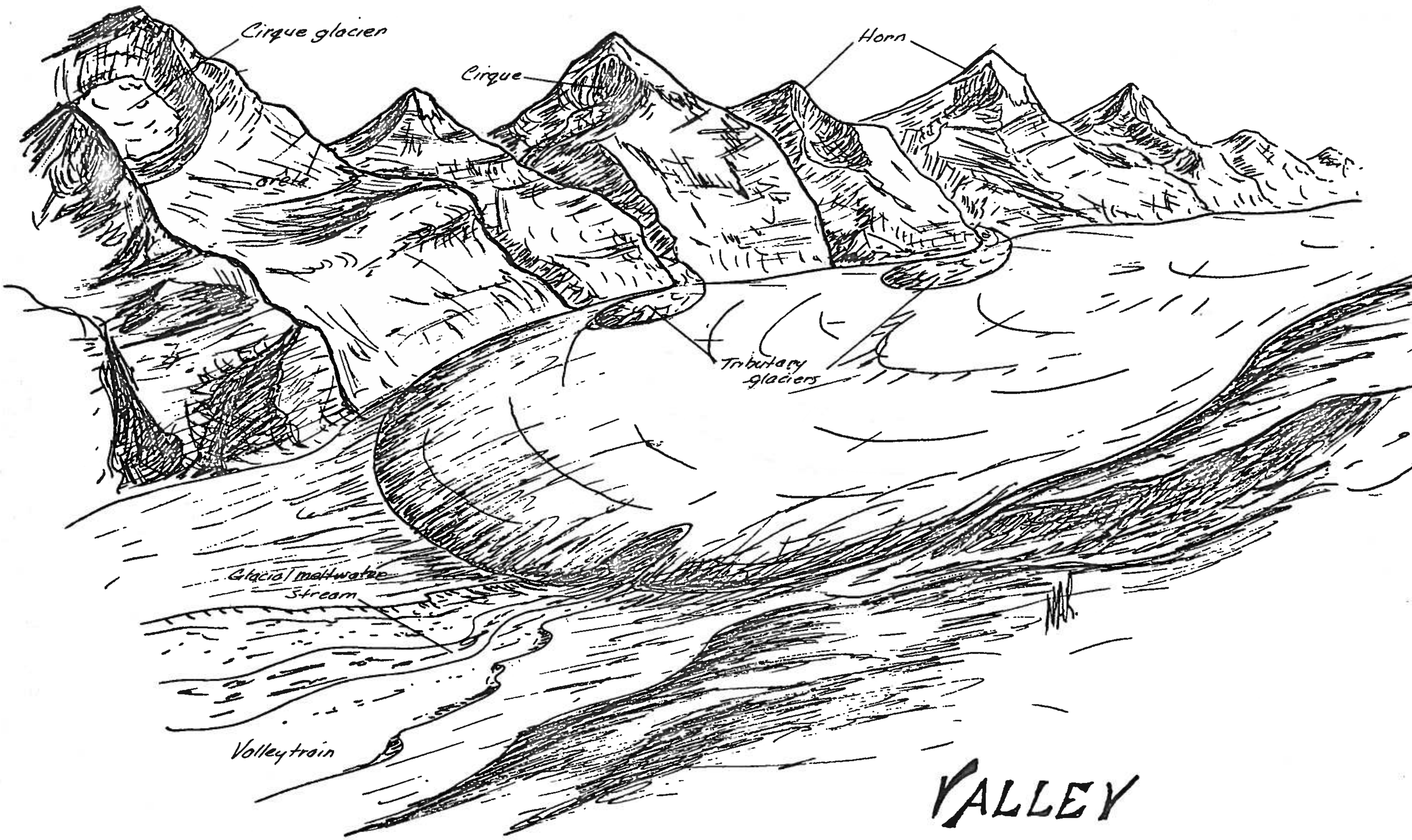
A valley glacier erodes mainly on its sides and on the bottom. Lateral erosion thus ultimately produces a U-shaped valley from an original V-shaped valley. Maligne Valley is an excellent example of a U-shaped valley. Also, small tributary valleys to the Maligne Valley have this shape, signifying their erosion by valley glaciers.

Erosion of a valley bottom by a valley glacier is not uniform, that is, in certain places it may erode a basin many hundreds of feet below the original bed of the pre-glacial stream that occupied the valley. At other locations, at the same time, a valley glacier will not necessarily erode to such a great extent. The result of this action is that after the recession of a valley glacier the U-shaped valley typically has large lakes develop in it, filling the deep basins. Maligne Lake owes part of its existence to the over-deepening of the valley by the former glacier. Small cirque glaciers after recession also show the over-deepening of their base and lakes found in these hollows are called tarns. Unfortunately, tarns, although numerous in the Maligne Lake area, cannot be observed from the highway or from the lake, being situated in the cirque basins well up on the mountain sides.

The larger the valley glacier the faster it erodes. Consequently, small tributary glaciers cannot maintain the fast rate of erosion of the large main valley of glaciers; thus their beds are left perched or high relative to the base of the main valley. Such high valleys are called hanging valleys. Countless examples of hanging valleys are present along the Maligne Valley, as also the Maligne Valley itself is an excellent example of a hanging valley with respect to the Athabasca River Valley.

The rapid undercutting of side walls of the valleys by the glaciers produced unstable conditions and as a result of this numerous and very large rock slides occurred along them. In the Maligne Valley rock slides of tremendous magnitude took place in the past. One of them blocked the Maligne River, thus producing Medicine Lake.

The recession of the main glaciers started probably about 13,000 years ago. The main retreat was fairly rapid, but after most of the ice had disappeared from the Maligne Valley there was a short readvance which deposited the magnificent



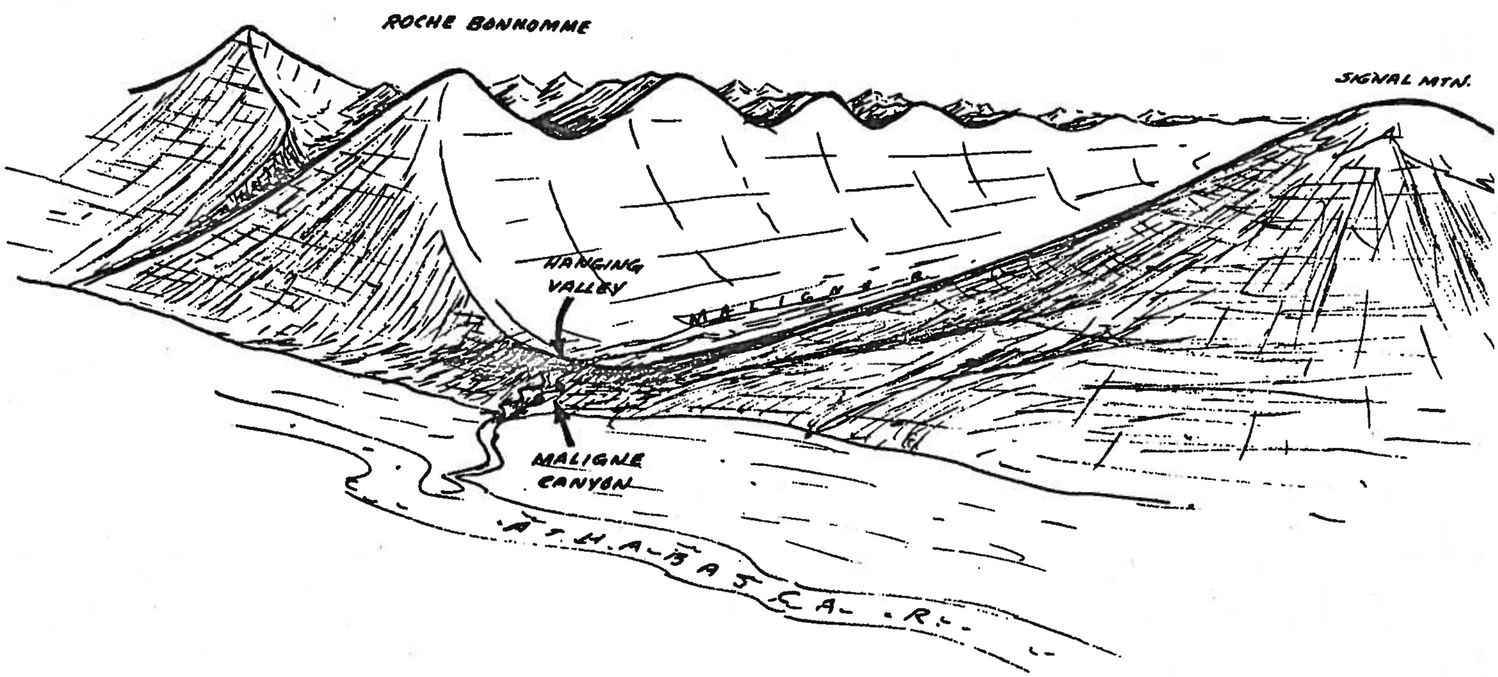
VALLEY GLACIER

typically has large lakes develop in it, filling the deep basins. Maligne Lake owes part of its existence to the over-deepening of the valley by the former glacier. Small cirque glaciers after recession also show the over-deepening of their base and lakes found in these hollows are called tarns. Unfortunately, tarns, although numerous in the Maligne Lake area, cannot be observed from the highway or from the lake, being situated in the cirque basins well up on the mountain sides.

The larger the valley glacier the faster it erodes. Consequently, small tributary glaciers cannot maintain the fast rate of erosion of the large main valley of glaciers; thus their beds are left perched or high relative to the base of the main valley. Such high valleys are called hanging valleys. Countless examples of hanging valleys are present along the Maligne Valley, as also the Maligne Valley itself is an excellent example of a hanging valley with respect to the Athabasca River Valley.

The rapid undercutting of side walls of the valleys by the glaciers produced unstable conditions and as a result of this numerous and very large rock slides occurred along them. In the Maligne Valley rock slides of tremendous magnitude took place in the past. One of them blocked the Maligne River, thus producing Medicine Lake.

The recession of the main glaciers started probably about 13,000 years ago. The main retreat was fairly rapid, but after most of the ice had disappeared from the Maligne Valley there was a short readvance which deposited the magnificent



Sketch of mouth of Maligne River showing hanging valley and distinct U-shaped valley of the Maligne River. The valley is a classical example of a glaciated mountain valley. The sketch is a view towards the east.

moraine and all of the associated features which now form the north shore of Maligne Lake. The retreat from this glacial stage was also signified by stagnation of the glacier. Many excellent examples of landforms produced by stagnation are visible in the area of the north end of Maligne Lake. The morainal deposits of this stage in part block the Maligne River, causing the establishment of the lake behind the moraine. A second stage of advance and stagnation may be represented by Samson Narrows. However, the narrowing of the lake at this point is also due in part to the presence of rock-slide material and to alluvial fans extending out into the lake.

Recent or post-glacial erosion in Maligne Valley is limited to mass action -- or erosion where gravity alone is the main factor -- and to incision of streams. In the first category belong the land slides and rock slides, alluvial fans, and scree deposits. In the second category is the incision of the Maligne River producing the canyon and also local incision at points upstream from there. Small tributary streams show also some post-glacial incision, but not of the same magnitude as the Maligne River, because of a much smaller volume of discharge.

Interpretation of Glacial Deposits North Shore of Maligne Lake

The north end of Maligne Lake and vicinity displays glacial features associated with the terminal moraine of a large valley glacier which flowed down Maligne valley from the Brazeau Icefield in very late glacial or very early post-glacial time. The different features are shown on the large-scale map and comprise the following landforms:

Hummocky moraine, outwash plain, kettle holes, kettle lakes, meltwater channels, valley train, abandoned delta, moulin kames, glacial erratics.

The origin of all of the features can be explained by picturing the snout of a large valley glacier standing in the area and melting or disintegrating in place.

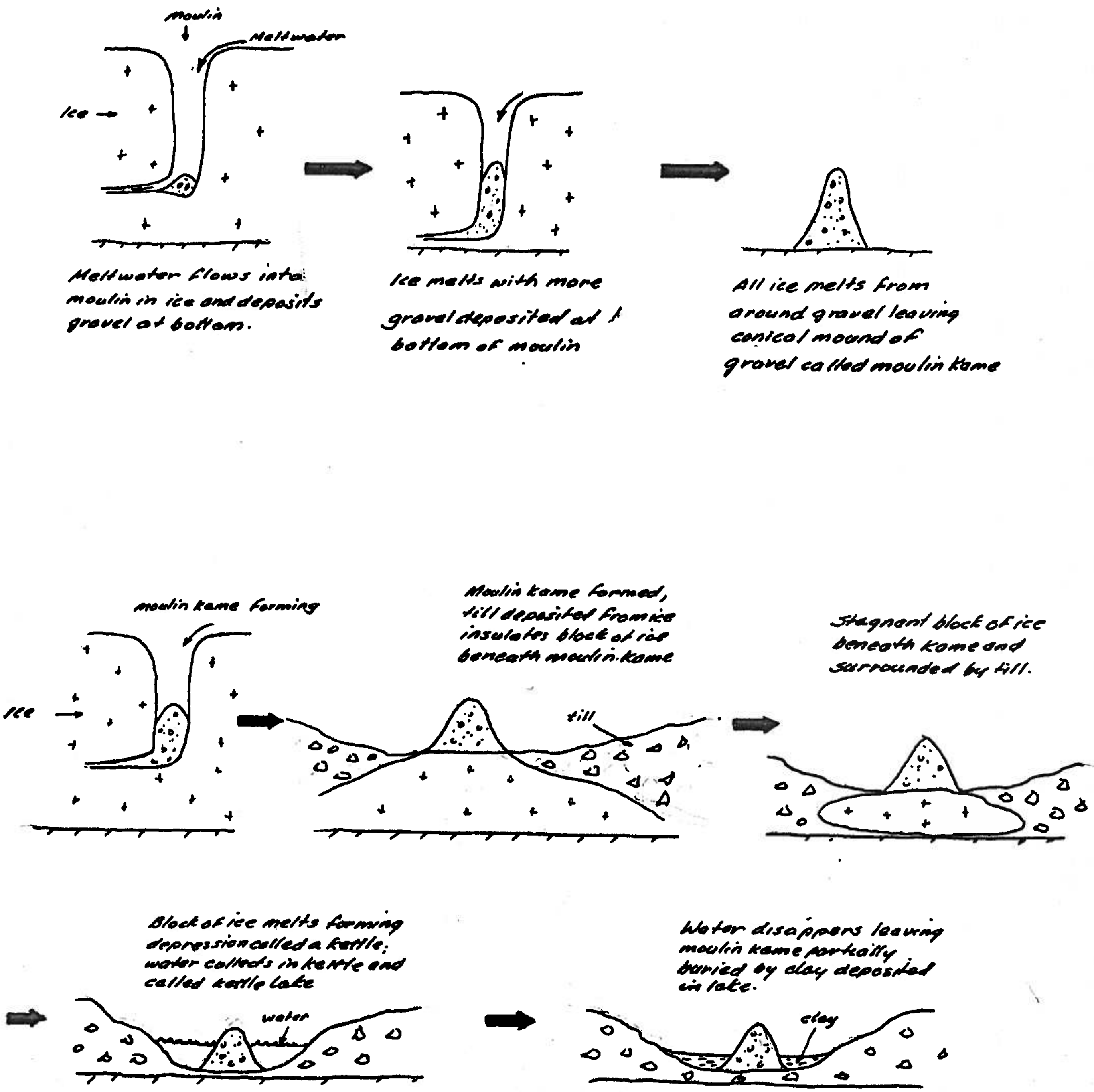
In reality the glacier was formed by the coalescence of two major glacier lobes, a large glacier from the Brazeau Icefield and a smaller one that came down the Maligne River Valley. The combined glacier only partly filled the valley, perhaps up to an elevation of about 6,500 feet and thus it was probably in excess of 1,000 feet thick.

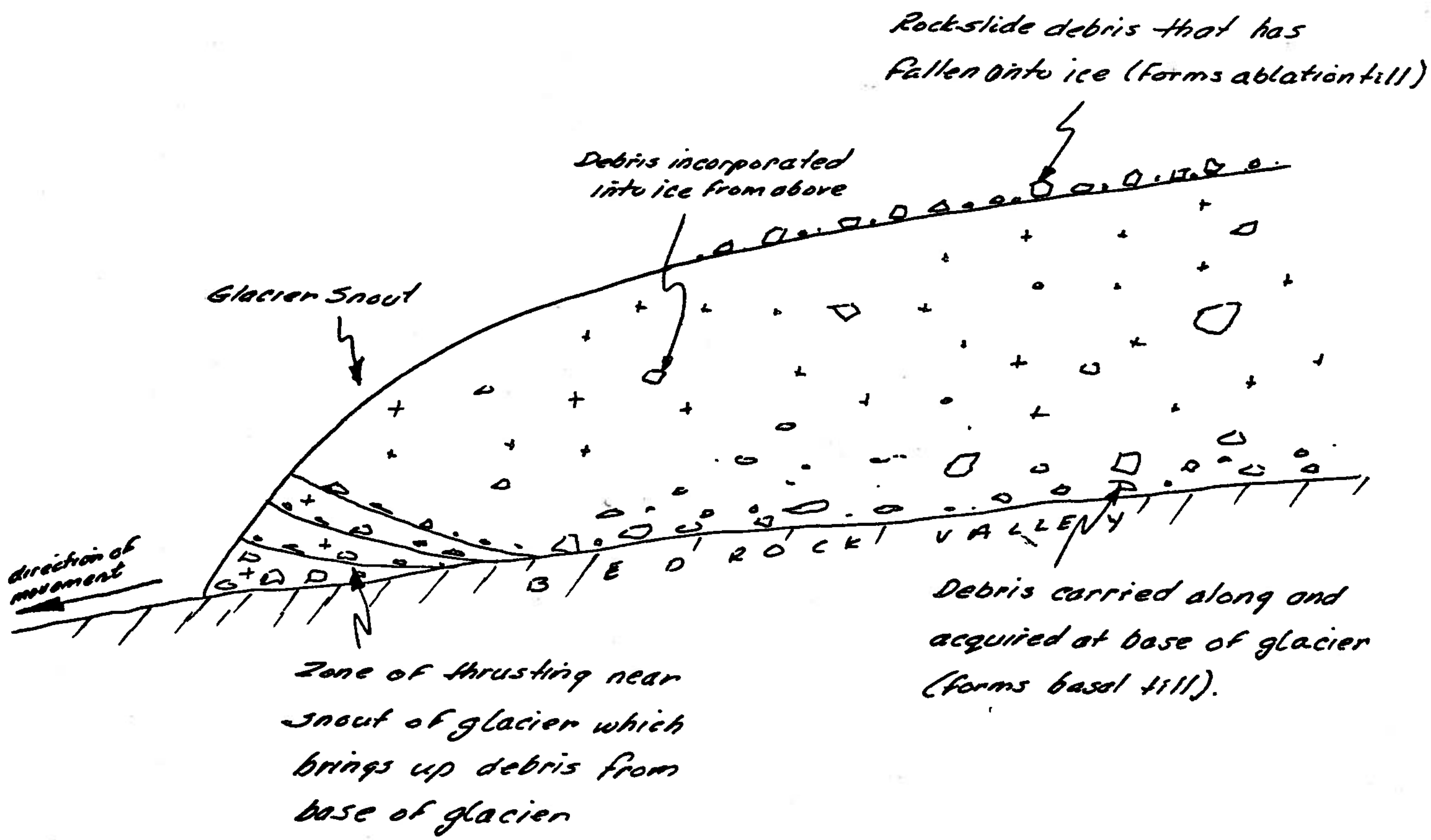
As the glacier melted it produced a large amount of meltwater which flowed out of the terminal part of the glacier where the Maligne River now flows. The volume of the meltwater flow was many times the volume of the present river. As a result a long broad valley train was deposited from this meltwater and this consists of rudely sorted gravel. This valley train is a classical example of deposition from glacial meltwater in a mountain valley.

As the ice melted, more and more debris accumulated on the surface of the glacier until the debris began to insulate most of the underlying ice from from the sun. Then differential melting took place and the surface of the ice became very irregular, with large depressions and mounds of debris similar to a typical karst topography. Material in the ice constantly slumped into depressions as these enlarged with ice melting and these thicker areas of debris now form the numerous till knobs in the area. There were also some open crevasses and moulins on the surface of the glacier into which meltwater was able to flow. When the meltwater carried enough material into the moulin or crevasse, a deposit of gravel was formed at the bottom of it. When the ice later melted completely, these deposits were left as individual high conical mounds of gravel that stand above the surrounding deposits; these mounds are referred to as moulin kames and the ridges as crevasse fillings. At times only till was deposited in the crevasses which implies that the till simply slumped into the crevasse and the resulting deposits are a short discontinuous sharp ridge.

At the end of recession or melting of the glacier in the area, the topography was very irregular due to the differential melting of the glacier and insulating effect of the debris on the surface. But here and there large buried blocks of pure glacial ice still existed beneath the debris or till. When ultimately these stagnant blocks melted, they left deep holes called kettles, the shapes of which reflect the shapes of the buried blocks of ice. Kettles in the area may be up to 125 feet deep. In some of these kettles or depressions, lakes (kettle lakes) formed in which clay and silt was deposited, which at present may be found on the floors of the kettle holes. As a rule the kettle holes of the area do not contain water except in the spring time. In some of the kettle holes, one in particular (see map), small moulin kames can be

ORIGIN of MOULIN KAME, KETTLE, and KETTLE LAKE





DEBRIS IN ACTIVE GLACIER.

moulin kames are 150 feet high and constitute the most spectacular glacial landform in the area. All of the moulin kames are composed of poorly sorted gravel.

Just east of the proposed site of the marina, there is a steep-sided valley which carries very little water at present. This valley or channel was eroded by water from the melting glacier. The sediments carried by the meltwater formed a substantial delta at its mouth in Maligne Lake. This delta, referred to as an abandoned delta, is composed mainly of sand, which in part has been modified to form the sandy beach on the edge of the lake in that locality.

The gigantic blocks of limestone that are abundant in the easternmost portions of the map area are part of a large rock slide that fell onto the glacier before the ice had completely melted. The limestone is of Devonian and Mississippian ages and is derived from the southeastern flank of the Opal Hills. The blocks of limestone constitute a most notable and peculiar feature of the landscape, being distributed more or less randomly over the area outlined on the map.

Notes on Miscellaneous Features of Maligne Valley

Rock Slides:

It has already been pointed out that glaciers have played a major role in the gouging out of the valleys and in rounding of some mountains while undercutting others but other processes of erosion were also very active during the Ice Age. For example, in several places in the Maligne Valley rock slides occurred in glacial times that rival the Frank Slide in magnitude. Large rock masses from the mountain-sides collapsed, perhaps due to undercutting by valley glaciers, and filled the valley below or buried the valley glacier. One such rock slide has aided in the damming of Medicine Lake. This slide is located at the north end of the lake and the highway is built through part of it. All major landslide areas are shown on the accompanying map but it emphasized that these areas are believed to be completely stable at present as the rock slides occurred during the waning stages of glaciation several thousand years ago.

Rock Glaciers:

Another interesting product of the cold climate are the numerous rock glaciers in Maligne Valley. Essentially a rock glacier is composed of angular boulders and rubble perched on the side of a mountain and showing remarkable glacier-like form. They may be over one-half mile in length and are characteristically lobate in outline with concentric lobes or wrinkles, near the terminus, suggesting mass flowage of the boulder rubble in a way somewhat similar to a glacier. The boulders are derived from a cliff at the head of the rock glacier by the freeze-thaw process along fractures in the bedrock. Theories on how a rock glacier actually moves differ slightly but it is generally concluded that there has to be a large amount of interstitial ice between the angular blocks before flowage is possible. The rock glaciers in the area appear to be of two different ages - those that are covered with trees and those that are nearly bare of any vegetation; the former are the older. Although detailed observations of the rock glaciers have not been made, it is believed that most are inactive at present. Only those at very high elevations could be active.

Cirques:

The rugged appearance of the higher parts of the mountains can be explained in many cases by the action of cirque glaciers. Cirques, which are also called corries, are giant armchair-like depressions located on the flanks of mountains or at the heads of valleys that were once occupied by glacier ice. They are present everywhere in the Maligne Valley but are most conspicuous at the south end of Maligne Lake. The cirques are produced by the headward erosion of small glaciers on the sides of mountains.

In areas where cirques are well developed, there are numerous examples of arêtes, cols, and incipient horns, all features related to alpine glacial erosion. Such features are well described in most books on geomorphology or glacial geology.

Origin of Maligne Canyon:

Maligne Canyon, located at the north end of Maligne Valley where that valley connects with the Athabasca River Valley, is a typical development at the mouth of a hanging valley (previously explained). The outlet stream from such a valley rapidly cuts downward immediately above the valley mouth, which is left hanging after glaciation due to the more intensive erosion of the main valley by the main valley glacier, such as the one that occupied the Athabasca River Valley. Underground streams can be observed gushing out of large cavities in the bedrock in numerous places in the canyon and represent, in part at least, some of the water that drains Medicine Lake through the underground channels that exist beneath the landslide that blocks the north end of the lake.

Origin of the Bald Hills:

The origin of the topography of the Bald Hills: that is, why the hills are bald and more subdued than their rugged neighbors across the valley, can be explained by the action of glaciers on the particular rock types. The hills are somewhat lower in elevation than the sawtooth peaks of the Colin Range and are composed mainly of quartzite. The glacier that overran the hills polished or rounded the rocks, thus producing the present bald appearance. A thin layer of till with numerous angular boulders mantles the entire area of the Bald Hills.

Diverted River:

The Maligne River, where it enters Maligne Lake, is flowing in a relatively new channel, on the east side of its old valley. As the glacier melted in this area, a large amount of moraine material was deposited filling the previous valley of the Maligne River and forcing the present river to cut a channel east of the moraine. Such diversions of drainage systems is very characteristic of glaciated terrain especially in mountainous valleys such as Maligne Valley.

Milky Appearance of Maligne Lakes

Apart from Maligne River, all of the streams that flow into Maligne Lake are fed by melting glaciers high in the mountain valleys that border the lake. Glacial meltwater carries a heavy load of very fine particles called "rock flour" derived from the grinding of rocks by the glacier. The rock flour remains in suspension for a long time because of its very small particle size and so settles out very slowly. Over 10 feet of this fine sediment of silt size covers the bottom of Maligne Lake in its northern part. Melting of glaciers in summer is rapid and as a consequence of this the milky appearance of the lake prevails throughout the entire summer.

The light bluish green colour of the water of some of the mountain lakes is usually due to a type of algae - blue-green algae - that thrive in this cool water.

The "Thumb" of Mount Paul: -

Mount Paul was originally called "Thumb" Mountain by Mrs. Mary T.S. Schaffer who first named it after the peculiar thumb-like protuberance that forms the peak. The "thumb" is actually part of a matterhorn or horn carried out by the glaciers and which has had one side removed either by a rock slide or by a valley glacier. This may well be described as half of a horn.

"Tea Kettle" on Top of Charlton Mountain: -

Visible for miles along the valley is a peculiar remnant of erosion high on the shoulders of Mount Charlton, referred to as the "Tea Kettle." The top of the Tea Kettle has never been glaciated and has evolved into its present form by nonglacial erosion of the summit coupled with glacial erosion of the flanks.

Fossil Localities: -

Fossils can be found by careful search in almost every rock outcrop on the east side of Maligne Valley, although they are generally quite rare and may well be missed by the untrained eye. The most prolific rocks in terms of fossils are the Mississippian, and somewhat less so the Devonian strata, the distribution of which is shown on the accompanying geological map. The most common types of fossils are brachiopod shells, single and colonial corals, and fragments of crinoids (sea lilies). No easily recognizable fossils are to be found on the west side of the Maligne Valley, as the rocks there are either too old or the wrong composition to contain fossilized animal remains. Fossils are quite rare in the Cambrian and Ordovician rocks around the south half of Maligne Lake, but locally fairly prolific thin fossil bands may be found.

Vertebrate Remains: -

In 1960, Mr. Charles Whitton, a National Parks employee, discovered a buffalo skull in an old alluvial fan on the east side of the Maligne River (Locality 6). Other buffalo skulls have also been reported from the mountains: Mr. Mac. Elder, Warden of the Maligne Lake District, reports finding a number of buffalo skulls in the Brazeau River country south of Maligne Lake. Thus, buffalo must have invaded even remote mountain valleys such as the Maligne Valley in the not too distant past. Presumably these buffaloes were wood buffalo (Bison bison athabascae) and not the plains buffalo (Bison bison bison).

Cold Sulphur Springs: -

A cold sulphur spring exists one mile northwest of the north end of Medicine Lake in the near-dry bed of Maligne River. The water of the spring is carried to the surface along a fracture in the bedrock related to a fault.

Brief History of Maligne Lake

It has been reported that the discovery of the Maligne Valley, as far as the white man is concerned, dates back to the curiosity-inspired wanderings of Mrs. Mary T.S. Schaffer and company in the summer of 1908. Tales of a magnificent lake nestled in the mountains reached Mrs. Schaffer's eager ears throughout her travels in the Canadian Rockies. While visiting some Stony Indian friends in 1907 she was fortunate in receiving precise directions to the lake. She describes the incident in the following manner:

> "One of the greatest trophies we carried with us when leaving the next day for the North Fork of the Saskatchewan was a tiny, grubby, bit of paper on which Samson (Samson Beaver, a Stony Indian) had with much care traced the lake we had tried so hard to find, which was supposed to lie north of Brazeau Lake. He had been there but once, a child of fourteen, and now a man of thirty, he drew it from memory, mountains, streams, and passes all included." (p. 183, Old Indian Trails by Mrs. Mary T.S. Schaffer).

Thus the following summer of 1908 Mrs. Schaffer and her determined and adventurous party set out to find the long-sought lake. They approached Maligne Lake by way of Poboktan Pass up Poboktan Creek and finally over Maligne Pass. The first sighting of the lake was made from Mount Unwin. Mrs. Schaffer makes the following comment in her book:

> "Indians, of course, had been there, but, unless a prospector or timber-cruiser has come in by way of the Athabaska River, we had reason to feel that we might be the first white people to have visited it."

Mrs. Schaffer was apparently wrong in believing her party was the first to discover the lake for Mr. Henry A.F. McLeod, a surveyor for the Canadian Pacific Railway, explored the lake in 1875 while on company duty. He named it Sorefoot Lake but the name Maligne Lake dates back to 1846 at least and it was so named in 1911.

Place Names

The origin of place names is a question that many people ask when visiting a new area, especially if the area is a National Park. The following account is a compilation of the known origin of place names in Maligne Valley but, unfortunately, does not include all of the named physiographic features in the area.

Roche Bonhomme - Resembles a man's face - mentioned in Grant's Ocean to Ocean (1873).

Mount Charlton - Named by Mrs. Schaffer after H.R. Charlton, then General Advertising Agent for the Grand Trunk Pacific Railway.

Curator Mountain - Named from its position of custodian of Shovel Pass (name of Pass suggested by Mrs. Schaffer who found snow shovels in the Pass).

Llysfran Peak - Named by Mrs. Schaffer after a "family name" of her companion Miss Mary Vaux.

Leah Peak - Named by Mrs. Schaffer after the wife of a Stony Indian, Samson Beaver.

Opal Hills - Locally named apparently after the everchanging color hues of the rocks that compose the mountains.

Maligne - River, lake and mountain. In 1846 Father deSmet refers to "Maligne" river, the name is French for bad; was originally applied to the river which was so known in 1846. H.A.F. McLeod who explored the lake in 1875 on C.P.R. surveys named it Sorefoot Lake. The name Maligne Lake was applied in 1911.

Mount Mary Vaux - Named by Mrs. Schaffer in 1911 after Miss Mary Vaux, who, like the other members of her family, had taken great interest in the Canadian Rockies.

Medicine Lake - Named in 1875 by H.A.F. McLeod, a C.P.R. surveyor. Probably reflects the belief of the early indians that the lake was either "good medicine" or "bad medicine" due to the lake's fluctuating water level.

Mount Paul - Named by Mrs. Schaffer in 1911 after Paul Sharples, the first white child to go into the Maligne Lake country; he made all the climbs and was only nine years old.

Mount Unwin - Named by Mrs. Schaffer after her second guide, Sidney Unwin, who climbed to the top of the mountain and first sighted the Maligne Lake.

Samson Peak - Named by Mrs. Schaffer in 1911 after a Stony Indian, Samson Beaver, who drew a map that enabled her to find Maligne Lake.

Mountain Warren - Named by Mrs. Schaffer after her chief guide.

Bibliography

Alberta Society of Petroleum Geologists, 1955: Guide Book, Fifth annual field conference; Jasper National Park: A.S.P.G.

Allan, J.A. and Warren, P.S. and Rutherford, R.L., 1932: A preliminary study of the eastern ranges of the Rocky Mountains in Jasper Park, Alberta: Trans. Roy. Soc., Canada, Sec. IV, P. 225-248.

Baird, David M., 1963: Jasper National Park, Behind the Mountains and Glaciers; G.S.C. Misc. Rep. No. 6.

Burwash, E.W.J., 1920: Geology of the Canadian Rockies; Canadian Alpine Jour., Vol. 11, P. 97-109.

Coleman, A.P., 1911: The Canadian Rockies; Fouede, Toronto.

Dawson, G.M., 1881: Report on an exploration from Port Simpson on the Pacific Coast, to Edmonton on the Saskatchewan, ...; Geol. Surv. Can. Rept. of Progress, 1879-80; Sec. B, 177 pages.

Dowling, D.B., 1913: Annotated guide; Tofield, Alberta to Tete Jaune, British Columbia; Geol. Surv. Can.; Guide Book No. 9, Transcontinental Excursion, P. 132-142.

Dowling, D.B., 1918: The pioneers of Jasper Park; Trans. Roy. Soc., Can.; Sec. 11, 1917, P. 241-252.

Edmonton Geological Society, 1964: Sixth Annual Field Trip Guide Book, Medicine and Maligne Lakes; E.G.S. Edmonton, Alberta.

Franchere, Gabriel, 1854: Narrative of a voyage to the northwest of America; translated by J.V. Huntington, Redfield, New York.

Grant, G.M., 1873: Ocean to Ocean; J. Campbell and Son, Toronto.

Grey, C.E., 1951: Cyclic sedimentation, Dessa Dawn and Rundle Formations, Mississippian, Banff and Jasper Parks, Alberta; unpublished Ph.D. thesis, Univ. of Wisconsin.

Hector, J., 1863: Journals of the exploration of British North America, London.

Heusser, C.J., 1956: Postglacial environments in the Canadian Rocky Mountains; Ecological Mono., Vol. 26, P. 263-302.

Kindle, E.M., 1929: The geologic story of Jasper National Park, Canada: Ottawa Dept. of Interior, National Parks of Canada, 48 pages.

Mackay, B.R., Geology of the National Parks of Canada in the Rockies and the Selkirks; reprinted from the Can. Geograph. Jour.

Mackay, B.R., 1941: Brazeau map-area, Alberta; Geol. Surv. Can. Paper 41-4.

McEvoy, James, 1901: Report on the geology and natural resources of the country traversed by the Yellow Head Pass route; Geol. Surv. Can. Ann. Rep. (1898), Vol. 11, Sec. D, 44 pages.

McNaughton, M., 1896: Overland to Cariboo; Wm. Briggs, Toronto.

Milton, W.F., and Cheadle, W.B., 1865: Northwest passage by land; Cassell, Petter and Galpin, London.

Mountjoy, E.W., 1960: Miette, Alberta; Geol. Surv. Can. Map 40 - 1959.

Mountjoy, E.W., 1964: Rocky Mountain Front Ranges between Rocky River and Medicine Lake, Jasper National Park, Alberta; Edmonton Geological Society Sixth Annual Field Trip Guide Book, P. 1-13.

Odell, N.E., 1948: The traverse of Mount Colin and other climbs in 1947; Can. Alpine, Jasper National Park, Alberta, Canada; ibid, Fifth Guide Book, P. 69-116.

Ogilvie, William, 1884: Report by William Ogilvie, D.L.S., 1884 (-- on my survey of the Athabasca and Peace River Valleys; Can. Dept. of Interior Ann. Rep. 1884, Pt. 11, P. 46-56.

Palmer, H., 1924: Climbs in the Maligne Lake district; Reprinted from Alpine Jour. No. 228, London; Spottiswoode.

Sanderson, J.O.G., 1939: Geology of the Brazeau area; Trans. Can. Inst. Min. Met., Vol. 43, P. 429-442.

Schaffer, Mary T.S., 1911: Old Indian Trails; Toronto; William Briggs, New York; C.P. Putnam and Sons.

Sherzer, W.H., 1907: Glaciers of the Canadian Rockies and Selkirks; Smithsonian Contributions to Knowledge, Vol. 34, No. 1.

Thompson, David, 1916: David Thompson's narrative, edited by G.B. Tyrrell; The Champlain Society, Vol. 12.

Thorington, J. Monroe, 1953: A climber's guide to the Rocky Mountains of Canada; Revised edition: The American Alpine Club.

Wallace, J.N., 1925: Southesk's journey through the west: Geographical Journal, Vol. 66, P. 246.

Wheeler, A.O., 1912: The Alpine Club of Canada's expedition to Jasper Park, Yellowhead Pass and Mount Robson region, 1911; Canadian Alpine Journal, Vol. 4, P. 1-83.

Maligne Valley looking southeast from the top of the Colin Range at the south end of Medicine Lake.

Plate 1. Famous view of the south end of Maligne Lake taken from view point at the Narrows. Samson Narrows have formed mainly by the deposition of a large amount of hummocky moraine from valley glaciers.

Plate 2. View of receding valley glacier, with Mount Mary Vaux in background. Photograph taken looking directly southwest. Llysfran Peak on the far right. Rocks forming the mountains are composed of dense limestone of Cambrian age.

Plate 3. View of east-flanking massifs of Llysfran Peak. Charlton Peak on far right. Photograph taken looking due west. Note large gouges in sides of mountains caused by erosion by hanging cirque glaciers that have now melted away. The mountains are composed of Cambrian limestone, except for the top part of Mount Charlton which is made of Ordovician limestone.

Plate 4. View looking east up Sandpiper Creek towards Maligne Glacier; note spectacular ice fall. Sawtooth peak on the right is part of the Maligne Mountains and is composed of Devonian and Mississippian limestone. Far left is the western flank of Samson Peak.

Plate 5. View looking southwest at Charlton Glacier; Mount Charlton in background and Mount Unwin at the far right. Note sharp crested lateral moraine to the left of the valley which was deposited by a glacier during its maximum advance. The moraine is ice-cored.

Plate 6. General view of Maligne Range looking northwest across the proposed campground. Curator Mountain is the high peak in the center of the photograph and is composed of Precambrian quartzites. (Locality 16)

Plate 7. Photograph of a former broad kettle lake with small moulin kames protruding up through the lake deposits. Leah Peak, in the background, is composed of limestones which are Mississippian to Devonian in age. The man in the lower left corner of the photograph indicates scale. (Locality 13)

Plate 8. Another photograph of a basin of a former kettle lake situated in an area of hummocky moraine and covered by dense forest. Many large limestone erratics are present here. Man to the left of the large erratic indicates scale. The snow covered mountains in the background are Opal Hills. (Locality 12)

Plate 9. Snow-covered prominence of Opal Peak is in sharp contrast to deep green of the forest in the foreground. Photograph taken from the north shore of Maligne Lake. (Locality 15)

Plate 10. The top part of a large moulin kame which is situated about 1.5 miles west of the Warden's Cabin at the north end of Maligne Lake and to the north of the Bald Hills lookout road. The kame is about 150 feet high. The man in the treeless patch to the right center indicates scale.

Plate 12. View looking west across the north end of Medicine Lake showing the coarse angular blocks of Devonian limestone that comprise the rock slide at this end of Medicine Lake. For scale note the jeep between the two large boulders on the right of the photograph. The Maligne Range, composed of Precambrian quartzite, is in the background. (Locality 7)

Plate 13. View looking north from the south end of Medicine Lake. This photograph was taken in September 1964, and shows the low level of Medicine Lake at this time of year. The rock slide that dams the lake is visible in the middle of the valley. The scar of the landslide is evident on the mountainside to the east. (Locality 18)

Plate 14. This large, angular limestone block is typical of the boulders associated with the rock slides in the Maligne Valley. The rock slides are believed to have taken place during glacial times when valley glaciers occupied much of the area. (Locality 10)

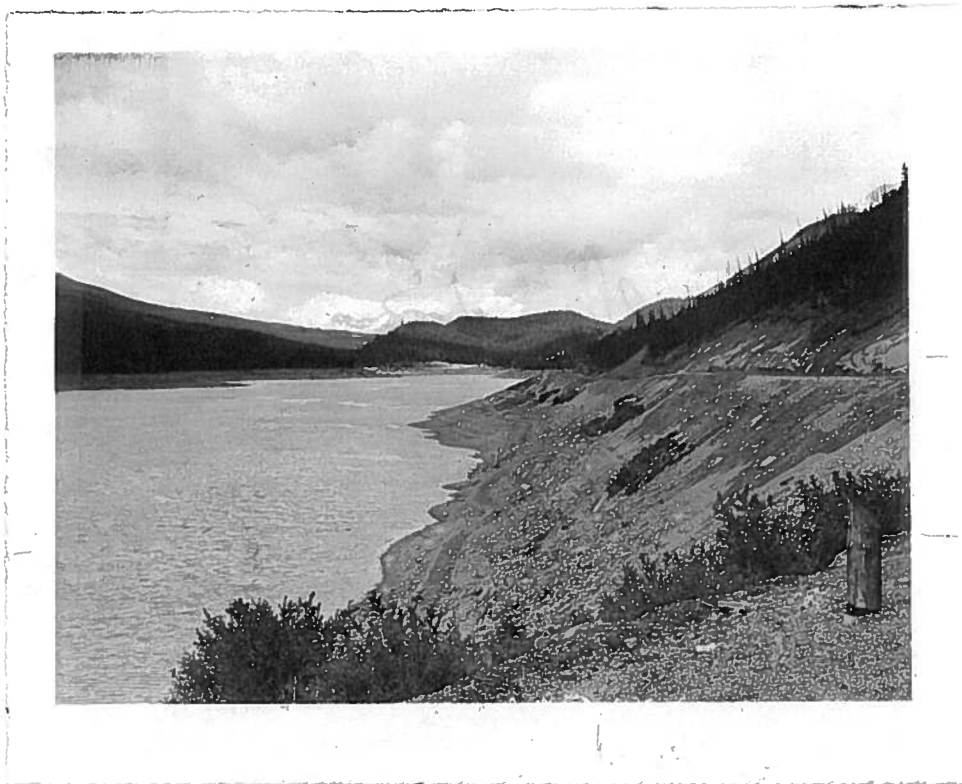


Plate 15.

Plate 16. Roadcut at the north end of Maligne Lake showing the composition of the hummocky moraine that is the surficial deposit of the area. The hummocky moraine is composed of glacial till which in this case can be separated into two units. One is an upper layer composed of large blocks of limestone and representing material that fell onto the glacier from valley sides -- this is called ablation till. The second type is the basal till which has been incorporated into ice at the base of the glacier from the underlying bedrock. In this case the basal till is composed of Triassic siltstone. (Locality 20)

Plate 17. (Same as Plate 8) Note the small hummocks in the foreground -- these are typical of alpine meadows and are due to a freeze - thaw process that disrupts the soil to form these characteristic features. (Locality 12)

Plate 18. Photograph taken from same location as Plate 7. The man (Mr. "Mac" Elder, Warden of Maligne Lake District), indicates scale.

Plate 19. Photograph from the same location as Plate 10, showing the large moulin kame composed of gravel. The man in the treeless patch on the right indicates scale. (Locality 11)

Plate 20. This is an embankment cut in glacial till on the new road to Maligne Lake. The photo is taken looking southeast. This type of till is subject to small earth flows which occur during abnormally wet periods. Striated limestone boulders which are typical of glacial till can be found at this locality. (Locality 21)

Plate 21. View of the top part of Two Creek Valley Canyon cut into Devonian limestone. The canyon is quite deep in places upstream from this location and may constitute an enjoyable scenic hike as it displays almost vertical walls and is very narrow. (Locality 4)

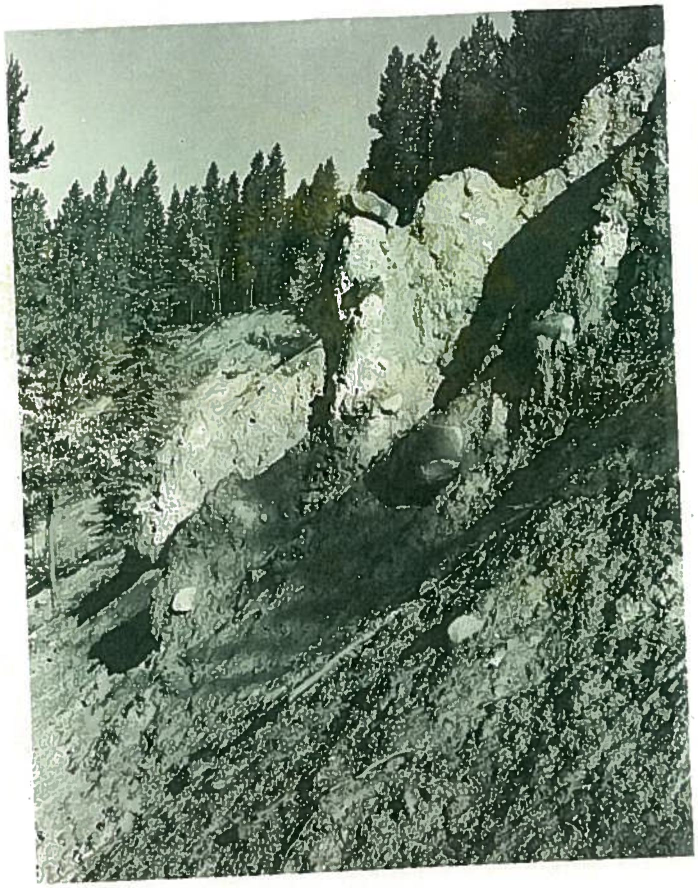


Plate 22. Hoodoos in glacial till on the east side of Maligne River between Medicine Lake and Maligne Canyon.. The hoodoos form as a result of gradual erosion of glacial till rich in lime. Photograph is taken looking north. Note the geological hammer at the base of the hoodoo, in the center of the photograph. (Locality 3)

Plate 23. Pothole eroded in Devonian limestone at a high stage of the Maligne River. Photograph is taken just to the north of Medicine Lake in the near-empty bottom of the Maligne River. Pothole is formed by water rotating pebbles and boulders in a circular fashion against the rock wall. Boulders can be found in the bottom of all of the potholes. (Locality 22)

The following nine photographs show a panorama of mountains visible from the north end of Maligne Lake. The photographs start at the Opal Hills in the east and continue southward around to the Bald Hills in the west.

The first five photographs were taken from the Warden's Dock; the others were taken from a point in front of Brewster's Lodge at the north end of Maligne Lake.

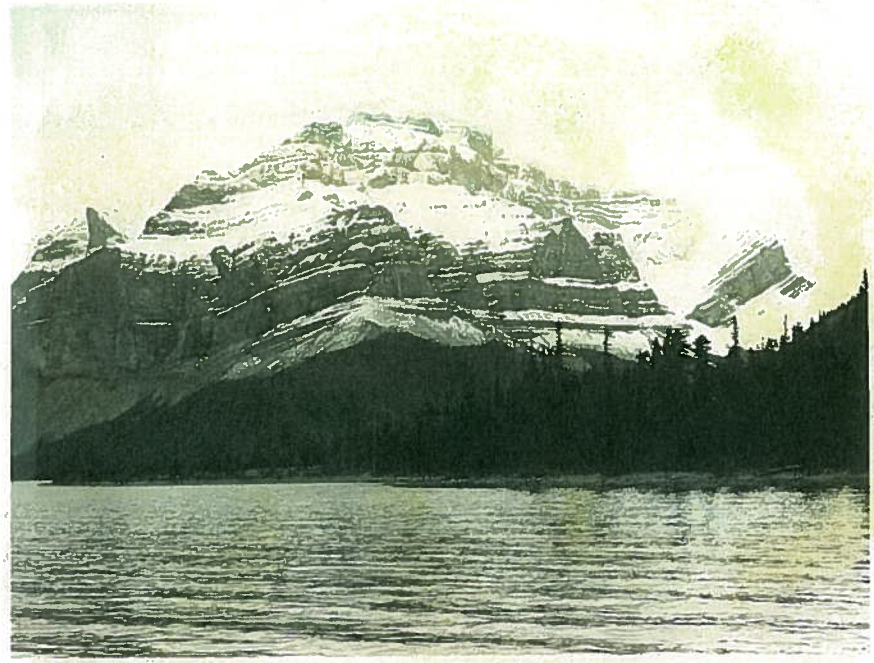


Plate 24. Majestic Monkhead guarding the south end of Maligne Lake. The top and shoulders are in the clouds which obscure the icecap on top of the mountain. The castellate appearance of the mountain is caused by erosion by snowfalls mixed with rock debris that cascade down the mountainside in narrow gullies in the springtime. In the foreground is a large tree-covered alluvial fan composed of gravel that has been deposited by glacier-fed Coronet Creek.

Plate 25. Hummocky moraine in the foreground and the terminal part of the Opal Hills in the upper right. (Locality 14)

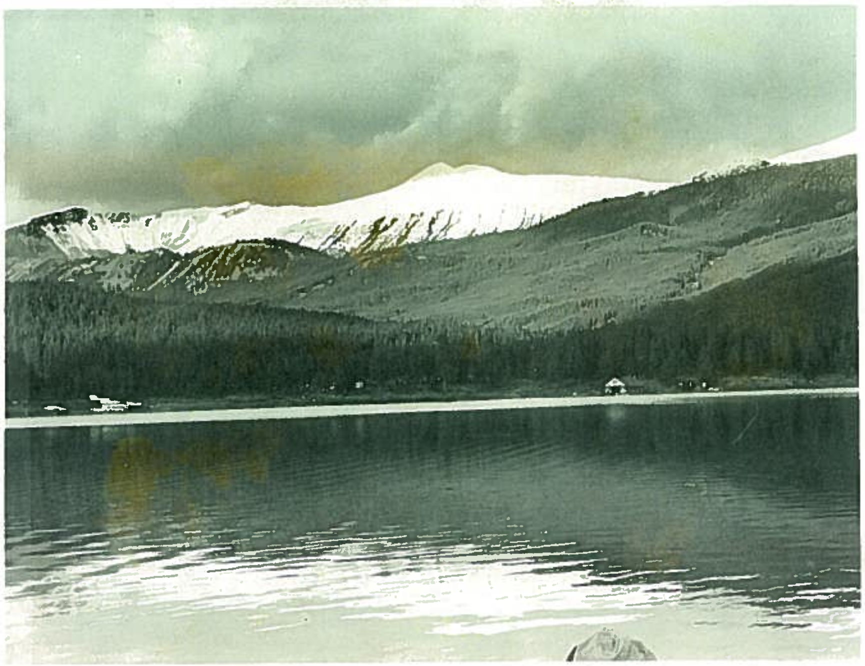


Plate 26. The snow-clad Opal Hills -- Opal Peak on the far right. The tree-covered area is composed of lateral moraine material deposited at the side of a glacier which once occupied the valley. (Locality 14)

Plate 27. The Opal Hills in the background and Opal Peak to the far left. Lateral moraine in the foreground. (Locality 14)

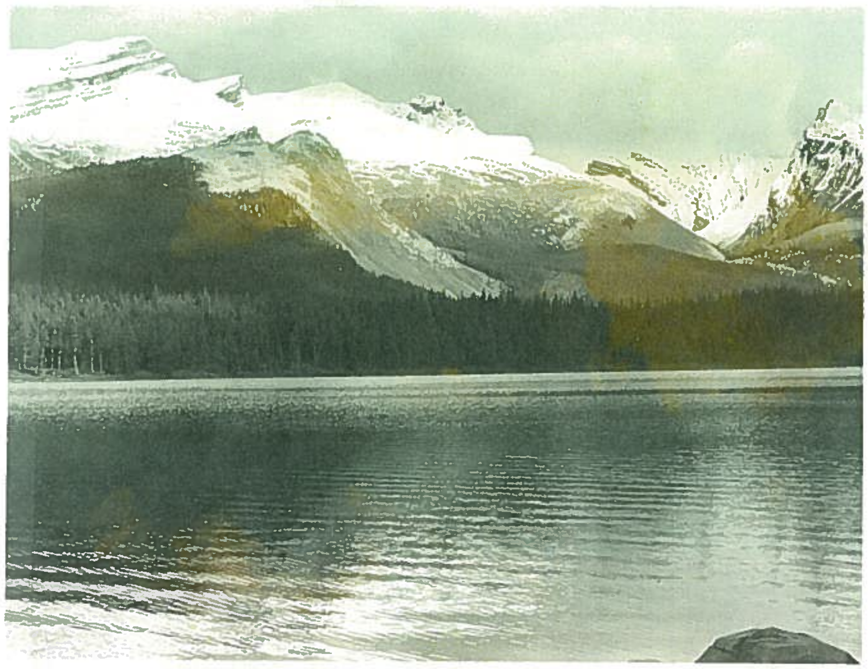


Plate 28. Opal Mountain on the left and Leah Peak on the right. All of these mountains are composed of Devonian and Mississippian limestone. The beds of limestone in Leah Peak have been complexly folded during the uplift of the Rocky Mountains about 40 million years ago. In the center of the photograph is a rock slide scar -- the rock slide occurred during glacial times and the debris can be seen on both sides of Maligne Lake in the vicinity of Lousy Bay. (Locality 14)

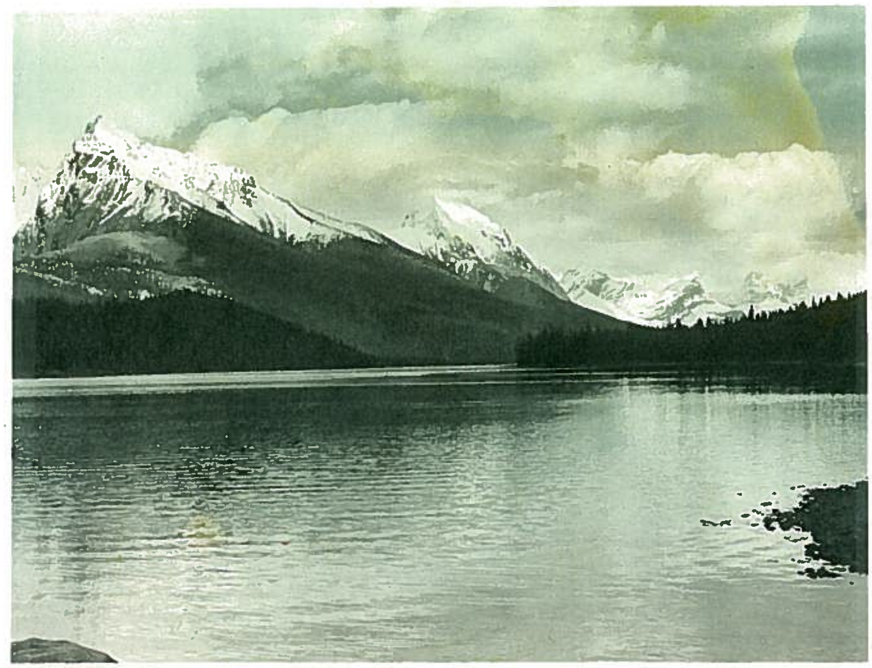


Plate 29. From left to right: Leah Peak, Samson Peak (composed of Devonian limestone) and Mount Paul, capped by clouds. The tree-covered area on the left is rock slide debris and glacial till. (Locality 14)

Plate 30. In the center of the photograph is Mount Paul, composed of Cambrian and Ordovician limestone. To the right and shrouded in clouds is Mount Charlton; Mount Unwin is on the extreme right. Note the "tea kettle" on a shoulder of Charlton Mountain. (Locality 15)

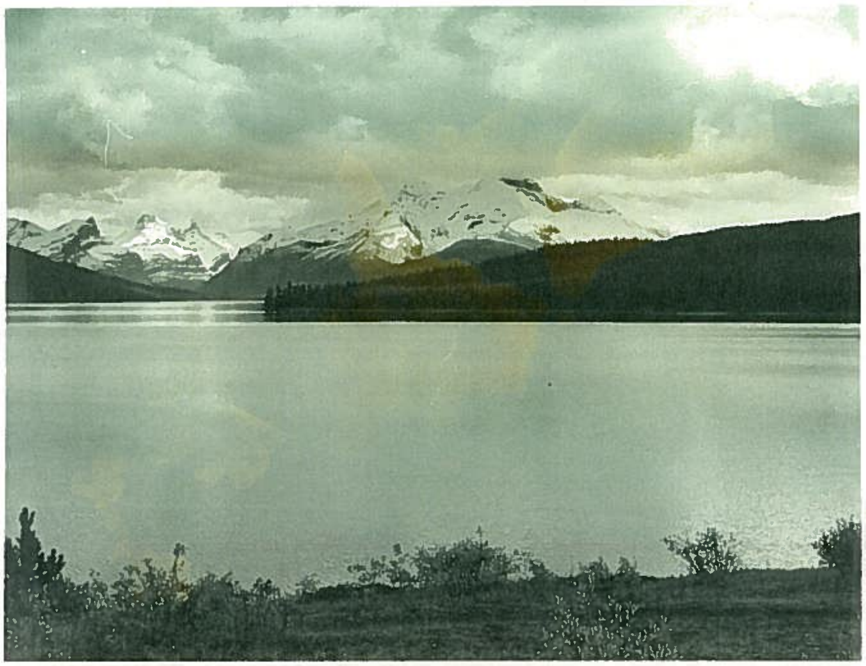


Plate 31. In the center of the photograph is part of Mount Charlton and the north part of Mount Unwin. The mountains have a number of peaks, all of which are composed of limestone of Cambrian to Ordovician in age. The tree-covered area in the middle ground is hummocky moraine deposited by a glacier that once occupied the valley. (Locality 15)

Plate 32. Photograph looking southwest, showing the subdued outline of the snow-covered Bald Hills. The hills are composed of quartzite and have been severely eroded by large glaciers which passed over them, smoothing them off and thus giving them a "bald" appearance today. (Locality 15)