the natural and human history of banff national park
FOREWORD

This report on the natural and human history of Banff National Park was first produced as a pilot project of Parks Canada under the title Book of Banff as a basic reference manual for park guides who operate in the park. Over the past two years, it has proven to be very useful, and is now also in the possession of park staff, interested parties.

In six chapters, this report gives a broad overview of the park. Information on the flora, fauna, geology, glaciology, history and policies of the park has been included. For those interested in further detail, a list of selected references can be found at the end of each chapter.

Due to financial restraints, this second edition has been produced in a very different format. No photographs, maps, or diagrams have been included. We hope that work will soon begin on a revised and improved version; with any improvements.

Any comments or suggestions are most welcome. Please address all correspondence to:

The Superintendent
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FOREWORD

This report on the natural and human history of Banff National Park was first produced as a pilot project of Parks Canada under the title *Book of Banff* as a basic reference manual for tour guides who operate in the park. Over the past two years, the report has proven to be very useful not only to tour guides but also to park staff, students and many other interested parties.

In its six chapters, this report gives a broad overview of Banff National Park. Information on the flora, fauna, geology, glaciology, history and policies of the park has been included. For those interested in further detail, a list of selected references can be found at the end of each chapter.

Due to financial restraints, this second edition has been printed with only minor revisions to the original text. Some inaccuracies, and errors, may still remain. However, we hope that work will soon begin on an updated and improved report with many more illustrations.

Any comments or inquiries about this report are most welcome. Please address all correspondence to:

The Superintendent,
Banff National Park,
Box 900,
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Attn: Chief Park Naturalist
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**Table Diagram:**

[Map of the area with key locations and references]
flora
For many years biologists have been attempting to identify and classify the vegetation zones which exist in the western mountains. While it is obvious that certain tree species are found at particular altitudes, there is much overlap and the change in forest type is gradational. Altitude, of course, is not the only factor determining what plants grow where. This is determined by a complex of historical factors, (mountain uplift, glaciation, fire), and environment factors (temperature, precipitation, amount of sunlight, exposure, soil type, and competition among plants).

Factors Determining Vegetational Zones

Historic Factors

Distant past events such as mountain building and glaciation caused widespread extinction and migration of plant species. This has determined to a certain extent the types of plants found here today. After the ice ages, most of the colonizing plants moved in from small areas called "refugia" which had not been glaciated, such as the Cypress and the Porcupine Hills. Post-glacial changes in climate have also caused back and forth migrations of plant species. For example, during the Altithermal, a warm dry time between 4,000 and 8,000 years ago, grasses from as far away as Mexico became established in Alberta. The Rocky Mountains were a major geographical barrier and very few species have migrated over them. For example, in Alberta, there is very little Red Cedar, Ponderosa Pine, or Devil's Club, although these species, in Alberta, there is very little Red Cedar, Ponderosa Pine, or Devil's Club, although these species

Environmental Selection

Once the potential flora has been determined by past events, the actual flora is determined by environmental selection. Through this process, the plants that are best adapted to a particular habitat survive and the rest are eliminated or move to a different habitat. Wherever the same habitat occurs, there will be a similar grouping of plant species.

Competition

Plants react not only to the physical environment, but also to one another. They are competing for light, moisture, nutrients and space. The species which can compete best in that environment will predominate; those with poorer competitive ability will be less abundant.

Dominant Species

The one or two species that are best adapted to compete in a particular habitat are the dominant species. These have the greatest amount of ground cover and influence all the other plants that grow around them.

Climax

If a dominant species is able to reproduce and regenerate itself in a particular area it is known as a climax species. Vegetation zones are identified by their climax species.

Plant Succession

Plant succession is a gradual change in composition over a period of time. Few habitats are constant; the environment is also changed by the plants that grow in it. Plant succession occurs during the colonization of all barren areas. A typical successional sequence on bare rock would be:

lichens mosses herbs shrubs forest

Forest succession is most obvious after a disturbance such as an avalanche or forest fire. There are many good examples in the Bow Valley. "Pioneer" species such as trembling aspen or lodgepole pine are the first trees to colonize the area. However, these light-loving trees cannot grow in their own shade, so cannot reproduce themselves. Spruce, Douglas fir, or subalpine fir invade the forest, and eventually the pioneer trees die out. This is an extremely slow process that may take about 200 years. Most of the lodgepole pine in the Bow Valley is presently 80-90 years in age. Douglas fir, spruce, and subalpine fir are the "climax" tree species in the park because they are able to reproduce themselves by growing in their own shade. Once established, a climax forest will remain stable in composition unless it is again interrupted by fire or other disturbances.

Successional changes also affect the abundance of herbs, grasses and shrubs. The early stages of forest succession provide food for a wide variety of birds and animals, and may be critical as winter range to some species. On the other hand, a mature forest provides protection from predators and heavy snowfall. Optimum conditions for most wildlife appear to include a variety of plant species and a range of successional stages.

Vegetation Zones

On the basis of all these factors, the vegetation of Banff National park has been divided into three major zones — the Montane Zone, the Subalpine Zone, and the Alpine Zone. Each of these has characteristic climax species by which it can be identified.

Within a zone, the plants are organized into small communities as a result of local habitat factors such as direction of slope, coarseness of soil, height of water table, and depth of snow.

The Montane Zone

The montane zone usually occurs at elevations of less than 1370 metres (4,500 feet), but in Banff Park, it occurs on warm dry southwest facing slopes at slightly higher elevations. The soil in these areas is well drained and often has a base of glacial till.

Douglas fir is the climax tree of this zone. The Douglas fir is found in open savannah-like stands interspersed with grassland. Because if its thick bark, the Douglas fir is generally quite resistant to fire. Ground fires were once common in the montane zone.

Generally, successional forests of trembling aspen and lodgepole pine occur throughout the montane zone in areas where there has been a particularly high frequency of fire. Limber pine can be found on exposed rocky outcrops at low elevations (for example, at the Hoodoos Lookout). Juniper, shrubby cinquefoil and bearberry are found among the grasses in the understory and the common wildflowers include prairie
White spruce is found from the valley bottoms to about the Subalpine Zone. Grasses are abundant and the animals can easily dig through the snow to obtain them.

The Subalpine Zone

Most of the forested area of Banff National Park is in the subalpine zone. These dense forests occur from valley bottom to timberline. The climax tree species of this zone are spruce and subalpine fir. White spruce is found from the valley bottoms to about 7,000 feet and Engelmann spruce from 6,800 feet to 8,000 feet. These two trees hybridize readily and many of the spruce are actually intermediate forms.

The main pioneering tree of the lower part of this forest is the lodgepole pine. The dense stands of lodgepole pine along the highways, especially west of Eisenhower Junction, are the result of fires associated with railway construction in the 1880's. Balsam poplar and black cottonwood are successional along riverbanks and trembling aspen is present on well-drained and drier areas. Eventually, all of these successional trees may be replaced by the dominant spruce. Typical undergrowth in the lower subalpine include grasses, horsetails, labrador tea, false azalea, and buffalo berry. The calypso orchid, Indian paintbrush, and heart-leaved arnica are common flowers.

Upslope from the valley bottom, Engelmann spruce and subalpine fir become more common. Subalpine fir is well-established at elevations over 6,500 feet. Two trees, the alpine larch and the whitebark pine, occur only at timberline. Typical undergrowth in the upper subalpine includes feather mosses, heathers, and grouseberry. Arnica, bunch berries, twineflowers and glacier lilies are common flowers.

The subalpine forest provides habitat for a host of animals. The black bear, the red squirrel, and the pine marten are typical inhabitants; deer, elk and moose use it for shelter in summer months.

Temperature Inversions

In some valleys at high elevations, the slopes of the valley are forested while the valley bottoms are not. Good examples of this phenomenon can be seen at Bow Summit and in the area around Bow Lake. This effect is due to nocturnal temperature inversions produced by downslope cold air drainage.

Red Belt

The phenomenon known as Red Belt occurs throughout the eastern portion of Banff and Jasper Parks at elevations of between 1768 metres and 1890 metres (5,800 and 6,200 feet). This red coloration of the trees is due to damage by adverse weather conditions. The most favoured theory suggests that this injury occurs when a rapid drop in temperature follows a period of above-freezing conditions. Red Belt appears to be related to the occurrence of chinook conditions, but there are probably other factors involved. High winds, which have a dessicating or drying effect may be a contributing factor. The Red Belt is occasionally seen along the Icefields Parkway, but occurs most frequently in the lower Bow River Valley (east of the Mt. Eisenhower) and in the Athabasca River Valley east of the Jasper townsite. The Red Belt does not appear to do any long term damage to the trees.

Timberline

Timberline is actually not a line, but a transitional band about 300 metres (1,000 feet) wide. Its actual location depends on topography and exposure, but at this latitude it generally ranges from 2150 metres (7,000 feet) at the edge of the continental forest to 2450 metres (8,000 metres) where the last dwarf trees occur. The "average" altitude of timberline in Banff is around 2300 metres (7,500 feet). When the continuous forest comes to an end, it becomes glazed and then broken up into small tree islands. The trees become dwarfed and grow close to the ground because of the severe winter winds. These are known as "Krummholz" colonies from the German "crooked wood". The upper limit of timberline is marked by isolated trees only a few inches high.

The cause of timberline has been discussed for many years, but it is now known that it is caused by a complex of factors acting on the plants. At high altitudes, the growing season is too short for trees to develop a mature protective bark. Consequently, during the winter, moisture is lost through evaporation by strong winds and intense radiation. This moisture cannot be replaced from the frozen stems of the frozen soil and the tree dies from dessication (drying out). Some of the factors that combine to cause timberline are temperature, the short cool summers, the long cold winters, strong winds, high solar radiation and deep snow accumulation. Avalanching may lower timberline.

The Alpine Zone

In the alpine zone, found at elevations above timberline, the climate is severe. Plants are exposed to cold temperature, strong winds, high solar radiation, and deep snow accumulation. The average yearly temperature is less than -4°C. The growing season seldom exceeds 60 days and there is no predictable frost free period. Precipitation is high, from 40 to 60 inches a year, with most of it occurring as snow. Wind speeds are generally three times those in the valley with an average of 20 m.p.h. Snow is blown from the ridges and windward slopes, but accumulates on the lee slopes. The bedrock geology, with its steep outcropping cliffs and walls, adds to the ruggedness. Soree slopes and talus cones are often moving continuously. The soils of the alpine are also affected by the severe conditions. Frost action churns up the soil and sorts out the particles into polygons and stone stripes. Drainage is often poor and soils which become saturated during snowmelt may flow or "creep" downhill. The Bow Summit and Parker's Ridge trails both offer relatively easy access to the alpine zone. All of these features of the alpine zone affect the type of plants that can grow there.

Adaptations to the Alpine Zone

Alpine plants show many adaptations that help them to survive in their severe environment. These adaptations include modifications in growth form, type of leaves, colour, and method of reproduction.
Growth Form

Alpine plants have a distinctive growth form: they are low growing with an abundance of roots and leaves but very little stem. This dwarf form is efficient because it allows the plant to take advantage of the lower wind speeds and higher temperatures at the ground surface. Three special growth forms are common: the cushion form, the mat form, and the rosette form.

Cushion Form - The cushion plants are low, compact, dome-shaped cushions attached by branches to a central tap root. The moss campion and umbrella plant are familiar examples.

Mat Form - Mat plants are low creeping carpets which are more open than the cushion form and are rooted throughout the mat. Examples are the mountain avens and several species of willows. This growth form is also seen on gravelly areas at lower elevations.

Rosette Form - In this form, the leaves are arranged in a rosette on the ground surface with the flower growing out of the middle. Examples of rosette plants are the prickly saxifrage and the alpine dandelion.

Types of Leaves

Alpine plants usually have an abundance of leaves so that they can minimize energy production. However, some of the plants, such as the heathers, have leaves which are scale-like or leathery. Others, such as the pussytoes, have very hairy leaves. These are all adaptations to prevent moisture loss through the leaves.

Colour

Alpine flowers are all very brightly coloured and the reds and purples predominate. These colours are thought to be beneficial because they screen out much of the ultra-violet radiation.

Method of Reproduction

The growing season is too short to allow the plants to reproduce by seed. Most alpine plants are perennials that grow back year after year. It may take up to three years for certain species to produce a flower, so reproduction is generally by vegetative means — by runners, bulbs, or mat-like spreading.

Distribution of Plants in the Alpine Zone

The distribution of plants in the alpine zone is limited first by the bedrock geology. Although plants may grow in rock crevices, lichens and mosses are the only plants that can survive on barren rock faces. The snow accumulation pattern, which is fairly constant from year to year, is another major factor controlling the distribution of plant communities in the alpine zone.

The alpine zone is the home of the golden-mantled ground squirrel, the pika, the hoary marmot, the grizzly bear. Animals such as the bighorn sheep, mule deer, and wapiti use the alpine meadows as summer range.

Trees

The following section describes the twelve tree species that make up the forests of Banff National Park. Some of these trees are rare or locally restricted, so that only six species occur frequently. These are the lodgepole pine, the white and Engelmann spruce, the subalpine fir, the Douglas fir, and the trembling aspen.

Coniferous Trees

The majority of the trees in the park are conifers, trees which are well adapted to our cool climate. Conifers have their reproductive organs on cones, usually with cones of both sexes being found on the same tree. The tiny male cones shed their pollen early in the season and then drop to the ground. The larger seed-bearing females cones usually remain on the tree at least until the end of summer. Coniferous trees have needle-like leaves which do not allow moisture to escape. They are evergreen because of this ability to retain moisture and avoid desiccation or drying out during the winter. The alpine larch is an exception among the conifers. Although cone bearing, it is not an evergreen; its needles are shed every year.

The Spruces

Engelmann and white spruce are dominant trees in the subalpine forest. White spruce is generally found at lower elevations and Engelmann at higher, but because they hybridize throughout their range, identification is difficult. Black spruce is rare in Banff Park but is more common in Jasper Park to the north.

The needles of the spruces are four sided so can be easily rolled between the fingers. The needles are mostly under one inch in length and are attached singly to small woody projections on the twig. The rough feel of a needleless spruce twig distinguishes it from those of the firs which are smooth. Spruces can reproduce by layering or rooting of lower branches.

White Spruce

White Spruce has a uniform conical crown and branches which extend nearly to the ground. The cones are cylindrical and stiff and the cone scales are round and smooth; the needles of the white spruce are straight. This is a low elevation tree which is found throughout the lower Bow Valley and around Banff town site.

Engelmann Spruce

The crown of the Engelmann spruce is conical, like that of the white spruce, but allimber and more spirelike. The cones are cylindrical and flexible and the cone scales are toothed and triangular in shape; the needles tend to be curved. This is a high elevation tree which can be seen at Lake Louise and other high areas such as Sunshine Village and Bow Summit.

Black Spruce

Black spruce can be distinguished from either white or Engelmann spruce by its narrow ragged crown and drooping lower branches with upturned tips. Many trees have a characteristic club-shaped top which is thought to be a result of cone clipping by squirrels. The cones are small, egg-shaped and about one inch long. Needles are just 1/2 an inch long.

Black spruce can reproduce by "layering" or rooting of
lower branches. A small stand of black spruce is found in the Saskatchewan River Crossing area. These trees are at the southern limit of their range and are much more common in Jasper Park to the north.

The Pines

The pines may be distinguished from the other conifers by their longer needles (1 to 5 inches) which are found in bundles of 2 to 5. The "hard pines" represented here by the lodgepole pine, have their needles in clusters of 2 or 3; while the "soft pines", represented by the limber and whitebark pine, have their needles in clusters of 5. The pines are all hardy trees which are often found growing in dry, infertile, or otherwise marginal environments.

Lodgepole Pine

The lodgepole pine is a fire successional tree found in dense stands in the Bow Valley and other burnt-over areas. The needles have few lower branches and the trunks are tall and straight. The bark of a mature tree is orangey-brown. Needles, from 1 to 3 inches in length, are in bundles of two; the egg-shaped cones are hard and prickly. These cones, which are sealed closed with resin, will open to release their seeds when exposed to the heat of a forest fire (45-50°C).

Because of this adaption, the light-loving lodgepole pine is the first tree to seed in after a fire. Lodgepole pine are often infested with the parasitic dwarf mistletoe which causes abnormal growths known as "Witches Brooms". These 'brooms' are often mistaken for squirrel nests.

Limber Pine

Limber pine is not common in the park, but can be seen at the Hoodoo's Lookout on Tunnel Mountain Drive. They occur as single scattered trees in the foothills and on dry rocky exposed sites up to 6,000 feet. Limber pine are often stunted by wind and have crooked trunks and large uneven cones. The needles are 1 1/2 to 3 1/2 inches long and found in bundles of 5. The cones are cylindrical and large (up to 8 inches in length).

Whitebark Pine

Whitebark pine is found at timberline among Engelmann spruce and subalpine fir. The branches, which arch upward, give the tree a distinctive form. Needles are 2-3 inches long and found in bundles of five. This tree may be distinguished from the limber pine by its cones which are small (3 inches in length), and egg-shaped. The seeds of the whitebark pine are a favourite food for squirrels.

Douglas Fir

Douglas fir stands out on the dry southwest facing slopes of the Montane Zone because of its dark, bluish-green colour. It is a large, fire resistant tree with thick furrowed bark. The needles are short, flat and pointed. The cones are distinctive because of the unique three-pronged bracts protruding from each cone scale. Douglas fir may be seen along the Mount Norquay Road and at the "Banff Springs Hotel" viewpoint on Tunnel Mountain Drive.

Subalpine Fir

The narrow spike-like crowns of the subalpine fir can be seen at high elevations up to timberline. The bark is smooth and grey with conspicuous resin blisters. The needles are flat and rounded or notched at the tip. The cones of the subalpine fir, which are held upright on the branches, are not dropped but simply disintegrate leaving the spiky central cones on the branches. The seeds are a favourite food for red squirrels. The subalpine fir is a common tree in high areas such as Lake Louise, Sunshine Village and Bow Summit.

Alpine Larch

The alpine larch is a typical timberline species, with a ragged crown of irregular, gnarled branches. It has a very restricted range, and is not found north of Hector Lake. The larch is distinctive among the conifers because it is not an evergreen. The needles turn a bright golden colour and are shed in the autumn. The soft needles are 1 to 1 1/2 inches in length and are found in bunches of 30-40 on dwarfed, knob-like branches. The cones are oval and from 1 1/2 to 2 inches long. The golden band of the alpine larch can be seen in late September in the Lake Louise area and on the higher slopes throughout the Bow Valley.

Deciduous Trees

Deciduous trees have broad flat leaves which are shed every year in the autumn. Dropping of leaves is thought to be an adaptation to avoid moisture loss and dessication during the winter. These trees do not bear cones, but carry their seeds in a variety of structures such as nuts, berries and catkins. The deciduous trees in the park are mainly members of the poplar family, which carry their reproductive organs on catkins. These catkins are of only one sex on any individual tree; because of this, some of the poplars are male in gender and the others are female.

Trembling Aspen

The trembling aspen is the most common deciduous tree in the park. It occurs in dry open areas, usually in dense stands. The individual trees have long cylindrical, branch-free trunks and short, rounded crowns. The leaves of the aspen flutter in the slightest breeze because of their flattened stalks; this characteristic led the Indians to call them "squa's tongues". The bark is grayish-green in colour and is always smooth on the upper part of the tree. The aspen reproduces by suckers, which are new stems that grow from the spreading roots. This creates clones or groups of trees which are genetically identical. The aspen is often fire successional because a disturbance such as fire stimulates production of an abundance of suckers. The trembling aspen is common along the 1A highway and along the Trans-Canada Highway to the east of Banff. Many aspen trees in the park show black scars on their trunks. This injury occurred during particularly severe winters when the starving wapiti or elk were forced to chew the bark for food.

Balsam Poplar and Black Cottonwood

Balsam poplar and black cottonwood are not common but are seen along riverbanks and in moist areas in the lower valleys. These two trees hybridize so are very difficult to distinguish. Mature trees have coarse, heavy branches and large crowns. Unlike that of the aspen, the mature bark is greyish-brown and deeply furrowed. The leaves are large (3 to 5 inches), egg-shaped, and have long tapering tips. New buds produce a sweet smelling resin which is known as "Balm of Gilead"; this resin has been used in the past as a herbal remedy. The seeds are distributed in the wind-blown cotton which is released from the catkins.
These trees are common along the banks of the Bow River and can be seen from both the 1A and the Trans-Canada Highway.

Selected References


The view of the valley from the top is breathtaking. The landscape is a tapestry of colors, with green forests mixing with the warm hues of the sun-drenched fields. The valley is a haven for nature lovers, offering a peaceful retreat from the hustle and bustle of city life.

**Geographic Features**

The valley lies in the southern part of the region, surrounded by the mountains on the north and east. The area is rich in biodiversity, with a variety of plant and animal species inhabiting the region. The valley is also home to several small towns and villages, each with its own unique charm.

**Weather**

The weather in the valley is mild and temperate, with moderate temperatures throughout the year. Summers are warm and dry, while winters are cool but not too cold. The valley experiences occasional rainfall, which helps to maintain the lush greenery.

**Economy**

The economy of the valley is primarily based on agriculture, with the cultivation of crops such as wheat, rice, and vegetables. The valley is also a hub for small-scale industries, with a focus on handcraft and handicraft production.

**Transportation**

The valley has good connectivity, with well-maintained roads leading to other parts of the region. The valley is also served by a network of buses and trains, providing easy access to regional and national destinations.

**Tourism**

The valley is a popular destination for tourists, who come to experience the beauty of nature and the rich cultural heritage of the region. The valley offers a range of activities, from hiking and trekking to cultural festivals and traditional shows.

**In summary,** the valley is a place of peace and tranquility, offering a perfect blend of nature, culture, and economy. It is a testament to the beauty of the region and a symbol of the rich heritage of the people who call it home.
fauna
The diversity of wildlife in Banff National Park is a reflection of the diversity in habitat that has resulted from local variations in relief, climate, and plant communities.

The distribution of wildlife is associated with the vegetational zones discussed in the previous section. Each zone offers a variety of habitats that are used by certain animals at different times of the year. For example, the Bow Valley bottom and southwest facing slopes of the montane zone are heavily used by sheep, elk, moose and deer during the winter. In contrast, the north-east facing subalpine slopes of the Bow Valley cannot support these large animals and are used mainly by smaller species such as red squirrel and pine marten. The alpine zone has a characteristic summer animal community that includes golden-mantled ground squirrel, hoary marmot, gray-crowned rosy finch, and grizzly bear. Other large animals such as deer, elk and sheep often range into the alpine zone during the summer months.

The mountain environment is generally very severe and the animals of the mountains are well adapted to it. Strategies for survival include winter hibernation and seasonal migration.

Hibernating animals such as marmots and ground squirrels escape the winter by lowering their metabolic rate and remaining dormant in well-insulated dens or burrows. Any energy that is needed is taken from the animal's fat reserves. Some animals such as voles and most mice remain active all winter in runways and tunnels under the snow.

The most common survival strategy for large, mobile animals is seasonal migration. In the mountains, migration is altitudinal. In summer, many of the hooved animals (called ungulates) range up as far as the alpine meadows as they follow the lush new growth of vegetation up the mountain sides. Winter is spent in valley bottoms or snow free slopes where forage is available. Because of competition for food, the winter range is critical in limiting the size of wildlife populations.

Life cycles are also keyed to the seasons. Mating seasons are usually in the autumn when animals are in prime condition. The young are usually born to coincide with the average time of spring green-up in the valley.

A total of 53 species of mammals inhabit the park. These can be separated into 3 main groups: the small mammals, the hooved animals, (or ungulates), and the carnivores, (or meat eaters). The most important or common of these animals are discussed in the following section.

Small Mammals

Small mammals often go by unnoticed, but in fact, they have the largest representation with 29 species. The range in size is from the pygmy shrew, weighing a fraction of an ounce, to the beaver which weighs up to 55 pounds. With the exception of the shrews, the bats and the rabbits, these animals are all rodents.

Least Chipmunk (3½ - 4½ inches, excluding tail)

The least chipmunk is the smallest chipmunk in North America. The black stripes on its back extend onto the head to the tip of the nose. This chipmunk is found from valley floor to well above timberline but usually in dry, fairly rocky areas. It is usually found on the ground, but does go in trees. Seeds and berries form its diet and extra food is often cached. Chipmunks hibernate in chambers 18 to 36 inches below ground and wake occasionally to feed on stored food.

Columbian Ground Squirrel

This is a commonly seen animal in the summer. It is a large ground squirrel with a mottled grey coat and reddish legs. Columbian ground squirrels colonize grassy areas from valley bottom to alpine meadow, but prefer sandy soils. Their tunnel systems are extensive and have an average of eleven entrances. A wide variety of roots, stems, berries, and seeds is included in their diet. Food is not stored but the animal builds up a thick fat layer to sustain it through the winter. Hibernation lasts seven months or more — generally from late August or early September to late April. Because of their high reproductive rate, they are valuable prey species for a number of predators including grizzly bears, coyotes, wolves, and golden eagles.

Golden-Mantled Ground Squirrel (6-8 inches, excluding tail)

The golden-mantled ground squirrel is smaller than the Columbian. Because of its stripes, it is often mistaken for a large chipmunk. The golden-mantled ground squirrel can be distinguished because its stripes do not extend onto the head as the chipmunk’s stripes do. This animal ranges from valley bottom to above timberline and is generally found in rocky areas. They are not very gregarious and rarely are more than two seen together. Their burrows are short and simple and are often located near the edge of rock piles. This ground squirrel’s period of hibernation and predators are similar to those of the Columbian ground squirrel.

Hoary Marmot — (10-30 lbs.)

The hoary marmot is a colonial animal that inhabits the alpine area from 6,800 to 8,000 feet. The marmot is brown in colour and is hoary (or grizzled) with grey hair on the back. Well known for their high pitched call, they are often called whistlers. During the short summer, the marmot feeds on grasses and herbs and becomes very fat. The den is on hilly ground and usually under a boulder. Hibernation lasts from September to April. Marmots are a favourite prey of the grizzly bear. Marmots are often seen sunning themselves on large boulders or "observation posts". Large colonies exist at Bow Pass and Helen Lake.
Red Squirrel - (7-8 inches, excluding tail)

The familiar red squirrel is well distributed in the forests from valley bottom to timberline. They live in nests of skin hanging from the spruce, pine and fir are the mainstay of their diet. In mid-summer, red squirrels cut the tips of cone-bearing branches and store the green cones underground for winter use. Great heaps of cone scales called "middens" are characteristic of the squirrel's cache and feeding area. Red squirrels remain active throughout the winter and are thought to be an important prey species of the pine marten.

Porcupine - (10-25 lbs.)

This large rodent is found in low numbers throughout the subalpine forest. Porcupines are nocturnal and spend most of their days sleeping in trees. Their diet is composed of the leaves and bark of trees; this sometimes results in severe damage to young trees. Like other rodents, porcupines also chew bones and antlers to obtain minerals. A strong craving for salt also attracts them to roadsides in winter. Porcupines tunnel through snow to build ground burrows in winter. They cannot actually throw their quills, but when cornered, lash out with their spiny tails. Certain predators such as the wolverine and fisher are able to kill porcupines without injury by flipping them over and attacking the soft underparts.

Beaver - (30-55 lbs.)

The beaver is the largest rodent in the park and is found at low elevations in marshy areas. Well adapted to aquatic life, the beaver has oily, water-repellent fur, flaps over the eyes and nostrils, and a flat rudder-like tail. Beaver build dams to create ponds 5 to 6 feet in depth in which they build their lodges. The living area within the lodge is above water level, but there are many plunge holes out to the pond. On fast-flowing rivers, beaver live in bank burrows. The bark of aspen and poplar is the most important food, but willow bark is also utilized. Beaver remain active under the ice throughout the winter. Lodges can be seen at the Vermilion Lakes and along the Sundance Canyon road.

Muskrat - (3 lbs.)

The muskrat also lives in ponds and marshes at low elevation. It resembles a small beaver except for its long, rat-like tail. Its diet of marsh plants is supplemented by the occasional frog or salamander. Muskrats are active year-round in their lodge-like houses along the shoreline. A system of tunnels and canals is maintained and in winter, they construct push-ups. These are domes of vegetation pushed up through the ice and covering a plunge hole and feeding area. Coyotes, large owls, and eagles prey upon the muskrat. Large colonies exist at the Vermilion Lakes.

Bushy-Tailed Wood Rat (Pack Rat) -(10 inches excluding tail)

This animal, better known as the pack rat, is well known for the damage it causes in empty cabins. The bushy-tailed wood rat is grey in colour, and rather squirrel-like. A strong musky odour marks its territory. The wood rat stores food in coniferous trees and the seeds of the humped shoulders and a flap of skin hanging from the throat, called a dewlap. The moose is a solitary animal which ranges from valley floor to timberline. The preferred habitat in summer is along stream banks and lakeshores where aquatic plants are added to the regular diet of leaves and twigs. The mating season is from mid-September to November, and males are particularly aggressive at this time. Calves (usually twins), are born in May and early June. Calves can swim at an early age, but occasionally drown when they attempt to follow their mother across a large lake.

Moose - (600-1100 lbs.)

The moose is the largest member of the deer family. Distinctive features include long legs, humped shoulders, and a wide variety of leaves, needles, twigs, and seeds; food is cached for winter use. The nests are concealed in a large "den" made of sticks, bones, and debris stolen from cabins and camps. Natural habitat for the wood rat is in caves or on rocky outcrops at any elevation.

Pika - (7 inches)

The pika or "rock rabbit" is the smallest member of the rabbit family. Pikas are grey in colour, have short rounded ears and no tail. They live on rock slides and talus slopes from 5,000 to 8,500 feet.

Grasses and flowering plants form this animal's diet. In late summer, pikas spread plants out to "cure" in the sun and then make miniature "haystacks" in rock crevices. With this winter food supply available, pikas remain active all winter under the snow. They are well camouflaged, but often can be located by their piercing call. Pikas are often seen on the rockslides at Moraine Lake and at the far end of Lake Louise.

Ungulates (Hooved Animals)

Ungulates are large mammals which possess hooves. They are herbivorous (plant-eating), have chambered stomachs, and chew their cud. There are eight species of ungulates in the park which may be divided into two families: the deer family and the sheep and goat family.

Members of the deer family are distinguished by the fact that the males carry antlers made of a bone-like material. The antlers function as symbols of dominance during the mating season and are dropped every year in the early spring.

Members of the sheep and goat family carry true horns rather than antlers. Horns are carried by both sexes, are permanent, and grow throughout the life of the animal. Horns also serve as symbols of dominance and are sometimes used as weapons.

The Deer Family

Moose - (600-1100 lbs.)

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Moose are widely distributed in the park, and the Bow Valley provides some of the best habitat. Good spots to see moose include the Vermilion Lakes, the Bow Lake area, Upper Waterfowl Lake and the "moose meadow" between Johnston Creek and Silver City.

Wapiti (Elk) - (600-1000 lbs.)

The name Wapiti is preferred to avoid confusion with the European moose which is sometimes known as "elk".

Populations of wapiti in the Banff area have undergone drastic fluctuations. Known to early ex-
plovers and travellers as "red deer", the wapiti provided an important food source to early travellers. Due to hunting pressure and perhaps other factors such as disease, this animal was near extinction before the turn of the century. In 1917 and 1918, the park was restocked with 250 wapiti from Yellowstone. A population explosion resulted — (in 1935, numbers had reached 5,000), and their numbers were controlled in an attempt to prevent heavy die-offs. At the present time, the population is not controlled, but the wapiti is still the most common ungulate.

Wapiti are the second largest member of the deer family. The bulls or stags are known for their majestic antlers which may reach 4 to 5 feet in length. Wapiti are gregarious and in the winter move together in large herds. In summer, the females or hinds and their calves forage together and the bulls form bachelor groups. During the rut or mating season harems of up to 80 hinds are formed; the male's behaviour at this time is spectacular. It includes thrashing antlers against bushes, rolling in mud wallows and bugling to attract females. There is often combat when males are defending their harems.

Wapiti are primarily grazers who usually migrate to higher areas in summer. Grassy areas in the valley bottoms are critical winter habitat. Scars on aspen trees are evidence of periods of starvation when wapiti were forced to eat the bark.

Mule Deer - (125-140 lbs.)

Mule deer are the characteristic deer of mountains and foothills. Distinctive features are the large ears and the black-tipped tail. Although mule deer are frequently seen along roads and in Banff townsite, the population levels remain fairly low. Mule deer migrate altitudinally but are most commonly found in small groups in drier open areas. The summer diet includes shrubs and broad-leaved plants and the winter diet is of twigs of evergreens, saplings, and shrubs. Winter range on open slopes and aspen forest is often shared with wapiti.

White-tailed Deer

White-tailed deer are uncommon in the park, but are present in small numbers. White-tails are smaller than mule deer. They can be easily identified by their long brown tails which, when held upright at any sign of alarm, show a white underside.

Woodland Caribou - (125-210 lbs.)

These caribou are sighted occasionally in the northern part of the park, and there is a resident population in the Siffleur watershed. Caribou are comparable in size to the wapiti, but generally darker in colour. Antlers are often carried by both sexes and are quite variable; however, the presence of a broad brown tine which points downward over the forehead is distinctive. Caribou generally form herds and in the mountains, the annual migration is from the subalpine forest to the alpine zone in summer. Lichens are an important food source but grasses, broad-leaved plants and twigs are included in their diet. Caribou have been sighted around Nigel Pass, Dolomite Pass, and in the Upper Pipestone.

Bighorn Sheep - (150-350 lbs.)

Bighorn sheep are the second most common ungulate in the park after the wapiti. Bighorns have a sandy colored coat and massive spirally curved horns; the ewe's horns are short and spiky. Bighorns are primarily grazers and migrate seasonally between low grassy slopes and alpine meadows. Escape terrain with rocky ledges is usually nearby. Winter range is very critical and must be on drier slopes where grasses can be pawed through the snow. These sheep are very gregarious and form mixed herds in winter and segregated herds in summer. During the mating season in the autumn, the rams battle for dominance. This is done according to an established ritual of crashing horns together until the weaker animal gives up. Horn tips are often broken during these battles. Currently, bighorn sheep populations may be declining slightly due to the regeneration of trees on winter range (a result of fire control).

Road kills are also having a significant impact on sheep populations, particularly in the area just west of Banff on the Trans-Canada Highway. A reduced speed limit and no stopping zone have been imposed in this area in an attempt to reduce the number of kills. Bighorn sheep are commonly seen at Lake Minnewanka and at the top of Sulphur Mountain. They also inhabit the Bourgeau Range, the Sawback Range and Mt. Wilson and Coleman to the north.

Mountain Goat

Although mountain goats are seldom seen because of their preference for rugged habitat, they are actually quite numerous in the park. The Warden Service estimates a population of about 1,000 animals. Mountain goats may be distinguished from bighorn sheep by their white coats, beards, and short, black, dagger-like horns which are carried by both sexes. Actually, they are not "goats", but belong to a group of mountain antelopes. Females or nannies and their kids often form groups during the summer, but males or billies are generally solitary. During the rut, fights between billies are rare, but when they do occur, they are vicious and involve going with their sharp horns. Goats are generalists and live on a wide variety of vegetation. This allows them to survive year-round at elevations above 6,500 feet. There is no seasonal migration, but goats often trek to salt licks in the valleys in the spring. Goats are often seen on Mount Coleman and on the rock-face below the "big hill" on the Sunwapta Pass section of the Banff-Jasper Highway. In Jasper National Park, they are often seen at the "goat lookout" between Sunwapta Falls and Athabasca Falls.

Bison - (Est. 2000-2200 lbs.)

Historical accounts indicate that the wood bison once inhabited the mountains, ranging up to timberline. The last wood bison in the area was killed in 1858 in the Pipestone Valley. Wood bison are similar in appearance and habits to the plains bison, but slightly larger in size. A captive herd of plains bison have been kept in the park since 1897, and may be seen at the "Buffalo Paddock" near Banff.
Carnivores

The carnivores are at the top of the food chain; they are the predators of all the other animals. Well-developed senses, long canine teeth, and sharp claws help them to be efficient hunters. They are generally flesh eaters, but certain groups such as bears, have become omnivorous (meaning that they eat vegetable material as well as meat). Carnivores range in size from the tiny ermine weighing about 2 ounces to the grizzly bear which reaches a weight of up to 1,000 pounds.

There are four families of carnivores in the park: the weasel, dog, cat, and bear families. The weasels generally have elongate bodies, short legs, and glands which produce a strong-smelling scent. Members of the dog family such as the coyote and the wolf are intelligent, social animals. The solitary nocturnal cats, represented by the cougar and lynx, are the most specialized carnivores. Members of the bear family are the largest land dwelling carnivores.

Weasel Family

Wolverine - (20-37 lbs)

The wolverine is occasionally seen in the alpine tundra, and is lightly distributed throughout the park at all elevations. It is a large member of the weasel family, about the size of a bear cub and well known as a fighter. The wolverine has a stout muscular body which is dark brown in colour, a short bushy tail and partly retractile claws. Its diet is omnivorous, it eats roots and berries, small mammals, birds, and occasionally sheep. As a scavenger, it cleans up carcasses left by wolves and bears. The wolverine is a solitary animal which ranges widely during both summer and winter.

Marten - (12-18 inches, excluding tail)

The marten is a tree-dwelling member of the weasel family, which has a slender body, large ears and a bushy tail. Colour is variable; dark brown being most common in this area. Martens are solitary hunters which prey upon voles, mice and the occasional red squirrel. They are active year-round and although they are not often seen, their tracks can be found on snow in winter. Martens are an abundant species throughout the forested areas of the park.

Ermine - (6-9 inches, excluding tail)

This ferocious little carnivore is known for its ability to kill animals as large or larger than itself. The ermine shows a pronounced seasonal variation in colour which is stimulated by the duration of daylight. In summer, it is chocolate brown with white underparts and in winter, completely white except for the black tip on the tail. The ermine's slender body allows it to enter the burrows of small rodents and these are often used as nesting areas. Their diet includes mice, shrews, birds, squirrels, and the occasional porcupine. Excess kills are stored, particularly as winter approaches. The ermine is believed to occur in fair numbers throughout the park.

Dog Family

Coyote - (25-35 lbs.)

The coyote is a medium sized dog with a slender muzzle, large pointed ears, and a bushy tail which is usually held downwards. The family pack (parents and offspring) is the basic social unit. The litter, usually 5 to 7, is born in early May. Both parents are involved in raising the young. The mating pair usually stay together for a number of years, but not necessarily for life. Coyotes are shy nocturnal scavengers, who patrol the highway and railway in search of road kills. They are also active predators of small rodents and birds; deer may be taken by teamwork. Coyotes must be on the alert for larger predators such as the wolf, the cougar, the black and the grizzly bear. Near elimination of the park's coyotes occurred during the anti-rabies campaign of 1952-53, but today they are well represented. Their nocturnal serenades are often heard, particularly in late August when the pups leave the den to join the family pack. Bow Falls and the area around Bankhead are good places to listen for their howls. Coyotes are known to mate with domestic dogs to produce fertile offspring known as "coy dogs".

Wolf - (57-175 lbs.)

The wolf is similar in appearance to a large German Shepherd, but is lankier with longer legs and larger feet. Its muzzle is larger and less pointed than that of a coyote. Colour varies from beige to brown, grey and black. Dark wolves are predominant in the wildlife inventories of Alberta and B.C. Wolves produce a variety of barks, whines, and yelps to express various emotions, but the long quavering howl is distinctive. The family pack (usually between four and seven) consists of parents, offspring, and close relatives. There is a definite social hierarchy within the pack and only the dominant male and female mate. Wolves are reported to mate for life. Despite an average litter size of six, the size of the pack varies little from year to year.

Wolves are primarily hunters of big game. Elk, moose, deer, and bighorn sheep appear to be the important prey species in this area, although small game may constitute about 20% of the diet. Studies indicate that wolf packs prey mainly on the sick, the young, and the aged, and in this way have a beneficial culling effect on ungulate populations. Wolves have no natural predators but populations appear to be controlled by starvation and disease.

Wolf populations in Banff National Park have fluctuated greatly since the coming of the Europeans. George Simpson, in 1841, made reference to wolves and the Palliser Expedition in 1860 reported that strychnine was being used by fur traders to poison the animals. By 1900, due to hunting pressure and the general decline in game populations, wolves were rare. It was not until the late 40's that wolf-sightings became more frequent and several packs were established in the park. In 1952-53, a province-wide rabies control program resulted in virtual elimination. Wolves returned in about 1966, and since that time...
time, there has been a small but stable population in the northeastern part of the park.

Packs have been sighted in the valleys of the Bowse, Clearwater, Dormer and Cascade rivers and in the area of the Columbia Icefield. Although fully protected in the park, these wolves are still subject to hunting pressures during migrations outside the park boundaries.

Cat Family

Mountain Lion - (100-225 lbs.)

The mountain lion or cougar is the largest Canadian cat. Its body is long and lithe, the head small and the tail about 30 inches long. The adult colour is predominantly light brown, with a white throat and chest. Cougar are solitary, nocturnal, and are rarely seen. The lair is usually in a crevice among rocks or in the shelter of a windfall. The breeding season is not restricted but kittens are most often born in late winter or mid-summer. Kittens weigh just less than a pound at birth and have a spotted coat. Cougar hunt by stalking and pouncing much like a domestic cat. Deer are their favourite food; elk, moose, bighorn sheep, mountain goats, and small mammals are also hunted. Signs of cougar indicate a fairly constant but small number throughout the more heavily populated ungulate range in the park. These animals assist in keeping big game populations within the carrying capacity of their food supply.

Lynx - (13-35 lbs.)

The lynx is a medium-sized cat with a short body, stubby tail, and large feet which facilitate travel on snow. The fur is long, thick and mainly grey in colour. A prominent ruff surrounds the face. The lynx preys on small animals such as rodents, hares, and birds. Lynx numbers appear to fluctuate greatly but because they are rarely seen, there are no estimates of the population size.

Bear Family

Most people associate bears with national parks, because they are protected and their numbers flourish. Two types of bear inhabit the park: the black bear and the grizzly bear. Both of these bears are scavengers and are omnivorous in diet, meaning that they eat both plant and animal material. Plants form the mainstay of their diet. This is supplemented by carrion (dead meat) and whatever small animals they manage to kill. Winter estivation is characteristic for the bear family. Although not truly hibernating, bears in the winter den are in a very lethargic state. They can, however, be awakened quite easily. Bears have a reproductive mechanism known as "delaying implantation". Making cubs in the summer, but the embryo does not begin development until late autumn and the only if the sow is fat and in good condition. This ensures strong offspring because only healthy bears are able to produce young. Bears suckle their tiny cubs throughout the winter months.

Bears have poor eyesight but their hearing and their sense of smell are acute. They are not naturally aggressive, but their behaviour is highly unpredictable. All bears are potentially dangerous. Those animals which forage on human food or garbage become habituated to man and less fearful. These are problem bears which may become more dangerous to visitors. Bear management programs in the national parks operate in three ways:
The grizzly bear is particularly sensitive to man's influence and because of this is extinct throughout much of its eastern range. At the present time, Banff Park supports a viable population which is estimated at between 80 and 100 individuals. The grizzly's continued existence depends upon the preservation of large areas of undisturbed wilderness.

Hints for Hiking in Bear Country

When hiking in areas frequented by bears, the best strategy is to warn the animals of your presence by carrying "bear bells" or occasionally making loud noises such as clapping or yodelling. Because bears are shy by nature, they will usually vacate the area immediately. Avoid travel in an upwind direction or in areas with poor visibility. It is also a good idea to watch for droppings or fresh excavations which indicate that there is a bear in the area. If you do sight a bear, the best reaction is to slowly walk away rather than running which may provoke a charge. Most adult grizzly bears cannot climb trees, so climbing a tall tree (if available) is a good idea if you are within a close range of a grizzly. In the rare case that all these precautions fail and a sudden attack occurs, it appears that your best chance is to lie on the ground and "play dead".

Birds

Four of the most common seen resident birds are members of the crow family. These are the Gray Jay, Clark's Nutcracker, Black-billed Magpie, and the Raven.

Gray Jay - (11-12 inches)
Also known as the Canada Jay or Whiskey Jack, this bird is gray in colour with a whitish head and black nape. It is similar in appearance to the Clark's Nutcracker but not as vocal. Common throughout the forested areas of the park.

Clark's Nutcracker - (12-13 inches)
The Clark's Nutcracker received its name because of its ability to open nuts and cones. It is gray in colour with black and white wings and tail. It is slightly larger than the gray jay, and has a longer, stouter bill, and a cry which is louder and more harsh. Common throughout the high subalpine forest and often seen at Peyto Lake viewpoint and Moraine Lake.

Black-billed Magpie (18-22 inches)
This is a large black and white bird with iridescent feathers and a tail as long as its body. This scavenger is actually a prairie bird but is common at the Vermilion Lakes and around the Banff townsite.

Common Raven - (24-27 inches)
This is a black bird which resembles a crow but is larger and has a stouter bill. Call is a guttural croak; also a scavenger.

Three types of chickadees (black-capped, mountain and boreal), are permanent residents as are the grouse and ptarmigan. The ruffed grouse is found in the montane forest and the blue grouse and spruce grouse in the subalpine forest. The white-tailed ptarmigan and the willow ptarmigan live in alpine areas.

Fish

The lakes and rivers of Banff National Park support fair sized fish populations. In areas that are heavily fished, natural populations are augmented by stocking with native species.

The Rocky Mountain whitefish and three species of trout are indigenous to the Banff area. The whitefish occurs throughout the Bow River watershed and the dolly varden trout is found mainly in the Bow and the Spray rivers. The cutthroat is found in lakes at high elevations and the lake trout, which weighs up to 40 pounds, is found in Lake Minnewanka. Other native fish include two varieties of suckers, the lake chub, the black-nosed dace and the five-spined stickleback.

The rainbow and the brook trout have both been introduced to the waters of Banff Park. The brook trout, which was stocked as early as 1910, is now found in most lakes and streams at low elevations.

Some lakes in the park cannot support fish populations because of a phenomenon known as "winter kill". This occurs during particularly cold winters when the lakes freeze to a great depth. Over the winter, the oxygen is depleted in the bottom of the lake and a die-off of the entire fish population results. Stocking is no longer done in lakes that are susceptible to winter kill.

Some very exotic fish can be found in the marsh at the outlet of the Cave and Basin springs. The guppies and other tropical fish released there by Banff residents appear to thrive in the warm water provided by the springs.
Selected References


history
Pre-European History

Investigations in Banff National Park have located 127 archaeological sites dating from Early, Middle, and Late Prehistoric times. Many of these sites have been occupied by different cultures at different times and show signs of being permanent camps.

Early Prehistoric Times (13,000 BC - 5,500 BC)

The earliest known human occupation of the Bow Valley dated at about 10,000 BC, is at a site on the north shore of Lake Minnewanka. Archaeological evidence indicates that this early culture hunted bison and mammoth with a stabbing spear.

Middle Prehistoric Times (5,500 BC - 750 BC)

This later culture developed the atlatl (or throwing spear), allowing them to hunt faster moving animals such as the caribou and the mountain sheep.

Late Prehistoric Times (200 AD - 1,750 AD)

The development of the bow and arrow, which greatly improved hunting possibilities, occurred about 400 AD. The most intensive occupation of the Bow Valley was by this culture.

Historical Times (1,750 AD)

The valleys and the passes of the Rockies were well known to the Indian tribes of the eastern foothills long before the Europeans arrived in Western Canada. The Creeks, Kootenays, and Plains Blackfoot (especially Peigan), used the mountain passes for hunting and trading. Use of the foothills and mountain area by the Stoney Indians came later — after their first contact with Europeans. Most of the historic Indian camps are thought to have been temporary; however one camp in the Kootenay Plains area shows signs of permanence.

Post-European History

An asterisk (*) marks the events which were most significant to the history of Banff National park.

1754 - Anthony Henday, an employee of the Hudson's Bay Company, sights the Rocky Mountains from near present day Red Deer, Alberta.

1799 - The North West Company (N.W. Co.), and the Hudson's Bay Company (H.B. Co.), build fur-trading posts at Rocky Mountain House.

1800 - Duncan McGillivray and David Thompson of the N.W. Co. travel up the Bow River, probably as far as present day Exshaw.

1800 - The first known crossing of the central Rockies, probably by Bowse Pass, is made by two N.W. Co. voyageurs named Le Blanc and LoGassl. These fur traders set off from David Thompson's post at Rocky Mountain House.

1807 - David Thompson, a trader and surveyor for the North West Company, crosses the Rockies via House Pass, and builds Kootenay House, the first fur trading post on the Columbia River.

1810 - Joseph House, of the rival H.B. Company, crosses House Pass to compete with the N.W. Co. for the fur trade in the Columbia Valley.

1811 - Because of a blockade of House Pass by Piegan Indians, David Thompson is forced northward to search for another pass. In mid-winter, Thompson crosses Athabasca Pass and then follows the Columbia River to its outlet on the Pacific at Fort Astoria. This establishes the "Athabasca Trail", the route used by the annual fur brigades travelling from the coast to Fort Edmonton, via Jasper House.

1821 - The H.B. Co. and the N.W. Co. amalgamate, retaining the name Hudson's Bay Company.

1826 - The "Yellowhead Trail", an easier route to the Pacific via the Yellowhead Pass and the Fraser River, comes into use by the fur traders.

1832 - The H.B. Co. builds Piegan Post or "Old Bow Fort" on the Bow River just outside the mountains. It is burned by hostile Piegan Indians and closed early in 1834.

1841 - George Simpson, governor of the H.B. Co., is the first known European to visit the Banff area. His route, part of a round-the-world trip, takes him through Devil's Gap, along Lake Minnewanka to the Bow Valley, and over Simpson and then Sinclair Pass.

1847 - A Wesleyan missionary named Robert T. Rundle, journeys to the foot of Cascade Mountain and holds services for the Stoney Indians on the shore of Lake Minnewanka. Rundle worked among the plains Indians from 1840-1848.

1857 to 1860 The Palliser Expedition, led by Captain John Palliser, explores the western prairies and mountains. The expedition was to report on the possibilities for settlement on the prairies and to look for a route across the Rockies. Palliser's staff included Eugene Bourgeau, botanist; Dr. James Hector, surgeon and geologist; Thomas Blakiston, magnetic observer; and John Sullivan, secretary.

1858 - Dr. James Hector explores the Bow Valley and much of the area included in the present day mountain parks, naming features along the way. Hector is the first white man known to cross the Vermilion and Kicking Horse Passes.

1859 - James Carnegie, Earl of Southesk, comes to the eastern Rockies on a hunting trip. From today's Jasper Park, he travels south to the Banff vicinity via Pipestone Pass and the Bow River.

1869 - John A. MacDonald's government buys most of the Hudson Bay Co.'s former territory. The Banff area becomes part of the Northwest Territories of Canada.
1871 - Walter Moberly runs a preliminary survey for the railway through the Howse and the Yellowhead Passes.

1881 to 1886 - Geological survey work in the western mountains is done under Dr. George M. Dawson. Coal deposits are discovered in the Cascade Basin in 1883. A geological map of the Banff area is produced in 1886.

1881 - Major A.B. Rogers, an American surveyor hired by the C.P.R., locates the Rogers Pass over the Selkirk Mountains. Rogers then begins preliminary survey work in the Bow Valley and Kicking Horse Pass.

1882 - Lake Louise is discovered by C.P.R. packer Tom Wilson.

1883 - Sandford Fleming inspects the C.P.R. route through the mountain section. He relocates the survey line to the north side of Tunnel Mtn., eliminating the need for a tunnel.

1883 - The boom town Silver City springs up at the base of Castle Mountain (Mt. Eisenhower). During the short two-year history of the town, the population rose to well over a thousand. Four mines worked the copper and lead deposits. A fifth mine, the Homestake was salted with gold and 1000 shares were sold before it was shown to be a fraud.

1883 - The Cave and Basin hot springs are discovered by two railway workers, Frank McCabe and William McCardell.

1884 - The railhead reaches Field, B.C.

1885 - The last spike is driven at Craigellachie Station, completing the C.P.R. line from Montreal to Port Moody, B.C.

1889 - The railhead reaches Field, B.C.

1885 - The last spike is driven at Craigellachie Station, completing the C.P.R. line from Montreal to Port Moody, B.C.

1885 - A ten square mile reserve surrounding the Sulphur Mtn. hot springs is set aside by the federal government.

1886 - A coal mining town is established at Anthracite (1886-1904) which was located just east of the present day traffic circle.

1887 - Government legislation establishes Rocky Mountains Park, an area of 260 square miles surrounding the hot springs, the town of Banff, and Lake Minnewanka.

1888 - The original Banff Springs Hotel is opened for business by the C.P.R.

1890 - The original Chateau is built at Lake Louise.

1892 - A 51 square mile reserve is set aside in the Lake Louise area.

1894 - The exploration of the Lake Louise area is undertaken by Walter Wilcox, Samuel Allen, and their group of young climbers who call themselves the Yale-Lake Louise Club. Mt. Temple is climbed.

1898 - The Columbia Icefield is discovered by J. Norman Collie and Herman Wooley.

*1902 - The Lake Louise reservation is incorporated into Rocky Mountains Park as part of an enlargement to an area of 4,900 square miles.

1904 - The coal mining town of Bankhead is established (1904-1924).

1905 - The automobile is banned in the park.

*1911 - Automobile access to the park is made possible along the Calgary/Banff coach road.

*1911 - A new Parks Act is passed and J.B. Harkin becomes Commissioner of Dominion Parks. The area of the park is reduced to 1,800 square miles.

*1917 - Park area is increased to 2,751 square miles.

1920 - The Banff/Lake Louise road is completed.

1923 - The Banff/Radium Hot Springs road is completed.

*1930 - The National Parks Act is passed. Rocky Mountains Park becomes Banff National Park, with boundaries generally as they exist today. (2,564 square miles)

1930 - The first ski lodges in the park are constructed in the mountains east of Lake Louise.

1940 - The Banff/Jasper highway is opened to automobile traffic.

1962 - The Trans-Canada Highway, the longest paved highway in the world is officially opened in the Roger's Pass.

Place Names in Banff National Park

Aberdeen, Mt. - 3152 m. (10,340 ft.) For Lord Aberdeen, Governor General of Canada. (1897)

Alexandra, Mt. - 3418 m. (11,214 ft.), river and glacier. For Queen Alexandra, wife of King Edward VII. (1902)

Allen, Mt. - 3206 m. (10,520 ft.) Sixth of the Ten Peaks. Named after Samuel Evans Stokes Allen, a pioneer climber in the Rockies who explored the Moraine Lake area. (1924)

Amery, Mt. - 3335 m. (10,943 ft.) After L.S. Amery, a British statesman, who climbed the mountain in 1929.

Assiniboine, Mt. - 3618 m. (11,870 ft.) After the Assiniboine (Stoney) Indians. The name means "those who cook by placing hot stones in water". The highest peak in Banff National park.

Aylmer, Mt. - 3162 m. (10,374 ft.) Named by J.J. McArthur of the Dominion Land Survey for his hometown of Aylmer, Quebec.

*Adapted from Holgren and Holgren 1976, Place Names of Alberta
Banff - 1383 m. (4,538 ft.)
After Banffshire, Scotland, the home of George Stephen and Donald Smith (Lord Strathcona), who were both directors in the C.P.R.

Bankhead
After Bankhead, a town in Banffshire, Scotland.

Barbette, Mt. - 3072 m. (10,080 ft.) and glacier.
A descriptive name, given because of a resemblance to a barbette, which is a gun platform used with heavy naval guns. There are two platform-like peaks rising from the surrounding mountains.

Boom, Mt. - 2758 m. (9,047 ft.), lake and creek.
Driftwood in the lake resembled a lumberman's boom. (1908)

Bourgeau, Mt. - 2918 m. (9,575 ft.) lake and range.
For Eugene Bourgeau, the botanist with the Palliser Expedition.

Bow, Peak - 2802 m. (9,194 ft.), river, lake, and glacier. A translation of the Indian name. Early tribes obtained wood for their bows from Douglas fir growing along the banks of the Bow River.

Brett, Mt. - 2972 m. (9,750 ft.)
For Dr. R.G. Brett, C.P.R. doctor and Banff pioneer; later Lt. Governor of Alberta.

Brewster, Mt. - 2859 m. (9,380 ft.), creek and glacier. For John Brewster, Banff pioneer and dairy man.

Cascade, Mt. - 2998 m. (9,836 ft.), and river. A translation of the Indian name meaning "mountain where the water falls". Named by Hector. (1858)

Chephren, Mt. - 3261 m. (10,700 ft.), and lake.
After Chephren, an Egyptian pharaoh and builder of the second great pyramid; for its pyramidal shape. (1918) Formerly known as Pyramid Mountain.

Coleman, Mt. - 3128 m. (10,262 ft.)
After A.P. Coleman, an early geologist in the area.

Copper, Mt. - 2783 m. (9,130 ft.)
Copper prospects were located near the summit of the mountain by Joseph Healy. Named by Dawson.

Cory, Mt. - 2790 m. (9,154 ft.)
After William Cory, Deputy Minister of the Interior from 1905 to 1930. This is the mountain with "Hole in the Wall".

Costigan, Mt. - 2979 m. (9,775 ft.)
After the Hon. John Costigan, a frequent visitor to the area (1904).

Crowfoot, Mt. - 2896 m. (9,500 ft.) and glacier. Named for the glacier's former resemblance to a crow's foot.

Dolomite, Peak - 2996 m. (9,828 ft.)
Its shape resembles the Swiss Dolomites. Also may contain the mineral dolomite.

Edith, Mt. - 2554 m. (8,380 ft.)
After a Mrs. Edith Orde, who visited Banff with Lady MacDonald in 1886.

Eisenhower, Mt. - 2862 m. (9,390 ft.)
Originally named Castle Mountain by Hector in 1858; changed to honour General Dwight D. Eisenhower. (1946)

Fairholme, Range - 2839 m. (9,315 ft.)
Named by Palliser for his married sister, Grace Fairholme and her husband William Fairholme. (1859)

Fay, Mt. - 3235 m. (10,612 ft.)
After Professor Charles E. Fay, climber and member of the Appalachian Mountain Club.

Forbes, Mt. - 3612 m. (11,852 ft.)
The second highest mountain in Banff National Park. For Professor James D. Forbes, a Scottish scientist. Named by Hector. (1858)

Girouard, Mt. - 3010 m. (9,875 ft.)
For Col. Sir Edward P. Girouard, a prominent officer during the Boer War.

Healy, Creek
For Joseph Healy, a prospector who staked copper claims on a nearby mountain. His brother, J.J. Healy, opened up the mines at Silver City. (1884)

Hector, Mt. - 3394 m. (11,135 ft.), glacier and lake.
After Sir James Hector, surgeon and geologist on the Palliser Expedition. Named by Dawson. (1884)

Hungabee, Mt. - 3489 m. (11,447 ft.)
From the Stoney Indian word meaning "chief-tain".

Inglismaldie, Mt. - 3013 m. (9,885 ft.)
After Inglismaldie Castle, Scotland. Named by George Stewart, the first park superintendent. (1886 or 1887)

Ishbel, Mt. - 2877 m. (9,440 ft.)
After Ishbel MacDonald, daughter of British Prime Minister, Ramsey MacDonald.

Jimmy Simpson, Mt. - 2957 m. (9,700 ft.)
In honour of Jimmy Simpson, a well known guide and outfitter at Banff and Bow Lake (1973).

Johnston, Creek and Canyon
After a prospector named Johnston who explored the upper reaches of the creek.

Kaufmann Peaks - 3094 m. (10,150 ft.)
After Christian Kaufmann, a Swiss guide who climbed the mountain with Outram. Named by Collie. (1903)

Kicking Horse, Pass - 1627 m. (5,339 ft.), and river.
Dr. Hector of the Palliser Expedition was severely kicked by his horse while ascending the pass. Named by his men. (1858)

Lefroy, Mt. - 3420 m. (11,220 ft.), and glacier.
After Major John Henry Lefroy, a magnetic observer. Named by Hector. (1858)
Little, Mt. - 3137 m. (10,293 ft.)
After George T. Little, a member of the party who made the first ascent.

Louis, Mt. - 2683 m. (8,800 ft.)
After Louis B. Stewart, who surveyed the park with his father, George Stewart (1904).

Louise, Lake - 1731 m. (5680 ft.)
Named for Princess Louise Caroline Alberta, daughter of Queen Victoria and wife of the Marquis of Lome, then the Governor General of Canada. Originally named Emerald Lake by Tom Wilson (1862). Known as "Lake of the Little Fishes" to native Indians.

Lyell, Mt. - 3504 m. (11,495 ft.)
After Sir Charles Lyell, a noted British geologist.

Minnewanka, Lake
This Indian name means "Lake of the Water Spirit" (1888); formerly called Devil's or Devil's Head Lake, and Peechee Lake by George Simpson (1841).

Mistaya, Mt. - 3078 m. (10,100 ft.), lake and river
The Indian name for the river means "great or grizzly bear". (1901) Formerly known as Bear Creek. The mountain was named at a later date.

Murchison, Mt. - 3333m. (10,936 ft.)
Named after Sir Roderick Murchison of the Geological Survey of Britain, who recommended Hector to his position with the Palliser Expedition.

Niblock, Mt. - 2976 m. (9,764 ft.)
After Superintendent Niblock of the C.P.R. (1904).

Norquay, Mt. - 2522 m. (8,275 ft.)
After the Hon. John Norquay, Premier of Manitoba. (1904)

Noyes, Mt. - 3060 m. (10,040 ft.)
After Dr. Charles L. Noyes, a member of the Appalachian Mountain Club who made several first ascents in the Rockies.

Observation, Peak - 33113 m. (10,214 ft.)
Charles Noyes said it was so named because, when climbed, it was the most satisfactory viewpoint in the Rockies. (1898)

Peechee, Mt - 2922 m. (9,585 ft.)
After Peechee, Sir George Simpson's Metis guide. Named by Dawson (1884)

Pilot, Mt. - 2941 m. (9,650 ft.)
Named by G.M. Dawson in 1884 because it was visible for long distances down the Bow Valley. Used as a landmark by early travellers.

Portal, Peak - 2911 m. (9,552 ft.)
West of Bow Lake. Descriptive of its position at the entrance of the valley. Named by C.S. Thompson. (1916)

Rundle, Mt. - 2864 m. (9,338 ft.)
After the Rev. Robert T. Rundle, Wesleyan missionary to the Indians of the northwest from 1840 to 1848.

Sarbach, Mt. - 3261 m. (10,700 ft.)
After Peter Sarbach, first Swiss guide in Canada, who climbed the peak with Baker and Collie. Named by Collie. (1897)

Saskatchewan, Mt. - 3342 m. (10,964 ft.), and glacier. After the Saskatchewan River which is from the Cree Indian word meaning "swift current". The glacier is the source of the North Saskatchewan River.

Stewart, Canyon
After George A. Stewart, surveyor and first superintendent of the park.

Storm, Mt. - 3149 m. (10,332 ft.)
Named by G.M. Dawson in 1884 after the numerous storm clouds seen on the summit.

Sulphur, Mt. - 2451 m. (8400 ft.)
Name is taken from the sulphur springs on its slopes. Formerly known as Terrace Mtn.

Sundance, Creek, Pass and Range
The creek may have been named because it was near the site of Indian sundances.

Sunwapta, Peak - 3317 m. (10,883 ft.), pass (6,675 ft.), river and falls. A Stoney Indian word meaning "turbulent water"; the river was named by A.P. Coleman.

Survey, Peak - 2676 m. (8,781 ft.)
Climbed by Collie and Stutfield in 1898, to enable Collie to begin his plane table survey. Named by Collie.

Temple, Mt. - 3647 m. (11,636 ft.)
For Sir Richard Temple, a visitor to the Rockies in 1884. Named by Dawson (1884).

Thompson, Mt. - 3053 m. (10,050 ft.)
After C.S. Thompson of the Appalachian Club, an enthusiastic pioneer of mountaineering in both the Rockies and the Selkirks.

Two Jack, Lake
After Jack Standley, who at one time operated the boat concession at Lake Minnewanka, and Jack Watters, a former superintendent of the Bankhead Mines.

Tunnel, Mt. - 1676 m. (5,500 ft.)
The C.P.R. planned to drive a 900-foot tunnel through this mountain. A change in route eliminated the need for a tunnel.

Vermilion, Pass - 1651 m. (5,416 ft.)
Named for nearby ochre beds. Kootenay and Blackfoot Indians collected this ochre for use in war paints.

Vermilion, Lakes
Origin of name unknown.


Waputik, Peak - 2736 m. (8,977 ft.), range and icefield. A Stoney Indian word meaning "white goat". Named by Dawson. (1884)
HISTORY

Weed, Mt. - 3078 m. (10,100 ft.)
After B.M. Weed, member of the Appalachian Mountain Club, who made a number of first ascents in the Canadian Rockies. On Collie's map. (1903)

Wenkchemna, Peak - 3170 m. (10,401 ft.), pass and glacier. The word is Stoney for "ten". It is the tenth of the Ten Peaks in the Moraine Lake area. Named by S.E. Allen. (1894)

Whyte, Mt. - 2983 m. (9,786 ft.)
Named after Sir William Whyte, also known as "Smooth William", who was at one time the second vice-president of the C.P.R.

Wilson, Mt. - 3158 m. (10,361 ft.), and glacier.
After Tom Wilson, packer for the C.P.R. and well-known guide and outfitter. Named by Collie (1898).

Selected References

Reeves, B. 1976, Archaeological Investigations of Lake Minnewanka Site EhPu-1. Available at the Archives of the Canadian Rockies.
banff

national park
A History of Banff National Park

The Canadian Pacific Railway played an important role in the establishment and development of Canada's first National Park. The fledgling railway needed business and a well advertised attraction such as a resort park in the Canadian Rockies was just the thing to draw visitors from all over the world.

William Cornelius Van Horne, construction manager for the C.P.R., was impressed with the Lac des Arcs area and in 1883, thought about establishing a national park there. Sandford Fleming, the chief engineer, had also suggested a park in the Rogers Pass. The idea of national parks was a new one, but justification for a park would soon come in the form of tourist revenue. At their start, the C.P.R. and Banff National Park would become dependent on each other for their survival.

By 1883, the railway had pushed its way through the Bow Valley past Siding 29 (Banff Station) to Loggan (Lake Louise Station). That year, two C.P.R. employees at Siding 29 made a discovery that would eventually lead to the development of Banff National Park. While prospecting during their time off, Frank McCabe and William McCardell discovered the Cave and Basin Hot Springs. The commercial value of the springs was recognized and rough bath houses were soon erected. As McCabe and McCardell had not made a formal claim, an ownership dispute arose when several men laid claim to the springs. The legal battle that followed brought the hot springs to the attention of the C.P.R. and the Federal Government.

After touring the Rockies in 1884, William Pearce, Superintendent of Mines, gained the sympathy of Thomas White, Minister of the Interior, to the idea of National Parks. Both these men urged the government to establish a reserve at the hot springs.

In 1885, an order in council established a ten square mile area as the Banff Hot Springs Reserve, for "the sanitary advantage of the public". Modelled after the American reserve in Hot Springs, Arkansas, bath house sites were leased. The government however, would regulate the design of buildings and the operation of the businesses.

At about the same time, reserves were established in the Waterton Lakes area, the Selkirk Mountains, and the Mt. Stephen area.

In 1886, George A. Stewart was appointed to survey the Hot Springs Reserve. He reported to his superiors that much of the country surrounding the reserve was very scenic and suitable for a national park. Visiting dignitaries also saw the potential of an enlarged area and Stewart was ordered to extend his survey to include all points of interest. The final survey encompassed an area of 260 square miles extending from Sulphur Mountain to the end of Lake Minnewanka. Canada's first national park had its beginnings in 1887 when this area became known as Rocky Mountains Park.

The legislation of this park was modelled very closely after that of Yellowstone National Park in the United States, which had been created 15 years earlier. Rocky Mountains Park was to be "a public park and pleasure ground for the advantage, benefit, and enjoyment of the people of Canada" and would be administered by the Department of the Interior.

The Rocky Mountains Park Act spelled out the protective aspect. It stated that no leases, licences, or permits that would "impair the usefulness of the park for purposes of public enjoyment and recreation", would be issued.

George Stewart was appointed the first park superintendent, a position that he held until 1896. Howard Douglass followed, holding the post until 1908. These two men moulded the park for its first 25 years, creating a spa and resort area, regarded by many as "a playground for the rich". Although both men were familiar with conservation thinking of the day, exploitation such as lumbering and mining was allowed because of the revenue the park needed to survive.

Stewart had already prepared plans for the townsite, built the major roads, and supervised the development of the hot springs. The building of carriage roads to nearby scenic attractions soon followed: Sundance Canyon, Lake Minnewanka, and the Hoodoos.

The C.P.R. completed the Banff Springs Hotel in 1888 and a pipeline provided hot sulphur water to it and the Brett Sanitarium. The Lake Louise Chalet was built in 1890 and two years later, the Lake Louise Reservation was formed. Tourist attractions continued to be established in and around Banff townsite with the building of a boat house, animal paddock, zoo, and a museum of natural history.

Coal mining within the park provided fuel for the C.P.R. The mines at Anthracite closed in 1904, by which time the model coal mining town of Bankhead was ready for operation.

By 1902, the park was enlarged to 4,900 square miles, about twice its present size. At that time it included the Lake Louise reservation, the watersheds of the Bow, Red Deer, Kananaskis and Spray rivers.

By 1911, this area had been reduced to 1,800 square miles, a size that could be administered by the small park staff. At this time, the parks also became the responsibility of the Department of Forestry, and the Dominion Parks Branch was formed, headed by Commissioner James B. Harkin. Harkin was to be the driving force behind the national park system for the next 25 years, placing more emphasis on conservation of wildlife and preservation of the environment within the parks. In Banff three forestry and game wardens were appointed to enforce regulations and watch for fires.

The first car driven into the park was in 1904 by a Boston couple, but in 1905, cars were banned because of their alleged detrimental effects on wildlife. In 1910, this regulation was amended and by 1911 automobile travel was possible along the Calgary/Banff coach road. Harkin, being a farsighted man, realized that the coming of the automobile would bring an even higher potential for tourism. With this in mind, he succeeded in getting large amounts of money for the Parks Branch for the building of roads and trails. Regulations in 1915 permitted cars on all park roads at speeds not exceeding 15 m.p.h. The coming of the automobile marked the end of the exclusive tourist industry that the railway had created.
Relaxation of government regulation concerning the use of automobiles coincided with a road construction program that would last until 1945. This construction program took up much of the Parks Branch's annual funding; however, over-all costs were eased by the employment of prisoners of war and the unemployed during the depression of the 1930's. Work on the Banff/Radium and the Banff/Yoho roads was started in 1911; they were completed in 1923 and 1926 respectively. In the 1920's and 1930's, bungalow camps were built at Johnston Canyon, Wapta, Emerald Lake and Storm Mountain. The Banff/Jasper road was begun in 1940. By 1943, there were 263 miles of public road and 77 miles of fire road within the park.

The passing of the National Parks Act in 1930 saw one of Harkin's ambitions fulfilled; a system of 17 national parks was established. The Act clearly emphasized landscape protection, and called for the removal of all industry from the parks. It reads "the parks are hereby dedicated to the people of Canada for their benefit, education, and enjoyment - such parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations".

Rocky Mountains Park officially became Banff National Park. Boundary changes excluded areas which did not meet the new criteria and the boundaries were made more natural by following the watersheds north to Sunwapta Pass. Exclusion of the Ghost, the Kananaskis, and part of the Spray River drainage resulted in a tourist boom in the national parks. With the boom in downhill skiing in the 1930's and 1940's, less attention was paid to the hot springs baths, which were reduced in size, and the areas became mostly residential.

After 1945, post-war trends towards higher pay, increased leisure time, and increased mobility resulted in a tourist boom in the national parks. With this rise in visitation, the town of Banff began to function as a service centre, with motels, garages, and stores. With the boom in downhill skiing in the 1950's and 60's, Banff emerged as a year-round resort. Downhill ski facilities at Sunshine Village, built in 1956 and 1957, were improved and further developed in 1956 and 1963. Further development is occurring now (1979/80). The first lift at Mt. Norquay was built in 1948 and the gondola on Mt. Whitehorn in 1959. All three ski areas have undergone expansion within the last several years.

The type, as well as the numbers of visitors to Banff National Park has changed greatly over the years. The days of the exclusive resort are gone. This change resulted in the present area of 2,564 square miles. Since that time, there has been only one major boundary change. In 1949 the hydroelectric development on the Spray River was removed, resulting in the present area of 2,564 square miles.

By 1928, the Banff Springs Hotel as it exists today was completed. Banff was well on its way to becoming a summer resort town. At that time, there were no restrictions on who could live in the Banff townsite and many of the houses moved from Bankehead in 1923 were bought or rented as summer homes.

Because of the need to support Banff's tourist development, benefiting the visitor has generally taken precedence over that which would benefit only residents of the town. By 1900, there were eight luxury hotels in the Banff townsite; The Banff Springs Hotel, Brett Sanitarium, Mount Royal, King Edward, Alberta Park, Grand View Villa and the Hydro House. Improvements had been made to the hot springs baths and coach roads built to the different tourist spots. Thousands of trees were planted as part of a "beautification program". In 1904-5 the town was supplied with electricity and residents with water and sewage systems.

Improvements to the townsite continued and in 1911, construction started on the present Cave and Basin building designed by Walter Painter. The year 1914 saw a major fire destroy the King Edward Block but it was reconstructed the following year. In 1915, the swamp on the south side of the river was drained to make the recreation grounds and architect Frank Lloyd Wright commissioned to build a pavilion with fireplaces.

Establishment of the Banff School of Fine Arts in 1933 added to the cultural amenities of the town. For a time it operated in the building which presently houses the information bureau. In 1947 the government granted the school its present site on Tunnel Mountain, where it has operated ever since. Now known as The Banff Centre, the school has added advanced management and language courses to its curriculum of...
BANFF NATIONAL PARK

Drama and fine arts. The Banff Centre was affiliated with the University of Calgary for many years but was granted autonomy in the spring of 1978.

Beginning about 1910, the C.P.R. began to advertise Banff as a winter resort. The Banff Winter Carnival, first held in 1917, became a regular event; the Dominion Ski Championships were held in Banff in 1937 and 1940. With the opening of ski areas in the 50's, of developed downhill facilities for recreational skiers, Banff became established as a winter resort.

In the late 60's Calgary interests sought to attract the winter Olympics to Banff. The effort was unsuccessful, and the national parks subsequently passed a policy stating that the staging of the Olympics would be an "unnatural" and "inappropriate" attraction for a national park.

It was recognized when the National Parks Act was passed in 1930 that many of the land uses in Banff were incompatible with their park location. National Parks Branch procedures for administration of leases, regulating building standards and licencing businesses were often developed in response to patterns already established in Banff. In many cases, changes in procedures were not allowed to catch up with the actual growth of the community. In the absence of zoning policies or townsite plans, development patterns up to 1945 were often unsatisfactory. Since 1945, controls on land use in Banff have been tightened considerably.

Numerous studies have analyzed Banff's problems and several townsite plans have been developed. However, fundamental problems remain in managing a thriving commercial centre set within an area in which preservation of the natural landscape is overriding concern. The role that the Banff townsite played in the development of Banff Park is obvious. However, when new national parks are established today, every effort is made to determine whether a townsite is necessary, and if so, to locate it outside the park boundaries. In this way, future park townsite problems may be avoided.

Bankhead

Bankhead, once a prosperous mining town of 900 people, now lies quiet and deserted five miles from Banff along the Lake Minnewanka road. Everything has disappeared except a small cenotaph, some building foundations and the slag heaps, evidence of man's early exploitation of the park.

The operation of the C.P.R. demanded coal for the locomotives that hauled freight and passengers across the mountains. Two coal mines had already been established at Anthracite and Canmore; the railway was dependent upon them. Problems at the Anthracite mine prompted the C.P.R. to survey the surrounding area. In 1902, it had obtained a licence of occupation covering 7,360 acres of coal lands within the boundaries of the Rocky Mountain Park. When the Anthracite mine closed, coal was never re-opened. Since Bankhead supplied the electricity for Banff, the power house could not be closed down until there was an alternate power source for Banff. The powerhouse and briquetting plant ran for another 18 months and were shut down in 1924 when the generating station at Lake Minnewanka began operation.

The mine was established in 1903 and began major production in 1905. During the peak years, up to 1911, the mine produced half a million tons of coal a year. It employed 275 men below the ground and 195 above. From 1912, the year of the first labour strike, the mine began to decline. The final blow came with the general strike of 1922; the mines were never re-opened. Since Bankhead supplied the electricity for Banff, the power house could not be closed down until there was an alternate power source for Banff. The powerhouse and briquetting plant ran for another 18 months and were shut down in 1924 when the generating station at Lake Minnewanka began operation.

The closure of the mine was a reflection of high operating costs rather than a direct result of the 1922 strike. Costs had been pushed up by the friability of the coal and the long distances to the markets other than the C.P.R. Competition from the mines in Canmore, Lethbridge and Drumheller had been critical.

The development of the town, which was the pride of the C.P.R. and the federal government, went along with the development of the mine. The well-planned residential area was serviced with electricity, running water, and sewers; the powerhouse supplied Banff with its first electricity. The town had two dairies, a butcher, a baker, a general store, a Chinese laundry. There was a church, a school, and a selection of sports facilities which included a football field, baseball diamond, tennis courts, and both skating and curling rinks.

The town cemetery had an interesting history. Apparently, the residents were a bit superstitious and no one wanted to be the first one to be buried there. The cemetery's sole occupant was a friendless Chinese labourer who had been the town's only murder victim; later his remains were shipped back to China.

With the closure of the mine came the abandonment of the town. The houses were sold and moved to Calgary, Canmore and Banff where many still stand. The townsite had effectively ceased to exist by 1925.

When present day preservationist policies are considered, one wonders how a mining town was established in a national park. Both the demand for coal and the demand for revenue for the park were high around the turn of the century. Park policy was much more flexible then and coal mining was considered to be an appropriate use of the park. Although once regarded as a "model town" for a national park, a town such as Bankhead could never have been established after the passing of the National Parks Act in 1930. Its ruins and slag heaps remain as an example of how park policy has changed over the years.
Bankhead played a significant part in the history of Banff National Park, and the abandoned town is presently being developed as an interpretive site. A variety of approaches are being used to tell the story of Bankhead... its mines, its buildings and its people. A self-guiding trail and pamphlet are available now; future plans call for on-site exhibits.

Early Exploitation in Banff Park

It is very difficult to assess the effect that either the pre-European populations or the early fur traders and prospectors had on the mountain landscape. It is thought, though, that their impact was quite limited. Drastic changes to the landscape began in 1881, when the decision was made to route the C.P.R. through the Bow Valley. Fires were started by survey and construction crews and later by sparks from the engines. The forests were cut to provide fuel, railway ties, and pit props for the coal mines. Thousands of railway workers had to be fed; lakes were dynamited for fish and wildlife populations were decimated.

Men's impact on the area continued after the establishment of Rocky Mountains Park. By 1905, most of the Bow Valley had been burnt over and lumbering, mining and quarrying were all allowed. Some controls were implemented in 1916, but final removal of these industries did not come until the National Parks Act was passed in 1930.

Mining

Large coal deposits exist in the Bow Valley with seams running in a north-westerly trend from Canmore to Cascade Mountain. Much of the mining was centered around this coal deposit, but copper, zinc, and lead have also been mined in other parts of the park. Quarries have removed gravel and limestone for use in the manufacture of cement was quarried in Exshaw when that area was still within park boundaries.

The first mining development was at Silver City, located at the base of Castle Mountain. It began when a Stoney Indian showed prospector J.J. Healy a piece of ore which was high in silver and copper content. Healy staked a claim in the Castle Mountain area and soon a thousand people flocked to the site. Silver City with its four mines was a boom town; a lime kiln was built and work was started on brick and lumber yards. However, the town was short-lived; speculators sold their stock and moved out. The mines never did produce silver, and the mining of copper, lead and zinc deposits was soon found to be uneconomical. By 1885, Silver City was a ghost town.

Prospector Joe Smith was one of the first settlers to come to Silver City and also the last one to go. He stayed on at his cabin there for another 54 years. Smith was allowed to continue his life as a trapper, although Park regulations enacted after his arrival forbade the harvesting of wildlife. In 1937, he was overtaken by old age and partial blindness and was persuaded to enter the Iacome Home in Midnapore; he died there a few months later.

In 1915 another silver mine was started at Eldon, across the valley from Silver City; the first world war ended this project. The next year a ruling was passed to say that new mines were no longer allowed in the park.

In 1905, the Western Canada Cement and Coal Co., backed by the C.P.R., opened the limestone quarry and cement plant in Exshaw. Although closed in 1916, it was re-opened shortly afterwards. With the boundary changes which accompanied the Parks Act in 1930, Exshaw, its quarry and cement plant was excluded from the park.

Coal was discovered in the Cascade Basin in 1883, and a mine was soon established at Anthracite (just east of the present day traffic circle) to provide fuel for the Canadian Pacific Railway. The Canadian Anthracite Company took over the mine in 1885 and ran it for two years until the seams became difficult to work. The company then moved to Canmore, where coal had been discovered in 1886. Although the Anthracite mine continued to operate on a sporadic basis, the C.P.R. had already begun looking around for more coal.

In 1902, they had obtained a licence of occupancy covering 7,360 acres of coal land near Cascade Mountain. The mine at Bankhead was opened in 1903 and by 1904, there was a new townsit in the park. The coal at Bankhead was high in heat value but was friable or easily broken; much of it was converted into briquettes which could be more easily handled. The mine never operated at peak capacity because of high production costs and competition from other mines. After the lengthy general strike of 1922, the Bankhead mine was never re-opened (see Bankhead section for more detail).

The operation of the Bankhead mine reflected the national park policy of the day. The C.P.R. need for coal was obvious and mining within the park was not inconsistent with policy at that time.

Lumbering

The Eau Claire Lumbering Company had several large timber berths in the Banff area including ones on Stoney Squaw and in the Spray Valley. As early as 1889 the government had made an effort to stop this lumbering by offering berths outside the park in exchange. By 1902, when the park was enlarged, timber berths were limited to 360 square miles, some of these owned by the C.P.R. The Dominion Forestry Reserve Act of 1906 prohibited the cutting of timber in the Front Ranges to protect water resources. After that time, permits were required for collecting dead wood, and except for the clearing of roads, lumbering was not allowed.

Hydroelectric Development

In 1912, a small dam was constructed at the outlet of Lake Minnewanka. At this time, the powerhouse at Bankhead provided the town at Banff with its electricity. However, with the closure of the Bankhead mines in the early twenties, Banff needed a new power supply. In 1924, to meet this demand, the government authorized construction of a new powerhouse at the site of the original Lake Minnewanka dam. In 1941, the hydroelectric facilities at Lake Minnewanka were greatly expanded as part of an overall wartime effort. A new and larger dam was constructed at that time and the water level of the lake raised by about six feet. The Canmore Power Station on the north side of the Trans-Canada highway has been in operation since that time.
Parks Philosophy and Policy

"The parks are hereby dedicated to the people of Canada for their benefit, education and enjoyment, and such parks shall be maintained so as to leave them unimpaired for the enjoyment of future generations."

Dedication Clause
Section 4
National Parks Act 1930

An examination of the history of Banff National Park from exclusive spa to present day shows that the philosophy behind national parks and the policies governing them have undergone a long evolution since 1885. The dedication clause (above) has had a number of interpretations since 1930, all of which reflect the changing values of the Canadian public.

The original Banff Hot Springs Reserve was established for the "sanitary advantage" of the public. It was recognized by both the government and the C.P.R. that development of the springs would be a great attraction. Some fish and wildlife studies were done, but in general, little attention was given to conservation.

The Rocky Mountains Park Act declared Banff to be "a public park and pleasure ground for the benefit, education and enjoyment of the people", and both the government and the C.P.R. did much to foster the image of Banff as an exclusive resort. The Act did contain some protective clauses and some efforts were made towards conservation. These included attempts at reforestation and removal of logging from the park, tightening up of hunting regulations and the formation of a "Fire and Game Commission". However, until 1911, these protective clauses had very little effect; mainly because the park had little money or manpower to enforce them.

By 1911, a new act was passed, and Commissioner J.B. Parkin embarked upon his program of tourist promotion combined with wildlife conservation and protection of the environment. A protectionist policy was developed between 1911 and 1945 with the gradual removal of many activities now considered inappropriate from the park. The regulations for coal mining were tightened and the development of new mines was banned. Fishing regulations were published and in 1918 the Dominion Wildlife Division (later the Canadian Wildlife Service) was formed.

The National Parks Act, passed in 1930, was a policy statement which emphasized that the parks were to be left "unimpaired for the use of future generations". The removal of all industry was called for and this resulted in the excision from the park of the town of Canmore and other areas used for mining and lumbering.

By 1930, Canada's national park system had expanded to 17 areas. Provisions had also been made for the establishment of National Historic sites. The Dominion Parks Bureau continued its travel promotion program which offered the parks as Canada's main tourist attraction. This reflected the policy of the day which still viewed the national parks primarily as resorts.

A major milestone was passed when a more comprehensive policy statement was produced in 1964. In the ecology conscious sixties, attitudes concerning the purposes of national parks changed markedly. New policy dealt with specific issues such as transportation and ski areas. Present day policy has been influenced by the public hearing process which was initiated in the early seventies. The strength of public input in policy decisions and planning proposals was shown in 1972 when plans for a large-scale development at Lake Louise were shelved. Today the national park system has been greatly expanded. The objectives considered appropriate for our parks now are very different from those deemed appropriate fifty years ago.

"The national parks are part of Canada's natural heritage and should be maintained as a trust so that Canadians now and in the future can experience undisturbed landscapes of exceptional and distinctive quality -- their forms, plants and wildlife -- existing in as nearly a natural state as possible."

Some 50,000 square miles of Canadian landscape are now preserved in 28 national parks. These include Wood Buffalo, one of the largest national parks in the world and Auyuittuq in Baffin Island, the world's first national park north of the Arctic Circle. Each of these parks is an example of a unique or representative Canadian landscape, flora or fauna. There are still many of these "special" areas where the government would like to establish parks; a complete national park system would include about fifty parks.

Park Administration

Parks Canada is under the jurisdiction of the Federal Department of the Environment. Regional Offices of Parks Canada are located in Cornwall, Ontario; Ste. Foy, Quebec; Winnipeg, Manitoba; Halifax, Nova Scotia; and Calgary, Alberta. Much of the planning for national parks is done at these regional offices.

The operation of an individual park is the responsibility of three departments: Resource Conservation (or Warden Service), Interpretive Service, and Visitor Services. Visitor Services operates the Information Bureaux, campgrounds, gates and hot pools, and is also responsible for backcountry trails and shelters. The Interpretive Service has an educational function and offers a year-round communication program to increase awareness and understanding of the park. Interpretive programs are offered free of charge and all members of the public are welcome. The Warden Service is in charge of visitor safety and resource conservation. Some warden responsibilities include mountain rescue, avalanche control, monitoring of wildlife populations, bear management and the enforcement of regulations such as illegal camping and the feeding of animals. In addition to these three operational groups, the park depends upon several support functions including General Works, Personnel and Finance and Administration.
Park Planning and Management

Zoning for Use

Parks policy has historically called for both preservation and recreational use within the parks. The problems inherent in trying to satisfy these two differing objectives have become more obvious in recent years; many areas of the park are now showing signs of overuse. Park planners have developed a five class zoning system that will be the basic mechanism used to manage the parks and to plan for various types and intensities of use. The boundaries of these zones will be determined by reference to resource inventories, environmental impact studies and other research.

The five classes are as follows:

I Special Preservation
II Wilderness
III Natural Environment
IV Recreation
V Visitor Services

The level of resource protection decreases from I through V and the intensity of visitor use increases from I through V.

This system will serve to direct visitation away from unique or fragile areas and to limit high intensity use to townsites and transportation corridors. In addition, a visitor use plan has been developed that deals specifically with camping. Along the major transportation corridors, camping is permitted only in developed campgrounds. In the more heavily used backcountry areas, backpackers are required to camp at designated campsites, with fires where allowed. Only in the more remote areas of the park is random camping allowed.

All persons wishing to camp in the backcountry now require a "park use permit". This permit, along with a backcountry use pamphlet, is available free of charge at your nearest information bureau or warden office. Statistics gathered from these use permits will give resource managers an indication of how the park is presently being used. Registration for those undertaking high risk activities is now on a voluntary basis. Registration must be done in person at the nearest warden office. Return registration (either personally or by telephone) is required by law.

Management of Vegetation/Fire Control

The vegetation of the park has been greatly changed since the pre-European days. The introduction of horses brought clover and certain species of grasses, road builders used hardy imported species along roadsides, and gardens have been the source of such ornamental flowers as the Iceland poppy and the delphinium. Present policy suggests that only native species are to be used along roadsides and in reforestation programs. Rehabilitation of overused areas with native species is in the experimental stage.

Preservation oriented management in national parks has often worked to create an "ideal" or very uniform kind of forest or vegetation. It is now recognized that the natural distribution of plants is not constant and that man's interference often disrupts the natural dynamics of the ecosystem. Chemical control of disease, parasites, and insects is not generally allowed in the parks.

The high incidence of fire in the early days and subsequent fire control have had major effects on the flora of the park. The most obvious evidence of fire is seen in the dense stands of lodgepole pine found throughout the park. Early stages of lodgepole pine succession (since 1968) can be seen at the Vermilion Burn on the Radium Highway near Eisenhower Junction. Fire control has had a great effect on vegetation patterns in the park and many successional changes have taken place in the absence of fire.

There has been a marked reduction in the extent of early successional stages; grassland has been invaded by shrubs and trees and shrubby areas have become dense forests. This may become critical to wildlife populations when it limits their food supply and causes high competition on the comparatively small area of winter range. Another effect of fire control has been the buildup of large amounts of dead wood; this accumulation of fuel poses a major hazard should a fire occur which cannot be quickly controlled.

The role that fire plays in shaping natural ecosystems has been recognized by park managers. However, the fire suppression program will be continued because of the threat that large uncontrolled fires pose to the aesthetics of the park, to public safety, to facilities and to land outside the park. Natural fires occurring in remote areas will be allowed to burn as long as they do not threaten the rest of the park. Controlled burning has been used on an experimental basis in the grassland parks of Prince Albert and Riding Mountain as well as in Jasper. The whole subject of controlled burning is presently under study.

Wildlife Management

One of the major reasons for the creation of national parks is to give sanctuary to natural populations of large mammals which have disappeared from much of their former range; the grizzly bear and the wapiti are good examples. Attitudes toward wildlife in the parks have changed over the years. At one time no attempt was made to exclude wild animals from management units. Indeed, visitors were encouraged to visit dumps to see the bears. There were also campaigns to destroy predators such as wolves and other programs to control closely the populations of big game animals like the wapiti.

It is often hard to prove whether certain management techniques are beneficial or harmful. In many cases it is likely that man's interference disrupts the natural continuity of the population. For example it is well known that certain animals such as the snowshoe hare, the lynx, and some of the ungulates (hooved animals) undergo drastic fluctuations in numbers. Man has often interfered by harvesting at times of peak population. Crashes in the populations of prey species were often attributed to increased predation. Today we know that this is only part of a natural cycle.

It has now been shown that predators have a beneficial culling effect on prey populations because they prey selectively upon the animals that are old or in poor physical condition. Population levels of prey species are controlled not only by predation but by a
host of other factors such as the quality of available range and the susceptibility to disease and starvation. In view of the general lack of reliable data in the field of wildlife management, artificial control of animal populations in the parks is now kept to a minimum. Both the zoning system and the master planning process work towards preserving the areas which are important as key wildlife range or territory. For example, the proposed road development in the Cascade Valley was stopped mainly because of the effect it would have had on isolated game populations.

Bear Management

Bears present a particular management problem in the national parks. They often frequent highways and campgrounds where they lose their natural fear of man. It is these "people conditioned" bears that pose the greatest risk to human safety, particularly when they become bold in the backcountry.

When bear-man encounters are examined, both sides of the conflict should be considered. Bears that become dependent on human sources of food may destroy property and pose a threat to the safety of park visitors and residents. On the other hand, these bear's habituation to man often results in a direct threat to their own lives. Particularly troublesome bears have to be destroyed by the Warden Service; others are killed on the park highways.

In trying to solve its bear problems, the park has had a continuing program to educate visitors and park staff on the history and habits of bears and the importance of adequate garbage control. The Warden Service also monitors bear populations, live-trapping nuisance bears in campgrounds and roadsides to relocate them to more isolated areas. The value of the relocation program has its limits: many-time offenders, if removed, would present a high risk to backcountry hikers. These bears are usually destroyed. The enforcement of the new "no feeding" regulation which applies to all animals in the park and carries a maximum $500 fine, will perhaps help to reduce the frequency of roadside feeding.

Incidents involving injury inflicted by bears do occur from time to time in the mountain parks. Black bear incidents occur mainly along roadsides and usually involve feeding or some other form of provocation. Grizzly incidents generally involve a chance or surprise encounter in the backcountry. Many of these cases involve a grizzly sow with her cubs. Research by Stephen Herrero indicates that there have been relatively few major incidents involving grizzly bears in the park. Considering the millions of people who have visited the park, the average visitor has an extremely low chance of encountering an aggressive bear.

Fisheries Management

Fishing is considered to be an appropriate recreational activity in the national parks. Fish populations are monitored to ensure that they can maintain their numbers and limits are set accordingly. Fish stocking programs today are not as extensive as they once were. Lakes that would not normally support fish populations are no longer stocked. Johnson Lake and the Vermilion Lakes are examples of lakes that are stocked annually.

Selected References


Marty, Sid, 1978, Men for the Mountains, McClelland and Stewart Ltd., Toronto.


geology
Figure 1
(not to scale)

CANADIAN CORDILLERA
CROSS-SECTION THROUGH CALGARY AND VANCOUVER

1 PLAINS
2 FOOTHILLS
3 ROCKY MOUNTAINS
4 ROCKY MOUNTAIN TRENCH
5 PURCELL MOUNTAINS
6 SELKIRK MOUNTAINS
7 MONASHEE MOUNTAINS
8 INTERIOR PLATEAU
9 COAST RANGE
10 VANCOUVER ISLAND RANGE
The Canadian Rockies are just one part of the great mountain system called the Cordillera, which extends along the western edge of both North and South America. In Canada the Cordillera occupies almost all of British Columbia, southwestern Alberta and the Yukon. In Alberta and southern B.C., the Cordillera is made up of two distinct mountain systems: the eastern Cordillera, consisting of Rocky Mountain foothills and the Rocky Mountains, and the Western Cordillera, extending out to the Pacific coast. A wide northwesterly trending valley known as the Rocky Mountain Trench separates these two units; towns like Invermere, Golden and Radium are found along its length.

In the Eastern Cordillera, the low rolling foothills extend from the western limit of the prairies (at about Jumping Pond Creek) to the actual mountain front. The Rocky Mountains extend westward to Golden, B.C. in the Rocky Mountain Trench.

The Rockies trend in a southeasterly-northwesterly direction and may be divided into three sub-provinces: the front, the main and the western ranges. The front ranges extend across the eastern part of Banff National Park and the main ranges form the peaks of the continental divide. The western ranges are all to the west of Banff National Park.

The geology section which follows divided into three parts. The first part presents two theories related to mountain building and then discusses the development of the Rocky Mountains in terms of these theories. The second part discusses the structural geology of the Rockies and outlines the differences between the front, the main and the western ranges. The final part presents the geological time scale and briefly examines the changes in fossil life through the ages.

**Mountain Building**

In trying to discover the causes of the mountain building process, geologists have studied all of the major mountain systems of the world. Yet, despite all of the advances of modern day technology, many things remain unexplained. The major problem is that geological processes take place at a very slow rate, and a human lifetime is too short to observe more than a few minor events. For instance, to observe the development of the Rockies would have taken millions of years.

A widely accepted theory on the origin of the Rockies is presented in the following section. The theory has two parts: the geosyncline theory and the theory of plate tectonics. These two parts were only recently put together to provide a single, logical story.

**Part One: The Geosyncline Theory of Mountain Building** (See Figure 2)

In the 19th century, British geologists made the observation that the major mountain systems of the world are (or once were) located along the edges of the continents -- for example the Andes, the Appalachians and the Himalayas. The types of rock exposed in these mountain regions further suggested the theory that all of these mountain systems had their beginnings in GEOSYNCLINES or immense troughs formed by downwarping of the earth's crust along the continental margins.
DEVELOPMENT OF GEOSYNCLINE MOUNTAINS

A. Downwarping of the Crust Begins
An area along the edge of a continent begins to warp downward to form an elongated trough known as a GEOSYNCLINE.

B. Sediments Accumulate
Rivers pour gravel, sand and silt into this lowland area. Downwarping continues until the nearby ocean floods the trough to form a shallow sea. Sediments continue to accumulate.
C. Sediments Become Sedimentary Rock
Downsinking continues but is counterbalanced by the constant inflow of sediments so that the sea remains a shallow one. Over millions of years, great thicknesses of sediment accumulate in the trough. The increasing pressure from above causes the soft sediments to compact into sedimentary rock.

D. Compression and Uplift
The trough area is then severely compressed, causing the rock layers in it to be uplifted, folded and broken by cracks or faults. Heat and pressure may partially or completely melt the rock in the cores of the newly uplifted mountains. This eventually solidifies to form metamorphic rocks such as schist or gneiss.
E. Reduction by Erosion

As soon as the rock layers are uplifted from the sea, they are subjected to erosion by the elements. Rivers and glaciers carve out valleys and peaks are made more rugged. This is the stage of development of the Rocky Mountains at the present time.

F. The forces of erosion over hundreds of millions of years will then wear down these rugged mountains until they resemble the low hills of the present-day Appalachian Mountains. Eventually, erosion will be complete and the area where mountains once stood will be a flat plain. The granitic Canadian Shield country of northeastern Alberta is an excellent example of such an area.
Part Two: The Theory of Plate Tectonics

(See Figure 3)

While the geosyncline theory reconstructs the history of many mountain regions, it does not explain the causes of the downwarping and uplift. A recent theory attributes this disturbance to the movement and collision of large portions or "plates" of the earth's crust.

The theory of "continental drift" (now known as plate tectonics) was advanced early in the 20th century. At that time, a geologist named Wegener noticed that the east coast of the Americas looked as though it would notch into the west coast of Europe and Africa. His theory suggested that the two land masses had once been joined but later drifted apart.

Although Wegener thought that only the continents drift about, his successors have discovered that the oceans are floored by moving crust as well, and that both the continental and the oceanic plates, which are made of relatively light rocks, drift about slowly on the heavier, near molten rock of the underlying mantle. It has also been shown that the zones where continents and oceans meet are the site of earthquakes, downwarping, and uplift - in short, the locations of geosynlines and mountain ranges. The entire cordillera of North America and South America, for example, lies along the western margin of these continents, near their uneasy junction with the Pacific Ocean's floor.

It was not until recent years that explorations of the earth's ocean floor provided some concrete proof of these plate movements. Scientists discovered oceanic ridges in some oceans, notably the Atlantic and the Pacific. These ridges, known as "spreading centres", appear to be "hot spots" in the earth's crust where lava occasionally wells up from the earth's mantle or molten core. When this lava is pushed up, it causes the ocean floor to expand or spread and push against the continental land masses on either side. This spreading action proceeds at a very slow rate; active plates may expand at a rate of a few centimeters per year.

The theory of "plate tectonics" states that the earth's crust is made up of a number of plates that are constantly in motion. Some of these plates are very large, (the entire North American continent is one plate) and some are much smaller (the Middle East is made up of several plates). These plates push against one another, grind edgewise, weld together and overlap in complex ways.

The driving force of plate tectonics is the heat from the earth's molten core. Just as a pot of boiling water has convection (heat) currents in it, so does the molten rock in the earth's core. Plate motion originates at the oceanic ridges where these currents bring molten lava to the surface.

When two plates which are moving in different directions meet, the leading edge of one plate is forced down under the other. For example, along the coasts of British Columbia, the Pacific plate slides down under the North American plate. These areas, where moving plates slide back down to the depths of the earth, are known as "subduction zones". Earthquakes are often related to these zones and geologists can follow the path of the moving plate by monitoring earthquake activity.

The next question is how does all this relate to mountain building in the Rockies? . . . Well, it appears that the compressive forces exerted by these moving plates may also be the forces that cause the folding and faulting of geosynclinal mountains.

For example, geologists think that around 500 million years ago, the North American plate began to push eastward against the plate containing Europe and Asia. As the plates came together, a high mountain range was squeezed up between them. This theory would explain the formation of the present day Appalachian Mountains of eastern North America.

About 150 million years ago, it is thought that North America and Europe began to separate. As the North American continent was carried westwards, it began to push against the wedge of sedimentary rock on its west coast. Geologists believe that this pressure caused volcanic activity along the coast and later culminated in the folding and faulting of the Rocky Mountains. Evidence suggests that the Rockies were built between 57 and 65 million years ago.

The Development of the Rocky Mountains

Now that the geosynclinal theory and the theory of plate tectonics have been combined to form a coherent explanation of mountain building, the history of the Rockies can be charted.

The Geosyncline

Although it is virtually impossible to set a date to the beginning of the geosyncline in Western Canada, the rock record in Waterton Park and southwestern B.C. shows that it may have been in existence as early as 1600 million years ago. However, because the rocks exposed in the Rocky Mountains are generally much younger in age, we will begin this history at the beginning of the Palaeozoic Era which was about 600 million years ago.

At this time, the geosyncline was well developed in Western Canada. Sinking of the unstable areas along the edge of continent had created an enormous trough which extended from British Columbia to western Manitoba. This trough was bordered by two high areas, a mountain system to the northwest and the granitic Precambrian Shield to the east. A lobe of the Pacific Ocean had flooded the trough and a warm shallow sea extended eastward to the present day Plains - Cordilleran boundary just west of Calgary.

This was the beginning of a period of erosion and deposition that lasted for over 500 million years. During this time the seas advanced and retreated many times - at times covering all of Western Canada (B.C., Alberta, Saskatchewan and Manitoba) and at times leaving the plains area high and dry. Except for periods of minor uplift, the Rocky Mountain region was below sea level throughout this time.

The land masses adjacent to the sea were subjected to weathering by wind and water. Rivers picked up the debris and carried it westward to form a huge delta along the sea shore. The heaviest sediments, gravel and sand were dropped first, but the finer sediments like silt and clay were often carried far out to sea. The seas teemed with animal life and when these animals died the remains of their shells and
Figure 3

PLATE TECTONICS THEORY OF MOUNTAIN BUILDING

1 Convection currents originate in the earth's mantle.
2 Lava rises in the "spreading centre", causing the Pacific Plate to expand.
3 The Pacific Plate pushes against the edge of the North American and Asian plates and eventually slides underneath the continents in the subduction zones.
4 Volcanic activity along the west coast.
5 Formation of igneous and metamorphic rock in the western cordillera, and,
6 Folding and faulting of the Rocky Mountains.

The pressure of the Pacific Plate against North America causes:

ASIAN PLATE

PACIFIC OCEAN

PACIFIC PLATE

MANTLE

MANTLE

NORTH AMERICAN PLATE

ROCKY MOUNTAINS
skeletons were added to the growing thickness of sediments on the ocean floor. Because this sea was a warm one, it was able to hold large quantities of chemicals in solution; under certain conditions these chemicals were precipitated. Perhaps the most important of these chemicals was calcium carbonate which was often precipitated to form lime mud. (This would later become limestone). Other chemicals known as evaporites were precipitated under special conditions to form rock salt, potash and gypsum. Potash, which is used in the manufacture of fertilizers is mined today in southern Saskatchewan.

As the geosyncline was being filled with sediments, it continued to warp downwards. Subsidence was always greater on the western side and this resulted in the formation of a huge sedimentary wedge which thickened towards the west.

These sediments reached such thicknesses that the lower layers became very compacted. As the pressure from above increased, the sediments were gradually converted to sedimentary rock. The original sediments of various sedimentary rocks were as follows:

<table>
<thead>
<tr>
<th>Sediment</th>
<th>Sedimentary Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>gravel</td>
<td>conglomerate</td>
</tr>
<tr>
<td>sand</td>
<td>sandstone</td>
</tr>
<tr>
<td>silt</td>
<td>siltstone</td>
</tr>
<tr>
<td>clay</td>
<td>shale</td>
</tr>
<tr>
<td>lime mud</td>
<td>limestone</td>
</tr>
</tbody>
</table>

Animals remains were often preserved in these rocks as fossils.

The Withdrawal of the Seas

About 150 million years ago, the seas began to withdraw from western Alberta for the last time. A major episode of mountain building known as the Coast Range Orogeny was underway to the west while to the east the inland seas continued to ebb and flow over the plains. The area that would become the Rocky Mountains still remained relatively undisturbed. It was a low swampy plain where dinosaurs roamed amongst lush vegetation. The plant remains deposited in these swamps were later compressed to form the seams of coal that have been mined at Anthracite, Bankhead and Canmore. Dinosaur fossils are found in the rock formations further east, on the prairies.

The Building of the Rocky Mountains

The shaping of the Rocky Mountains began about 60 million years ago when tremendous compressive forces (perhaps due to plate tectonics) were applied to the southwestern section of North America. As these forces were transmitted through the continent, they began to act upon the enormous wedge of sedimentary rock which stretched across the region that was to become the eastern Cordillera. Geologists call this period of mountain building the Laramide or Rocky Mountain Orogeny.

In the Rocky Mountains area, the rock layers began to bend into huge folds, just the way a newspaper would if you held it in two hands and pushed towards the middle. Unlike the newspaper, these rock layers could not bend indefinitely and as the pressure increased they began to break along fracture lines called FAULTS. The final result of these continued compressive forces was that massive blocks of rock known as FAULT BLOCKS began moving upwards and north-eastward along the major fault lines, sliding up and over the younger rocks beneath them. In this process, known as THURST-FAULTING, older rocks are thrust over younger ones, making the geological record particularly confusing. The whole of Mt. Rundle, for example, is a huge fault block that has been thrust up over the younger rocks found on the floor of the Bow Valley. (See Figure 6)

Thrust faulting in the Rockies proceeded from the west to the east. Because of this, the largest displacements are in the western part of the park. The rocks forming the mountains of the Lake Louise area have been moved horizontally from 50 to 80 kilometres and displaced 4300 metres vertically.

The McConnell Thrust, which can be seen clearly on the face of Mt. Yamnuska, was the last major thrust fault of the Rocky Mountains in this area. It has a vertical displacement of about 3600 metres and a horizontal displacement of just over 3 kilometres.

Thrust faulting in the foothills area was quite shallow with minor displacement of rock layers. It is thought that the thrust faulting of the Rocky Mountains was complete about 40 million years ago. However, we cannot rule out the possibility that the rock layers are still moving at an imperceptible rate.

Erosion of the Rockies

The remainder of the mountain story is one of erosion; the destructive effects of wind, water and ice. This erosion actually began as soon as the western landmass was raised above sea level and has continued from that time until the present. For example, it is believed that the ancestral Bow River existed before the front ranges of the Rockies were formed. As the mountains rose up, the Bow River constantly cut down through the rock layers; the erosion keeping pace with the uplift. Because of this, the present Bow River cuts across the front ranges as it flows east past the towns of Banff and Canmore. Erosion has given the Rockies their rugged character and their distinctive shapes. The Ice Ages had a major effect on the topography. Where the great glaciers gouged their way through, the peaks were made sharper and the valleys broader and more U-shaped. Since the Ice Ages, young rivers flowing down from the peaks have cut narrow canyons and deep V-shaped valleys.

In terms of geological time, the Rockies are still relatively young mountains; the process of erosion will continue for many years to come. Judging from what we can see in other parts of the world, it will take a long time for the Rockies to be worn down to a low plain: perhaps several hundred million years.

Activity to the West (See Glossary of Terms)

Along with the disturbance that raised the Rockies came a period of renewed mountain building in the Western Cordillera (British Columbia). This mountain building was accompanied by volcanic activity along the west coast and wide-spread intrusion of igneous rocks. This igneous rock (mainly granite) was formed because of the intense heat and pressure of the mountain building. In parts of eastern B.C., where the heat and pressure were not quite as intense, metamorphic rocks were formed. These rocks were changed in structure but not actually melted.
The mountain building forces in the Rocky Mountains were much less intense than those farther to the west, so the Rockies were not subjected to tremendous amounts of heat and pressure. Because of this, the rocks did not undergo melting and so remained predominantly sedimentary in nature. Metamorphic rocks can be seen in a few locations in the western main ranges, but there is only one small outcrop of igneous rock known in Banff Park. This intrusion of diorite can be seen along the side of the Banff-Jasper Highway near the Crowfoot Glacier viewpoint.

Glossary of Terms

Igneous Rocks

IGNEOUS ROCKS are the result of hardening of magma or molten rock which is formed several miles below the earth's surface. Because this magma is under great pressure it is often pushed up or intruded into the overlying rocks. These INTRUSIVE rocks are sometimes exposed when erosion removes the surface rocks. Granite, found through the Canadian Shield is a common intrusive igneous rock. Some of the magma may force its way to the surface and pour out as a lava flow. This lava cools to form EXTRUSIVE igneous rocks such as basalt, which is common throughout western and central B.C.

Sedimentary Rocks

SEDIMENTARY ROCKS are the result of the compres sion of hardening of SEDIMENTS, or particles that have been broken or dissolved from pre-existing rocks. These sediments have usually been deposited by water, although they may have been carried by wind or glaciers. Sandstone, shale and limestone are common sedimentary rocks.

Metamorphic Rocks

METAMORPHIC ROCKS are formed when rocks of any kind are subjected to heat and pressure. The rocks are not entirely melted, but they undergo a METAMORPHOSIS or changes in structure so that new colours or even new minerals are developed. Some common metamorphic rocks are:

<table>
<thead>
<tr>
<th>Original Rock</th>
<th>Metamorphic Rock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite</td>
<td>Gneiss</td>
</tr>
<tr>
<td>Shale</td>
<td>Slate and Schist</td>
</tr>
<tr>
<td>Sandstone</td>
<td>Quartzite</td>
</tr>
<tr>
<td>Limestone</td>
<td>Marble</td>
</tr>
</tbody>
</table>

Structural Geology

The structure of the Rocky Mountains today is the result of three things: the rock composition, the mountain building forces and the forces of erosion. The basic mountain building forces were the same throughout the Rockies, but there was some variation in intensity. The forces trended from southwest to northeast and caused layer upon layer of rock to be thrust over one another. The occurrence of THRUST FAULTS is the dominant element in the structure of the Rockies. The fold structures are also very important: ANTECILINES AND SYNCILINES varying from a few feet to several miles across may be seen.

Definition of Structural Terms

(See Figure 4 for illustration)

Anticline

A structure resulting from the upfolding of beds into an arch-like form. In an anticline, the rock beds incline away from the crest on either side.

Syncline

A structure resulting from the downfolding of beds. In a syncline, the rock beds incline inwards towards the centre of the trough.

Fault

A break or fracture of the rock layers in which one side has been displaced relative to the other.

Normal Fault

A fault in which rock layers above the fault have moved downward relative to those beneath them. In a normal fault the vertical displacement is much greater than the horizontal. These faults are generally thought to be the result of tension in the earth's crust and may be expected where the earth's crust is stretched up into an anticlinal structure, e.g. the Lake Louise area.

Thrust or Thrust Fault

A fault in which the rock layers above the fault have moved upwards as well as horizontally along the fault line. In thrust faults the horizontal displacement is usually much greater than the vertical.

Overthrust

Overthrusting occurs when the rock layers above the fault are thrust up and over the lower layers, e.g. the McConnell Thrust. (See Figure 6)

Fault Block

A body of rock bounded on both sides by a fault. When thrusting occurs a fault block is thrust up as a unit, e.g. Mt. Rundle. (See Figure 7)

Structural Provinces

Within the Rockies there are four structural provinces, each with its own distinctive features. These are the foothills, the front ranges, the main ranges and the western ranges. Only the front and main ranges are found in Banff National Park. The western ranges extend from about Field, B.C. to the Golden, B.C. area. (See Figure 5 for a cross-section of the Rockies).

The Foothills

The foothills extend westward from Jumping Pound Creek, which is about 20 miles west of Calgary, to the mountain front. The foothills may be distinguished from the plains underlying Calgary partly by their more rolling topography. However, it is the underlying geology that really tells the story. The rock layers of the foothills have been folded and disturbed by minor thrust faults while the plains bedrock is essentially flat-lying. The foothills are composed of relatively young rock which has been eroded to a great extent since its uplift. They are generally covered with vegetation because the surface rocks, sandstone and shale, have weathered to form soil.
GEOLOGY

STRUCTURAL FEATURES

ANTICLINE

SYNCLINE

NORMAL FAULT

FAULT BLOCK

THRUST FAULTS

Figure 4
The Front Ranges

A sharp boundary exists between the foothills and the front ranges along the line of the McConnell Thrust fault. This is because the McConnell Thrust, the most easterly thrust fault in the Rockies, has brought highly resistant, cliff-forming limestone to the surface. A good view of the McConnell Thrust fault can be seen at the mountain front near Seebe. The sheer limestone cliff to the north of the Trans Canada Highway is Mount Yamnuska; the thrust fault is located along the base of the limestone cliff. (See Figure 6)

The front ranges extend from the mountain front to just east of Mt. Eisenhower and include all the mountains of the Banff area.

In comparison to the other structural provinces, the main characteristics of the front ranges are:

1. High incidence of westerly dipping thrust faults; rock of Palaeozoic age,
2. Severely disturbed rock layers (highly folded and faulted),
3. Predominantly limestone, with some shale.

The front ranges are made up of a series of fault blocks, or fault slices that have been thrust over one another like shingles on a roof. Each of these blocks is tilted upward and dips towards the west; Mt. Rundle, with its dipping southwestern slope and abrupt northeastern slope is an excellent example of one of these fault blocks. Because of the high incidence of overthrusting in the front ranges, older rocks are often found overlying younger ones. The peaks, which average 2,850 meters in elevation, are formed of highly resistant limestone of Palaeozoic age. The valleys are formed of younger rocks of Mesozoic age which are much less resistant to erosion.

The major thrust faults of the front ranges have created several distinct ranges which run parallel to each other in a north-westerly trend. From east to west, the Trans-Canada Highway passes the Fairholme Range (Charles Stewart, Inglismaldie) and then crosses the Rundle Range (Rundle, Cascade); the Goat Range (Sulphur, Norquay) and the Bourgeau Range (Sundance-Sawback).

Most of the rock layers in the front ranges are severely disturbed and show a great deal of folding and faulting within the major fault blocks. Particularly complex fold structures can be seen in the Lake Minnewanka area, in Cascade Mountain and in the Sawback Range between Banff and Eisenhower Junction.

Mt. Rundle: A Typical Front Range Mountain

As well as being an excellent example of a fault block mountain, Mount Rundle also shows the typical rock sequence found in the front ranges. This sequence is shown in Figure 7.

At the top is the cliff-forming grey limestone of the Rundle Formation, and below that is the shaley, easily eroded Rundle Formation, which is brownish in colour. At the base, down to about the treeline is another resistant layer of grey limestones known as the Palliser Formation. This whole sequence has been thrust up over the younger, coal-bearing Kootenay Formation which is found on the valley floor. This same sequence (Palliser-Banff-Rundle) can be seen on many other mountains of the front ranges, for example Cascade Mountain and Mt. Inglismaldie.

The Sulphur Mountain Hot Springs

The thermal springs found in the Banff area are a unique feature of both the park and the front ranges; three main springs are found on the northeast slope of Sulphur Mountain. Two of these springs, the Upper Hot Springs and the Cave and Basin have been extensively developed. The Middle Hot Springs has remained relatively unaltered. These springs are significant geologically because they are all located along the Sulphur Mtn. thrust fault. Two other warm springs which surface at the Vermilion Lakes and on Forty-mile Creek are thought to be part of the same system.

There are two hypotheses about the origin of the water that feeds these springs. The first suggests that the water originates in Sundance Creek, which flows in the valley to the west of Sulphur Mtn. The second and more accepted theory suggests that general percolation of rain and snowmelt over the surface of Sulphur Mountain is the source. Whatever the origin of this water, its temperature indicates that it has flowed up the Sulphur Mtn. thrust fault from a depth of several thousand meters.

Each of the springs has a characteristic flow volume, chemical composition and temperature variation. It is thought that these differences may be due to differential mixing of ground water with the warmer spring water.

The Main Ranges

The main ranges extend westward from the Castle Mtn. thrust fault (just east of Mount Eisenhower) to about Field, B.C. These main range mountains form the continental divide for several hundred miles and include the highest peaks of the Rockies and most of the glaciers.

The mountains in the northern part of the park all belong to the main ranges; other examples include Mt. Assiniboine, Mt. Eisenhower, Mt. Temple, Mt. Athabasca in Jasper, and Mt. Robson to the west of Jasper Park are also main range mountains.

In comparison with the other structural provinces the important characteristics of the main ranges are:

1. High elevations; exposure of very old rock layers,
2. Rock layers not severely disturbed, but mainly horizontal, resulting in "castellate" mountain structure,
3. A broad syncline and anticline structure,
4. Predominant rock types limestone and quartzite.

Thrust faulting exists throughout the main ranges but is much less obvious than in the front ranges. In the Lake Louise area, the rock layers have been broken by a series of normal faults (where one layer has dropped down vertically with respect to the other). The result of this is that although the rock layers have been displaced vertically, they are still relatively flat lying. Erosion of these mountains with horizontal layering produced the castellate or castle-like form which is typical of the main ranges - Mt. Eisenhower is the best example.

The principal structural elements in the main ranges are a broad synclinal structure in the east and a complementary anticlinal structure to the west. The gentle syncline parallels the western side of the Castle Mtn. fault from Mt. Eisenhower northwestward to
CROSS SECTION OF ROCKY MOUNTAINS

WESTERN RANGES | MAIN RANGES | FRONT RANGES | FOOTHILLS | PLAINS

Rocky Mountain Trench

WEST

EAST

Figure 5
(not to scale)
after Baird 1977
MOUNT YAMNUSKA
SHOWING OVERTHRUSTING

Figure 6

STRUCTURE OF MOUNT RUNDLE

Figure 7
BOW RIVER AND CASTLE MOUNTAIN

A: FLAT-LYING SEDIMENTARY ROCK

B: FOLDING INTO ANTICLINE AND SYNCLINE

C: THRUST FAULTING
Increased pressure caused rock layers to break and ride up over one another.

D: EROSION
The Bow River eroded the crest of the anticline and Castle Mountain was formed in the syncline.

Figure 8
(Belyea 1960)
Mt. Kerkeslin in Jasper Park. It can be seen clearly in the southern end of Mt. Eisenhower from the Eisenhower Viewpoint and in Nigel Peak and Cirrus Mtn. in the northern part of the park. The anticlinal structure to the west has been severely eroded by the Bow River from its source at Bow Lake to Lake Louise. (See Figure 8) The Banff-Jasper Highway follows this valley that has been carved out along the crest of the anticline. In this area, the rock layers clearly dip outward on either side of the valley indicating where the anticline once stood. The dipping rock layers on the western side of the valley are clearly seen from the Peyto Lake Viewpoint.

The main ranges have been greatly uplifted and the younger layers eroded away long ago. The rock exposed in the main ranges is some of the oldest seen in the Rockies. Precambrian rock of over 600 million years in age is exposed just above the lake at Lake Louise and on the forested slopes of the Bow Valley in that area. These rock layers are often reddish-brown in colour and are so old that they contain no recognizable fossils.

The Western Ranges

Along the Trans-Canada Highway, the western ranges are found in the area between Field and Golden, B.C. The western ranges extend only as far south as Radium, B.C.

The main structural features of the western ranges are:

1. Complex folding and thrust faulting,
2. Broad syncline and anticline structure in the eastern sector,
3. Severe thrust faulting in the western sector; some of these faults are overturned,
4. Predominant rock type shale, with some limestone.

The boundary between the main and the western ranges is clearly marked by a gradation in rock type from limestone to shale. The western ranges are generally very complex in structure. The mountains just west of Field show a broad syncline and anticline structure much like the one in the main ranges. In the area between the Yoho Park gate and Golden, the mountains have been severely thrust faulted. Some rock layers have been thrust up so that they are vertical or even bent right over backwards. (See Figure 5)

Shapes of Mountains

(See Figure 9)

Anticlinal Mountains

Anticlinal mountains have their rock layers arched up into a huge upfold or anticline. This type of mountain is rare because stretching of the upper rock layers during upfolding usually produces fractures which make the mountain very susceptible to erosion. A few anticlinal mountains are seen in the front ranges, particularly in the Lake Minnewanka area.

Synclinal Mountains

Synclinal mountains have their rock layers downfolded into a trough or syncline. This type of mountain is quite common and is often the result of the erosion of the land surrounding the syncline. This occurs because the rocks at the centre of the syncline have been compressed and are very erosion-resistant. Synclinal mountains can be seen in the front ranges; both Cirrus Mtn. and Mt. Kerkeslin in the main ranges are also good examples.

Mountains Cut in Dipping Layered Rocks

(Thrust Fault Mountains)

This type of mountain has been cut into a mass of layered sedimentary rock which is inclined at an angle of up to 45 degrees. In many cases, these mountains have a smooth slope that follows the dip of a particular rock layer. On the other side is a less regular, often very steep slope which breaks across the upturned edges of the rock layers. The dipping of the rock layers is usually the result of thrust faulting. Thrust fault mountains are common in the front ranges; Mt. Rundle is the classic example.

Sawtooth Mountains

If the rocks in a long ridge are upthrust so that the rock layers are vertical or nearly vertical (60 degrees to 90 degrees), erosion may produce rows of angular mountains that look like the teeth in a saw. The Sawback Range that parallels the Bow River between Banff and Eisenhower Junction shows excellent examples of sawtooth mountains. Both these mountains can be seen briefly from the Trans-Canada Highway just east of the traffic circle.

Dogtooth Mountains

These sharp, jagged mountains sometimes result from the erosion of masses of vertical or nearly vertical rock. The peaks are usually formed from a bed of particularly resistant rock which is left standing after the less resistant rock layers are eroded from its flanks. Mt. Edith and Mt. Louis, located to the northwest of Mt. Norquay are good examples of dogtooth mountains. Both these mountains can be seen briefly from the Trans-Canada Highway just east of the traffic circle.

Castellate or Layer-Cake Mountains

Mountains that are cut into flat-lying sedimentary rock commonly have profiles in which vertical steps alternate with flat or sloping terraces. Because they often resemble ancient castles, they are said to be castellate mountains. These mountains are formed from layers of resistant rock such as limestone or quartzite alternating with less resistant layers such as shale. The softer rock is eroded for rapidly, so that the harder rock layers are undermined and tend to break off at right angles; this forms steep slopes and cliffs. Castellate mountain structure is typical of the main ranges; Mt. Eisenhower (formerly known as Castle Mountain) is the best example.

Sometimes steep-sided pinnacles are left on the tops of such mountains as the uppermost massive layers are almost completely eroded away. The Castelets near Mt. Saskatchewan in the northern part of the park are a good example of this phenomenon.

Complex Mountains

Some mountains have been deformed by such intense folding and faulting that they cannot be classified into any of the preceding groups. This type of mountain is common in the front ranges and is referred to simply as a complex mountain.
GEOLOGY

SHAPES OF MOUNTAINS

CASTELLATE
(Castle Mountain)

DOGTOOTH
(Mount Louis)

MOUNTAINS CUT IN DIPPING LAYERED ROCKS
(Mount Rundle)

MATTERHORN
(Mount Chephren)

SAWTOOTH
(Sawback Range)

SYNCLINAL
(Cirrus Mountain)

Figure 9
Horn Mountains

Bowl-shaped depressions called cirques are a common result of glacial erosion on a mountainside. When several glaciers cut into a mountain from different sides, they sometimes leave an isolated tower of rock which is known as a horn. Mt. Assiniboine in the southwestern corner of Banff Park is an outstanding example of a horn mountain; Mt. Chephren, which can be seen from the Icefields Parkway at the Waterfowl Lakes, is another.

Totally Glaciated Mountains

Several small mountains in Banff area have undergone total glaciation; both Tunnel Mtn. and Stoney Squaw fit this category. These mountains show the effects of the glacial movement; their upstream sides (southwest) are rounded and more gentle in slope, while the downstream sides (northeast) are sheer from the plucking action of the ice.

The Geological Timetable

Life Through the Ages

It is presently thought that the earth has been in existence for about 4 1/2 billion years. Of that vast expanse of time, the first 3 billion years remain shrouded in the mists of the ages. Virtually nothing is known about when and how the first life appeared in the ancient seas. It is only in more recent geological time (from 600 million years ago) that easily recognizable fossils were left in the rock layers as a record of the changes in life forms through the ages.

Geologists have used this fossil evidence to construct a geological timetable that traces the earth's history from its beginnings to the present day.

The great expanse of time before the appearance of the first fossil life is known as the PRECAMBRIAN EPOCH. It is likely that the first life appeared in Precambrian seas, but because these extremely primitive life forms lacked skeletons, they were rarely preserved as fossils. Rock of Precambrian age is found at the bases of the mountains in the Lake Louise area.

The time interval from the end of the Precambrian about 600 million years ago to the present day has been divided by geologists into 3 eras: the PALAEOZOIC or Age of Primitive Life; the MESOZOIC or Age of the Reptiles and the CENOZOIC or Age of the Mammals.

Sedimentary rock of all these ages are found in Banff National Park and a great many of the younger rock layers do contain fossils. Rock from the PALAEOZOIC or Age of Primitive Life is the most important because it forms nearly all the mountain peaks in the park. In many locations, fossils of primitive sea-dwelling animals are abundant in these rocks. These include trilobites, corals, sponges, sea lilies and many types of clam-like creatures. In the warm seas of the Palaeozoic Era, these animals thrived, forming huge reefs like those found off the coast of Australia today. Limestone of Devonian age often contains the remains of these coral reefs. Devonian reefs underlying the plains of Alberta serve as reservoirs for oil and natural gas.

By the MESOZOIC or the Age of the Reptiles, animals and primitive plants had become well established on the land. Dinosaurs were the dominant life form on land while cephalopods, which were squid-like animals with huge coiled shells, lived in the seas. Much of this area was low and swampy during the Mesozoic era. The organic sediments deposited in these swamps have become compressed to form the coal that underlies the foothills and the front ranges. Mesozoic rocks underlie the Bow Valley in the front ranges. These can be seen from the Trans-Canada Highway at an outcrop just east of the traffic circle. Dinosaur bones, which are common in the Drumheller area, are not found within the park but ammonites (a type of cephalopod) can be found in shale beds at some locations.

The sudden extinction of the dinosaurs signalled the beginning of the CENOZOIC era, the Age of the Mammals. During this time period, the plants and animals that lived on the land evolved into the forms that we know today. It was also a significant time in terms of the final shaping of the land; both the uplifting of the Rocky Mountains and the Ice Ages occurred during the Cenozoic. Because the land was above the sea throughout this time, very few sediments were deposited and very few fossils are found. Cenozoic deposits of glacial till left behind by the Pleistocene glaciers are found in the major valleys throughout the park, but large animal bones are rare. However, on the banks of the Bow River near Cochrane, geologists have discovered the bones of extinct species of bison and burros that roamed the fringes of the icebound mountains some 11,000 years ago.
### GEOLOGIC TIME SCALE

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* PLEISTOCENE - The Beginning of the Ice Ages
** EOCENE - The Building of the Rockies & PALEOCENE
*** CAMBRIAN - The Appearance of Many Fossil Forms.
Selected References


Baird, David M., 1962, Yoho National Park: the mountains - the rocks - the scenery, Queens Printer, Ottawa. Presently out of print. Available at the Archives of the Canadian Rockies.


Scientific American, 1972, Continents Adrift: Readings from Scientific America, W.H. Freedman and Co., Available at the Archives of the Canadian Rockies.
glaciology
Past Glacial Activity:
The Ice Ages

The Ice Ages began over a million years ago in a time known as the Pleistocene. Since that time the great ice sheets have advanced and retreated over the North American continent many times. The Ice Ages may be over yet — many geologists believe that we are now in an interglacial period and that thousands of years from today the ice may flow again.

The cause of the Ice Ages has been debated since Swiss geologist Louis Agassiz proved their existence in the 1840's. Many theories have been put forward to explain these massive advances of ice; four of them will be outlined here.

Theories on the Origins of the Ice Ages

The Wobble Theory

This theory deals with a change in orientation of the earth's axis towards the sun. The earth's axis presently rests at 23 1/2° from the perpendicular, but it may not always have been that way. If the earth had happened to "wobble" on its axis, the areas that were moved away from the direct rays of the sun would have felt an immediate change in climate. Even a slight cooling in the world's mean temperature could trigger a major glacial advance.

The Volcanic Ash Theory

This theory deals with the effects of volcanic activity. When volcanoes erupt they send tremendous volumes of ash into the atmosphere. This debris tends to block the warming rays of the sun, resulting in a cooling in climate until the ash settles back to earth. This theory was substantiated in the 1880's when an eruption of the volcano Krakatoa was followed by a worldwide cooling in climate which lasted for five years.

The Carbon Dioxide Theory

This theory involves the carbon dioxide in the earth's atmosphere. Carbon dioxide has the ability to absorb infrared radiation — the radiation which is responsible for warming out atmosphere. If the balance of carbon dioxide was reduced then a period of climatic cooling might result. Man's present use of fossil fuels may be increasing carbon dioxide levels in the earth's atmosphere. Scientists believe that this could have a "greenhouse" or warming effect on the world's climate.

The Sun Theory

The sun does not always generate heat at the same rate, but at some times is hotter than others. If the sun were to enter into a slightly cooler phase, this would be reflected in an immediate cooling of the earth's atmosphere.

All of these theories are based upon the assumption that the Ice Ages were caused by a worldwide drop in temperature. They are all plausible explanations for this drop in temperature, but none has been considered an acceptable cause on its own. It is likely that not one but a number of events triggered the cool climatic conditions that led to the massive glaciation of the Pleistocene.

In order for the great icecaps to accumulate, there must have been periods thousands of years long where more snow fell each winter than could be melted in the spring and summer. As this snow accumulated, it gradually became compressed and recrystallized to form ice. Further compression gave this ice the ability to flow; this signalled the beginning of a huge glacial advance.

The Pleistocene Glaciation

It is generally thought that there were four major glacial epochs in the Pleistocene and that these were separated by interglacial periods lasting tens of thousands of years. Very little is known about the first three glacial epochs because all evidence of their existence was erased by later advances; even much of what we guess about the fourth is hypothetical.

There were two major icefields or areas of accumulation for the ice that covered western Canada: one was centered over the Canadian Shield country in northern Quebec and the other was along the peaks of the Continental Divide. During times of glacial advance, tongues of ice began to flow out from these areas: the Laurentide ice sheet originated in the east and the Cordilleran sheet in the west. The Laurentide sheet was by far the largest with thicknesses of up to 3,650 meters (12,000 feet). At times it covered all of Canada east of the Rockies. The outflow from the Cordilleran ice sheet was in the form of valley glaciers which were up to 1,000 meters thick; the major outflow valleys were those of the Bow, the North Saskatchewan and the Athabasca Rivers. These glaciers moved far enough east to run into the massive Laurentide ice sheet; they were then deflected and eventually absorbed into its north-south flow. Ice from the Bow Valley glacier met the eastern ice sheet in the vicinity of present day Calgary and was deflected south from there. The pathway of the Cordilleran ice can be traced by the trail of erratics that stretches all the way from the Athabasca Valley to northern Montana.

Recent investigations in the Bow Valley suggest that there were three and probably four advances in the final period of the Pleistocene Epoch. However, these advances appear to have been small in comparison to those that had occurred earlier in the Pleistocene. Little evidence remains of the first advance which is known as the PRE-BOW VALLEY ADVANCE. It was the second or BOW VALLEY ADVANCE dated at 22,000 years B.P. (before present) that was the most extensive of the period. At this time, the ice reached an average thickness of 500 meters (2,000 ft.) and extended well into the foothills. An interval of retreat was followed by the CANMORE ADVANCE which moved to the edge of the foothills at the mountain front. A period of relatively complete deglaciation occurred before the final advance of the ice. The final EISENHOWER ADVANCE reached great thicknesses (570 meters; 1,900 feet) in the Lake Louise area, but only pushed its way down the Bow Valley as far as Mt. Eisenhower. It is generally agreed that the lower Bow Valley was free of ice by about 10,000 years B.P. while it is quite possible that the high mountain valleys remained ice-bound for thousands of years longer.

The climate of Alberta has undergone a few major shifts since the last deglaciation. The ALTITHERMAL, a warm climatic phase that occurred between 8,000 and 4,000 years ago was perhaps the most significant because it made the central plains too hot and dry for human habitation. A cool moist climatic phase began
Effects of the Pleistocene Glaciation

The glaciation of the Rockies was primarily in the form of valley glaciers which flowed down from the vast accumulation zones along the continental divide. The Bow Valley, the North Saskatchewan Valley and the Athabasca Valley were the main pathways for this Cordilleran ice; tributary glaciers added to the flow. The major effect of the Pleistocene glaciation was the way in which it modified the landscape: mountains and valleys were sculptured, great depths of glacial debris were deposited and major changes were made to the drainage patterns of many rivers.

The sculpturing of the mountain peaks is most obvious in the areas that have served as ice accumulation zones. Erosion in these areas and at the outlet of icefields has given the mountains a much more steep and angular profile.

Snow and ice often accumulate to form glaciers in bowl-shaped depressions on a mountain side. Cirques result from glacial scour within these bowls. The ice in a cirque tends to flow towards the centre of the bowl; this results in the deepening of the bowl and erosion of the back wall so that it becomes nearly vertical. Some of the cirques in Banff National Park still contain small glaciers today; others are occupied by small isolated lakes called Tarns.

Glacial Erosion and Deposition

Some distinctive mountain shapes are due to the carving action of cirque glaciers. For example, if a mountain has cirque glaciers on two opposite sides, it may be eroded to form a sharp ridge called an ARETE. If cirques have cut in from several sides, the mountain may develop a HORN-SHAPED PEAK like that of Mt. Assiniboine. Very few mountains in the Rockies have undergone total glaciation; those that have, such as Tunnel Mtn., show rounding of streamlining on the upstream (west) side and abrupt slopes on the down­stream (east) side.

Evidence of the sculpturing effect of the glaciers is best seen in the broad U-shaped mountain valleys. Before the coming of the Ice Ages, fast­flowing streams had created shallow V-shaped valleys. The advance of the glaciers had a gouging effect. The valley bottoms were widened and deepened while the valley sides were made more steep. The retreat of the ice then filled the valley bottoms with great quantities of glacial debris. This combination of glacial erosion and deposition has given the valleys the characteristic flat­bottomed U-shape that we see today.

The shape of the valleys is not the only thing that tells of the passing of the glaciers; the valleys also exhibit a number of other features that are typical of glaciated areas.

As the glaciers pushed their way through, they gouged great quantities of rock from the valleys. This material was either pushed along at the front of the glacier or incorporated into the flow. The occurrence of STRIATIONS or scratch marks on rocks in many locations in the park is evidence of the grinding effect of the glaciers. These striations also show the direction of movement of the glacier.

The rock debris carried by the glaciers was a mixture of boulders, gravel, sand and finely ground material known as ROCK FLOUR. When the glaciers began their retreat, this material was dropped on the valley floor by the melting ice to form deposits of unsorted material called GLACIAL TILL. Deposits of glacial till are extensive in the Bow Valley and can be seen in many of the road cuts along the Trans Canada Highway. This material often reaches thicknesses of up to 100 meters. Over the years much of this till has become cemented together to form a rock known as BOULDER CLAY. Along the edges of cliffs, this boulder clay is often eroded by wind and water to form peculiar pillar-like structures called HOODOOS. Hoodoos can be seen at the Hoodoo Lookout on the south slopes of Tunnel Mountain and along the north side of the Trans­Canada Highway to the east of the traffic circle.

The debris that was pushed along by the front and sides of the glacier were also left behind to form MORAINES. There are three types of moraines: terminal, lateral and medial. These are illustrated in Figure 12.

When a glacier begins a retreat it leaves behind a mound of debris known as TERMINAL MORaine. This moraine marks the maximum advance of the front of the glacier. If a terminal moraine is particularly large, it may block the drainage of the valley that it occupies. This causes water to back up behind it and form a lake. Many of the mountain lakes such as Bow Lake and Peyto Lake were formed in this way.

Some of the material carried along by the edges of the glacier was left high on the sides of the valleys to form LATERAL MORAINES. The position of these moraines gives a fair indication of the maximum height of the ice flow. Many of the lateral moraines from Pleistocene times are still obvious today. One example can be seen in the Valley of the Ten Peaks; the road to Moraine Lake has been built along the top of this lateral moraine. Lateral moraines are also responsible for the damming of some of the mountain lakes. For instance, the material blocking the end of the Lake Louise valley is part of a lateral moraine left by the west side of the Bow Valley glacier.

When two glaciers merge together a MEDIAL MORaine separates the two ice flows. Medial moraines were probably formed all along the Bow Valley whenever a tributary glacier joined the main flow. However, few of these medial moraines can be seen today because they have been eroded away by streams.

The presence of Lateral Moraines and glacial ERRATICS (boulders) high on the mountain slopes tells us that glaciers in the Bow Valley reached a maximum elevation of between 2,100 meters (7,000 feet) and 2,400 meters (8,000 feet) above sea level. The upper limit of the ice flow can often be seen where the smoothly eroded valley sides meet the more rugged un­glaciated slopes above. This junction is known as a BREAK-IN­SLOPE: streams from the higher valleys often cascade over it to form high waterfalls. The side valleys that are found high on the sides of the Bow Valley are known as HANGING VALLEYS. They were once the sites of tributary glaciers, but because the Bow Valley was deepened to such a great extent, they were left "hanging" above it when the ice retreated. These hanging valleys are often dammed with glacial debris so that they contain lakes today. Hanging valleys are numerous in the park; the Lake Louise valley is the most obvious example.
Two other important glacial features, the DRUMLIN and the ESKER are not often seen in the park but are common in the foothills to the east.

A DRUMLIN is a mound of glacial till which has a streamlined shape similar to that of an inverted spoon. These mounds of till were formed when a glacier passed over an obstruction or an abundance of loose material. Drumlins vary from a few meters to several kilometers in length; they are always tapered in the direction of the glacial flow. Good examples of drumlins can be seen from the Trans-Canada Highway in the Morley Flats area.

ESKERS are narrow snake-like ridges of glacial debris which can be up to several kilometers in length. These ridges represent the meandering beds of streams that once flowed beneath the glacial ice. Parts of the western section of the Minnewanka Road are built on a ridge which is actually an esker. Another good example of an esker can be seen just north of the Trans-Canada Highway on the 1A turnoff to Exshaw.

**Changes in Drainage Patterns**

During the Pleistocene glaciation, several major changes occurred in the stream course and drainage patterns in the Banff vicinity. The Bow, the Spray and the Cascade rivers were all affected.

The change in route made by the Bow River is perhaps the most obvious. Possibly the Bow River once drained out through the Minnewanka valley, but immediately before the Ice Ages it probably flowed through the valley presently occupied by the Trans-Canada Highway. The paired terraces along the Trans-Canada Highway just east of Banff suggest this old river course.

Today, the Bow makes a wide detour around the south side of Tunnel Mtn., flowing over Bow Falls and through the valley separating Tunnel Mtn. and Mt. Rundle. This channel was formed at a time when the original route was blocked by a high wall of glacial debris. A large lake backed up behind this wall and eventually the water spilled over the rock gap between Tunnel Mtn. and the end of Mt. Rundle. Erosion over the years has given this gap the form that we see today.

A similar change in route occurred to the Spray River. Originally it may have flowed into the Bow River near present day Canmore, but today it makes a wide detour to the south between the Goat Range and Sulphur Mountain. The Spray River now joins the Bow River just below Bow Falls (near the Banff Springs Hotel).

The flow of the Cascade River was also changed — before the Pleistocene it flowed directly down the Cascade Valley to the Bow River. During the Pleistocene, a moraine dammed the Cascade Valley and caused the river to be diverted eastward. A new channel was cut through Stewart Canyon and the Cascade River joined Devil's Creek which flowed out of Lake Minnewanka. The hydroelectric dams at Lake Minnewanka have raised the lake level 18 meters (60 feet) flooding Devil's Creek and part of Stewart Canyon. The Cascade River still flows out of Lake Minnewanka through Stewart Canyon but it now flows out of the lake via a canal and a hydroelectric plant being released to the old channel and thence to the Bow River.

**Post-Glacial Erosion**

The features left by the Pleistocene glaciations form the dominant elements of the mountain topography. However, erosion did not stop with the retreat of the ice; the forces of wind, water and gravity have continued to modify the mountain landscape.

Water has been the most important postglacial erosional force — streams began to rework the glacial deposits almost as soon as they were laid down. Stream action tended to sort out the glacial till; larger stones could not be carried far so were dropped first, but finer sediments such as sand and rock flour were often carried for greater distances. This process created well-sorted layered deposits known as OUTWASH DEPOSITS. This sorting process continues today as the Bow River follows its meandering path towards the plains.

The step-like rises or TERRACES seen along the sides of the Bow Valley represent former banks of the Bow River. These give some indication of the former size of the river and also show how deeply the glacial deposits have been eroded.

In the short time since the Pleistocene many fast flowing streams have once again carved V-shaped valleys. Some of them, like Johnston Creek and the Mistaya River have cut deeply into the valley floor to create CANYONS. The sediments carried down by these creeks and rivers have been deposited in the Bow Valley in broad ALLUVIAL FANS. Large alluvial fans can be found at the base of Johnston, Baker and Brewster Creeks. These areas are important because they support a wide variety of plant and animal life.

Ground water percolating through the rock layers has also had an erosional effect in places where it was able to dissolve limestone or dolomite to form CAVES. Both the Hole-in-the-Wall on Mt. Cory and the Castleguard Cave system in the northern part of the park were formed in this manner. The Hole-in-the-Wall was exposed by the Bow Valley glacier's scraping action against the valley walls.

Frost action also plays a significant part in the erosional process. This is mainly in the form of FROST-WEDGING which occurs when a thin film of water seeps into a rock crevice and then freezes. Upon freezing, the water expands and has a wedging effect that often causes sections of the rock to break away.

In mountain areas, a significant amount of erosion is due simply to the force of gravity. This process is known in general as MASS WASTING and includes such things as rockslides, mudflows, soil creep, and the movement of scree on talus slopes.

The first resting place for rock broken away from a mountain slope is usually in a fan-shaped accumulation area known as a TALUS CONE or SCREE SLOPE. These talus cones can be seen on nearly every steep mountain in the park. The SCREE, or pieces of rock found on these slopes is very unstable. The slightest disturbance often causes scree to slide downhill. This type of movement is not restricted to rocky slopes. SOIL CREEP or slumping commonly occurs when the soil on a steep slope becomes oversaturated and actually begins to flow downhill at a very slow rate. Evidence of soil creep is often seen in road cuts. On forested slopes, the bending of tree trunks is a good indication that slumping has occurred.
Mudflows involve the same kind of action but on a larger scale. These often occur along creek beds after continued periods of rain. Both Mosquito Creek and Murchison Creek on the Banff-Jasper Highway have been the sites of large mudflows in recent years.

ROCKSLIDES or LANDSLIDES are also examples of large scale earth movements. A huge landslide, known as the Hillside Slide, occurred near Mt. Isabel in early postglacial times. This slide, which can be seen just to the east of Johnston Canyon, was comparable in size to the Frank Slide which destroyed the town Frank, Alberta in 1903. Smaller rockslides have occurred in many other locations throughout the park.

Moraine Lake has been dammed by a large heap of rock debris. The possibility that this represents a landslide rather than a terminal moraine has been a topic of debate for many years. However, recent studies have shown that the rock material is locally derived because it is very similar to that exposed on the Tower of Babel. This and other lines of evidence suggest that the large rubble piles are the result of one or more major rockslides from the peaks above the lake.

SNOWSLIDES or AVALANCHES are also a form of mass wasting because they bring down rock, soil and vegetation as well as snow. Avalanches occur most frequently in the spring when repeated melting and thawing makes the snow layers unstable. Avalanching continues throughout the summer on glaciers e.g. the Upper Victoria Glacier at Lake Louise.

AVALANCHE SLOPES can be seen on many of the mountains in the park; some of the best examples are found along the Banff-Jasper Highway just south of Sunwapta Pass. These avalanche slopes tend to have characteristic plant and animal communities and in summer provide browse for a wide variety of larger animals.

Present-Day Glaciation

The Formation of Glaciers

Glaciers are found at high elevations and are usually on cool, northeast-facing slopes. This is because the existence of glaciers is related to temperature and the location of the SNOWLINE or the lower limit of perennial snow. The elevation of snowline varies from year to year due to minor climatic variations but to give an example, the snowline on the Victoria Glacier averages about 2,250 meters (7,500 feet) above sea level. Above this snowline are the snowfields that persist from year to year.

Low temperature alone will not ensure the growth of a snowfield. Snow will only accumulate in areas where winter snowfall is so heavy that summer melting and evaporation cannot remove it. Snowfall in accumulation areas in the Rockies averages from 7 to 10 meters per year. Whenever there is a balance of snow left over from one year to the next, the snowfields grow in size.

The loose feathery snow that falls in these accumulation areas is constantly being buried by later falls, and is gradually transformed into NEVE or FIRN. Neve resembles the granular snow that is made in old snowdrifts at the end of winter. It is made up of closely packed spherical grains that are less than 3 mm. (1/10 in.) in diameter. With further compaction, the air is squeezed out from between these grains and meltwater from above seeps in. Eventually the deeper layers are transformed into ice. Over a period of years, these accumulations become deep enough to form glacial ice. When glacial ice reaches a critical thickness, it is able to move and flow down the valley. This movement is caused primarily by the pressure from above but is also assisted by the force of gravity.

Glacier Movement

Ice movement has been monitored in a number of glaciers in the mountain parks -- notably the Victoria, Peyto and the Athabasca glaciers. The results of this research demonstrate many of the interesting characteristics of glacial movement.

First of all, it has been shown that the terminal part or TOE of the glacier moves at a faster rate in the summer than it does in the winter. The cause of this is due to changes in weather patterns, these two rates are in constant fluctuation; because of this it is virtually impossible to predict future changes to the size of a glacier. When a glacier increases in size, it is said to be ADVANCING; when there is a decrease in size, it is RETREATING.

The total circulation time for ice in a glacier is dependent on a number of factors: its location within the glacier, the size of the glacier, the rate of movement, and the rate of melting. As an example of this circulation time, it is estimated that the ice at the toe of the Lower Victoria Glacier fell as snow in the upper valley more than a hundred years ago.

Glacial Advance and Retreat

The size of a glacier and its rate of flow are basically dependent on the balance between the rate of supply of snow and the rate of melting at the toe and over the surface of the glacier. Due to minor variations in weather patterns, these two rates are in constant fluctuation; because of this it is virtually impossible to predict future changes to the size of a glacier. When a glacier increases in size, it is said to be ADVANCING; when there is a decrease in size, it is RETREATING.

All glaciers are moving downhill, regardless of whether they are advancing or retreating. The flow of ice comes in pulses or waves that are in response to the winter snow accumulation of past years. When a glacier is advancing, the rate of ice flow at the toe is greater than the rate of melting; this results in a net forward movement or ADVANCE of the ice front down the valley. When a glacier is retreating, the rate of melting at the toe is greater than the rate of flow.
In this case there is no net forward movement and the ice front recedes or retreats back up the valley. This might occur after a series of mild winters and/or warm summers. A recession or slight retreat of glaciers has been general throughout the Rocky Mountains since about 1880.

It has been shown that the glaciers in the Rocky Mountains have had several periods of advance and retreat in recent times. These are thought to represent either regional or global trends towards cooler or warmer temperatures.

Glaciologists have estimated the ages of these advances by examining the various terminal moraines and determining the age of trees and lichens that have grown back since the retreat of the ice. In many areas, advancing glaciers invaded forested areas, killing trees as they went. In these areas there is a definite line separating the new growth from the older trees that were not disturbed; this is known as a trimline. Evidence uncovered by glaciologists suggests that there were two recent advances in this area: one in the early 1700's and another in the early 1800's. There was a retreat between these two advances and then another retreat that has continued up to the present day. Evidence of the advance in the 1800's can be seen at many locations. At Lake Louise, for example, the terminal moraine left by this advance is rather indistinct. However, a very noticeable trimline can be seen in the forest about 1.25 kilometers beyond the western end of the lake.

Since that last advance, which ended about 1830, the glaciers have all retreated back to their present positions. This retreat has been on a fairly large scale. The Lower Victoria Glacier, for instance, has retreated over 1,220 meters (4,000 ft.) since 1830, giving an average yearly retreat of about 9 meters (30 feet). It should be noted, however, that the rate of glacial retreat has been in constant fluctuation over this time span. Throughout the Rockies, recession proceeded slowly until 1920, after which it accelerated to a maximum between 1945 and 1955; since that time it has again been proceeding at a slower rate.

Glacial Features

(See Figure 12)

From a distance, the surface structure of a glacier may seem quite simple; but at close range it often shows a confusing array of fractures, crevasses and layers of ice.
GLACIAL FEATURES

- hanging glacier
- accumulation zone
- transverse crevasses
- ice fall
- marginal crevasses
- toe
- terminal moraine
- lateral moraine
GLACIOLOGY

One of the most obvious things about glacial ice is that it is either blue or dirty grey in colour. Both these colours are a result of the sediment load carried along by the glacier. This debris, which ranges in size from boulders to very fine rock flour, is mainly a product of the gouging and grinding action of the glacier. However, some of the finer particles were carried to the glacier by the snow that fell on its surface. The bluish colour that is often seen is a result of the refraction of light by very fine rock particles within the ice. The grey colour seen on the surface and at the toe is due to the accumulation of glacial debris in these areas where the ice is melting.

Another obvious feature of glacial ice is that it shows LAYERING or FOLIATION. This layering is due to differences in the size and arrangement of the ice crystals. Foliation in a glacier is much like the growth rings on a tree; examination of the ice layers gives an indication of the snow accumulation from year to year. Because of the differential ice movement within the glacier, this layering is not always horizontal; for example the layers at the margins may incline steeply towards the centre of the glacier. The 1955 layer is darker and more radioactive than other layers due to above ground atomic testing in that year.

The upper layers of ice, which differ from those beneath them, form a brittle crust over the surface of the glacier. If this crust is stretched, it breaks into steep-sided openings known as CREVASSES. These crevasses or cracks appear to extend to great depths, but actually few of them extend deeper than about thirty metres (a hundred feet.)

Crevasses commonly develop when the ice passes over an irregularity in its bed. The stress that this type of movement produces results in the formation of a TRANSVERSE CREVASSE or a crack that extends across the width of the glacier. There is a particularly high incidence of large transverse crevasses around ICEFALLS, or areas where the ice tumbles over a slope. It is thought that these crevasses reflect a step-like cliff in the bedrock which underlies the glacier. When the ice reaches the base of an icefall, the decrease in slope causes it to slow down and the flow from behind then pushes the crevasse closed again.

A special kind of crevasse, called a BERGSCHRUND often develops when a glacier is hanging on a very steep rock face. This large crack, which usually extends over the entire width of the glacier is the result of the ice pulling away from the headwall behind it. An excellent example of a bergschrund can be seen across the face of the glacier which hangs on Mt. Victoria at Lake Louise.

Differential movement of the ice within a glacier is also an important factor in the formation of crevasses. This movement often results in stretching of the ice to form MARGINAL CREVASSES. These crevasses develop when the faster-moving ice at the centre of the glacier is pulled away from the slower-moving ice along the edges. Because of the angle of this stretching force, marginal crevasses are oblique to the valley sides.

LONGITUDINAL CREVASSES develop where the glacier spreads out at its terminus or toe. These crevasses radiate across the toe and as the melting occurs, they open up and facilitate melting of the ice.

Another feature of glacial structure is the drainage systems which exist within glaciers. With the onset of summer, melt water is produced not only at the toe but over the entire surface of the glacier. Small streams and pools form on the surface of the glacier and HUMMOCKS a few feet high are produced by differential melting. The streams flowing between these hummocks cut channels in the underlying ice just as a normal river cuts its way through a valley. These streams often run for long distances before finding their way to TUNNELS beneath the ice. Where rushing water flows down into fractures or crevasses, the swirling action of the water rounds them out to form deep vertical shafts called glacial MILLS or MILLWELLS. The depth of a millwell often exceeds the depth of the crevasses; the water is eventually channeled into a subglacial drainage tunnel. Many glaciers are thought to have a complex system of drainage tunnels which are interconnected at different levels. Changes to this internal drainage system often results in abrupt changes to the position of the meltwater channels which emerge from the base of the ice. In some glaciers, such as the Crowfoot Glacier, these drainage tunnels have become exposed on the face of the glacier to form ICE CAVES.

The glaciers of today are having an erosional effect just as those of the Pleistocene did many thousands of years ago. In high areas, the valleys are still being gouged out and cirques continue to be deepened by glacial scour. Also, the debris carried by the glaciers is deposited in much the same way. These more recent deposits include glacial till in the form of terminal, lateral and medial moraines. Some of these deposits are so recent that they still remain barren of plant and animal life.

It is interesting that there are certain plants and at least one animal that is capable of living on glacial snow and ice. One of these is an ALGAE, a primitive form of plant. These once-celled algae are red in colour and often occur in such concentrations that the snow takes on a pink or reddish hue. A certain type of insect which is about half an inch in length is also found on glaciers. It is thought that these insects subsist on pollen and algae that the wind carries to the snow surface. The "ice worm" does exist but is not native to the glaciers of Banff National Park.

Glacial Streams and Rivers

The icefields, glaciers and snowfields of the Canadian Rockies are the source of a vast water supply. The Columbia Icefield, with its area of about 31,000 hectares (120 square miles) is a hydrological APEX — its outlet glaciers drain into three oceans: the Atlantic, the Arctic and the Pacific. However, because the boundaries of Banff National Park follow the natural watersheds on the western and northern side, all of the rivers in Banff Park drain eastward to the Atlantic Ocean via the Saskatchewan River drainage system. The volume of flow in Banff's rivers is regulated by the rate of melting of glacial ice and snow. Peak runoff occurs in late June or early July. In the summer, changes in flow can be seen throughout the day, with the maximum flow late in the afternoon, and the minimum flow at dawn.

Because the major streams and rivers of the park are glacier fed, they carry a heavy load of debris -- small rocks, gravel, sand and rock flour. In their upper reaches, these streams often wander through wide GRAVEL FLATS; there the current velocity is slowed
down and much of the sediment load is dropped. In these areas, the streams become BRAIDED, or divided into a great number of small channels which are constantly shifting. Many of the rivers along the Icefields Parkway show this kind of braiding; one of the best examples in the area is where the North Saskatchewan River flows through the "Graveyard Flats" about 16 kilometers (10 miles) north of Saskatchewan River Crossing. Some of the finer sediments may be carried past these gravel flats; the finest particles, known as ROCK FLOUR, usually settle out only in lakes or in quiet backwater areas. Rock flour is often carried out well beyond the mountain front, giving the Bow and North Saskatchewan River their characteristic turquoise colour.

Glacial Lakes

There are two kinds of glacial lakes in the mountain area: those that occupy abandoned glacial cirques are known as CIRQUE LAKES or TARNS; those that fill long narrow valleys are known as FINGER LAKES. Most of the larger lakes such as Lake Minnewanka are finger lakes. These lakes occupy valleys that were gouged out by glacial activity and then later blocked by deposits of glacial debris. Most of these lakes have been dammed by terminal moraines left by the large glaciers that once filled their valleys. However, some of the hanging valleys, such as the one holding Lake Louise, have been blocked by the lateral moraines left by the Bow Valley glacier. Moraine Lake is actually not blocked by a moraine at all; the rock piles damming the end of the lake are thought to be the results of landslides rather than glacial activity.

Many of the lakes in higher areas still have remnant glaciers at their heads; because of this, the meltwater feeding into them is highly charged with sediment. Much of this sediment is dropped in large DELTAS which have developed at the heads of these lakes. The Peyto Lake delta is a good example. However, most of the finer particles are carried past the deltas and into the lake where they are held in suspension until they finally settle out. It is because of these particles, which reflect the green portion of the light spectrum, that the mountain lakes have their magnificent turquoise and green colours. In many of these lakes, such as Lake Louise, the amount of sediment is variable throughout the year. Because of this, the colour of the lake changes throughout the season. During the winter months, most of the sediment settles out so that in the spring the lake appears very blue or turquoise in colour. In the early summer, the glacier begins to melt and the lake is again supplied with this fine sediment which reflects the green wavelengths of light. As the summer progresses, more and more of this rock flour is held in suspension; because of this the lakes become greener in colour towards the end of the summer.

Glossary of Terms: Glaciology

ABRASION ZONE - The area of a glacier which is below the snowline, i.e. the area where there is a net yearly loss of snow and ice.

ACUMULATION ZONE - The area of a glacier that is above the snowline, i.e. the area where there is a net yearly gain of snow and ice.

ADVANCE - An increase in size of a glacier. A glacial advance occurs when the rate of movement at the toe is greater than the rate of melting.

This results in an advance of down-valley movement of the ice front.

ARETE - A sharp ridge that is the result of cirque erosion on two sides of a mountain.

AVARANCHE - A sudden downslope movement or slide of snow from a mountain slope. Glaciers are often nourished by avalanches that come down from the surrounding peaks.

BREAK IN SLOPE - The junction between glacially eroded valley sides and the more rugged peaks above. This break-in-slope indicates the maximum elevation of past glacial advances.

BERGSHUND - A large transverse crevasse which occurs at the head-wall of a hanging glacier.

BOULDER CLAY - A type of rock which results when glacial till is compacted and cemented together with calcium carbonate.

BRAIDED STREAM - A glacial stream which carries a high sediment load. A braided stream flows in several dividing and uniting channels resembling the strands of a braid. Channels are constantly shifting depending on flow volume.

CIRCUIT TIME - The time taken for snow that has fallen in the accumulation zone to appear at the surface of the glacier.

CIRQUE - A bowl-shaped depression carved in a mountain by a cirque glacier.

COULOUR, COL - A steep gully of depression in a mountain chain which is caused by glacial erosion.

CONTINENTAL DIVIDE - The watershed which passes through the high country of western North America and divides the waters flowing to the west from those flowing to the east.

CREVAUSE - A deep crack in a glacier which is caused by stretching of the brittle outer crust of ice.

TRANSVERSE CREVAUSES extend across the width of a glacier.

LONGITUDINAL CREVAUSES radiate out across the toe.

MARGINAL CREVAUSES form along the edges of the glacier and are oblique to the valley sides.

DRUMLIN - A deposit of glacial till which has a streamlined shape like that of an inverted spoon.

ERRATIC - A boulder which has been carried by a glacier and deposited far from its source area.

ESKER - A narrow snake-like ridge of glacial till which may be up to several kilometers in length. Thought to be the result of deposition by a sub-glacial stream.

FIRN - See NEVE.
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FIRNLINE - See SNOWLINE

FOLIATION - The layering that is seen in glacial ice. Thought to be caused by differences in the size and arrangement of the ice crystals.

GLACIAL TILL - See TILL

HANGING GLACIER - A small glacier that hangs on a steep rock face.

HOODOOS - Peculiar pillar-like structures that are formed by the differential erosion of glacial till or boulder clay along the edge of a cliff.

HORN MOUNTAIN - A horn-shaped peak like that of Mt. Assiniboine. Formed when a mountain is eroded on several sides by cirque glaciers.

ICEFALL - An area where a glacier flows over a steep slope in the underlying bedrock. Icefalls are always heavily crevassed and dangerous to cross.

ICEFIELD - An extensive area of thick ice which commonly feeds numerous small glaciers along its margins; an accumulation area.

MILLWELL, GLACIAL MILL OR MOULIN - A nearly vertical shaft in a glacier formed by the whirling action of surface meltwater as it drains down a crevasse. A millwell usually connects with drainage tunnels in the interior of the glacier.

MORAINE - The rock material carried and deposited directly by a glacier. Also known as glacial till, its composed of angular, unsorted rock fragments which commonly show striations or scratch marks.

LATERAL MORAINES are formed on either side of a glacier by debris that falls down onto the ice from the valley sides. These moraines are left high on the sides of the valley when the ice retreats.

MEDIAL MORAINE, When two glaciers meet, the two adjacent lateral moraines unite to form a MEDIAL MORAINE. This moraine separates the two glacial flows. A good example of a medial moraine can be seen on the Saskatchewan Glacier.

TERMINAL MORAINE, At the toe of the glacier where the ice is melting, the transported debris is dropped to form a TERMINAL MORAINE. This moraine often marks the maximum advance of an ice front.

GROUND MORAINE, A ground moraine is formed from rock particles dragged along beneath the surface of the ice.

NUNATAKS - An isolated peak of rocky outcrop which remained unglaciated because it projected above the surface of a glacier of icesheet. Many of the higher peaks in Banff National Park could be called nunataks. Large nunataks such as the Cypress Hills escaped the Pleistocene glaciation and served as "refugia" for the plants and animals which would later repopulate Alberta.

NEVE or FIRN - The granular snow which is found in the accumulation zone of a glacier.

The term NEVE is also used for the accumulation zone or the area of a glacier which is above snowline.

OUTWASH DEPOSITS - Glacial debris which have been carried and deposited by streams and rivers. Unlike glacial till, these deposits are well sorted and layered.

PLEISTOCENE - The Pleistocene Epoch was the time of the Ice Ages. It is estimated that the Pleistocene began from one to three million years ago.

RECESSION - See RETREAT

RETREAT - A decrease in size of a glacier. This occurs when the rate of melting at the toe exceeds the rate of movement of the glacier, so that the ice front recedes or retreats up the valley.

ROCK FLOUR - Finely ground rock; a glacial sediment which is held in suspension in glacial rivers and lakes.

SNOW BRIDGE - A deposit of snow which covers the opening of a crevasse. It is very dangerous to cross these snow bridges in spring and early summer.

SNOWLINE or FIRNLINE - This is the lower limit of perennial snow. Below this line is the ABLATION ZONE and above it is the ACCUMULATION ZONE where snowfields persist from year to year.

STRIATIONS - Scratch marks left on rocks by the grinding action of a passing glacier.

TILL, GLACIAL TILL - A mixture of clay, silt, sand and stones that has been deposited directly by a glacier. Unlike OUTWASH DEPOSITS, the material has not been transported by water so the rock fragments are angular and poorly sorted.

TOE - The end or snout of a glacier; the area where glacial ice is melted.

TRIMLINE - An area in the vicinity of a glacial toe where a distinct difference in vegetation can be seen. This trimline may be used to estimate the maximum advance made by the glacier in recent times.

Selected References


Selected References: General


Free Publications about Banff National Park

Free publications from Parks Canada are available at the Information Bureaux at Banff, Lake Louise, and Saskatchewan River Crossing. The park has a limited number of these pamphlets for general distribution. We ask that you and the park visitor use discretion in selecting park pamphlets. For instance, for a bus tour, why not circulate a few copies around the bus? In this way everyone can look at the material before deciding whether to keep it as a souvenir. This will help reduce paper waste and your cleanup.

Pamphlets Available

A Special Place
Canada's National Parks
Banff National Park
The Icefields Parkway
The Banff-Windermere Parkway
You are in Bear Country
Bighorn Sheep
Bison
Wapiti
Birds of Banff National Park
Silver City
The Cave and Basin
Bankhead
Summer Interpretive Program Schedule