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Geology and Scenery of The Banff National Park, Canada

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The Rocky Mountains of Canada consist of numerous NW-SE trending ranges. The Main Range forms its backbone and the Front Ranges are towards the east. The Banff National Park extends eastward from the continental divide to the eastern slope of the Main Range and much of the Front Ranges that includes the mountains around the town of Banff. The foothills of the Rockies are located to the east of the Park, between Calgary and Canmore.

In the first week of June 2013 I along with my daughter Anita, her husband Paresh and their baby daughter Diya spent one week in Canada's internationally famous Banff National Park in Canada's western province of Alberta. My children flew in from Seattle, USA, to Calgary and I flew to Calgary from Ottawa, Canada, and from there we drove to this sprawling national park in the lap of the Rocky Mountains. I present here a short account of the geology of this region and show how geological history has shaped its stunning scenery. I have added an aerial photograph (refer to the last figure) taken from the window of the airplane while flying from Calgary to Seattle that shows the snow covered peaks of Mount Baker and Glacier Peak volcanoes.

Banff National Park

Banff National Park is Canada's first national park and was established in 1885 after the discovery of the Cave and Basin Hot Springs near the town of Banff in southern Alberta (Figure 1). There was a dispute about who discovered these hot springs and who would develop them for commercial gain. As a result Canada's Prime Minister of that time Sir John A. Macdonald decided to settle the issue by setting aside a small reserve of 26 square kilometers around the hot springs at Cave and Basin as a protected public park and named it the Banff Hot Springs Reserve in 1885. The Rocky Mountains Park Act, enacted on June 23, 1887, under which this protected reserve was expanded to 260 square miles and named Rocky Mountains Park. It was Canada's first national park, and only the second in North America after the Yellowstone National Park in the USA (website 2).

This park encompasses a variety of geological landscapes, like high snowcapped mountains, deep gorges, glaciers and ice fields, beautiful lakes, alpine meadows, mineral hot springs and amazing hoodoos. The park has a variety of wildlife including bighorn sheep, wolves, black and grizzly bears, elk, coyotes, caribou and mountain lions. This park was declared a UNESCO World Heritage Site in 1984 (website 2).

Figure 1: The location of the Banff National Park in Alberta showing location of places mentioned in this article (Website 1).

The present park is located 110 to 180 km west of Calgary in southern Alberta (Figure 2). It covers an area of 6,641 square kilometers of mountainous terrain, with various glaciers and ice fields, abundant and dense coniferous forest and alpine landscapes. The town of Banff is the main commercial center located in the Bow River valley. The Canadian Pacific Railway company built two enormous and elegant hotels in the park, Banff Springs Hotel and Chateau Lake Louise. Since the 1960s, park accommodations have been open all year. Since Banff is one of the most visited national parks in the world, the health of its ecosystem has been threatened. Parks Canada's new policies aim to preserve its ecological integrity (website 3).This region has a long history of human habitation. Radiocarbon dates of the archaeological artifacts found at Vermilion Lake indicate that the first human activity in the Banff area dates back to 10,300 B.P. when aboriginal people were common in this region who hunted bison and other games for their sustenance (website 3).

Geology of the Banff National Park

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Figure 2: Snow covered mountains, valleys and alpine forests offer magnificent scenic views while driving on the Canada Highway-1from Calgary to Banff National Park. (Photo: The author)

The Canadian Rockies are predominantly composed of shallow marine sedimentary rocks that were deposited on a continental shelf. The rock formations of the Banff National Park area range in age from Precambrian to the Jurassic and the main period of mountain building occurred between 80 -120 Million years ago. This resulted in the shortening and deformation of the ancient continental shelf and was associated with several parallel thrust faults and associated folds (Website 3).

Glacial landforms that characterize geomorphology of the park area and the surrounding regions are cirques, aretes, hanging valleys, moraines and U-shaped valleys. The pre-existing structures left after mountain-building tectonics have guided glacial erosion. The mountains in Banff include complex, irregular, anticlinal, synclinal, castellate, dogtooth and sawback types of mountains and many of the mountain ranges trend NNE, with sedimentary rocks dipping towards West at 40^0 to 60^0.This leads to dip slope landforms, with generally

steeper East and North faces, and trellis drainage, where rivers and old glacial valleys followed the weaker layers in the geological succession (Website 3).

Mount Rundle is a classic dip slope mountain near Banff and the Spray and Sulphur rivers flow parallel to the geological strike of the mountain range. North of Banff is Castle Mountain; a castellate shape, with steep slopes and cliffs, is composed of Cambrian limestone of the Cathedral Formation and the Stephen shale above it. Mount Louis is a type of dogtooth mountain that exhibits sharp and jagged slopes. The Sawback Range consists of near-vertical sedimentary rocks that have been eroded by cross gullies. Talus deposits and cones are common at the bottom of many mountains and cliffs (Website 3).

Glaciers and Ice fields

The Banff National Park has several easily accessible glaciers and ice fields and small cirques are fairly common that are situated in depressions on the side of mountains. The glaciers in Banff are retreating and glaciologists are analyzing the impact of reduced glacier ice on water supplies to the streams and rivers of the region. The largest glaciated areas are the Waputik and Wapta Ice fields covering an area of around 80 km^2. These ice fields lie on the Banff-Yoho National Park border. Bow Glacier has retreated approximately 1,100 m between 1850 and 1953, and further retreated since then forming a lake at the terminal moraine. Peyto Glacier too has retreated approximately 2,000 m since 1880, and could disappear in the next 30 to 40 years. Crowfoot and Hector Glaciers are not affiliated with any major ice sheet (Website 3).

The Columbia Ice field situated at the northern end of this park connects the Banff and the Jasper National Parks that extends into British Columbia. The giant Snow Dome in this ice field feeds water that flows in all directions. Melt water from this point flows into the Pacific Ocean through the Columbia River, into the Arctic Ocean through the Athabasca River, and into the Atlantic Ocean via Hudson Bay through the North Saskatchewan River. The Saskatchewan Glacier which is around 13 km long and covers an area of 30 km^2 is the major outlet of the Columbia Ice field that flows into Banff. This Glacier had retreated around 1,364 m between 1893 and 1953. The glaciers of the Canadian Rockies lost 25% of their mass during the 20th century (Website 3).

Geology of Banff's Springs

The Sulphur Mountain Thrust Fault on the east facing slope of this mountain is located west of Banff (Figure 3). The thermal springs of the area result from this fault, and the evolution of the Banff Springs Snail (*Physella johnsoni*) which is confined to the thermal springs are found along this thrust fault. The springs are located at various heights; the Upper Hot spring at 1584 M, the Middle Springs at about 1500 M and four thermal springs at the Cave and Basin National Historic Site are at 1400 M above sea level. By comparing the stable-isotopes in the water from the springs at different elevations it was found that water in the thermal springs of the Sulphur Mountain originates from water falling on the local mountains at an elevation of approximately 2000 to 2100 M. As the water or snow falls on the Sulphur Mountain, it sinks underneath to almost 3.2 km below the surface and gets heated and when this hot water reaches the Sulphur Mountain Thrust Fault it comes to the surface as

springs (Figure 4). During the past few years the thermal springs have been gradually drying up (Website4).

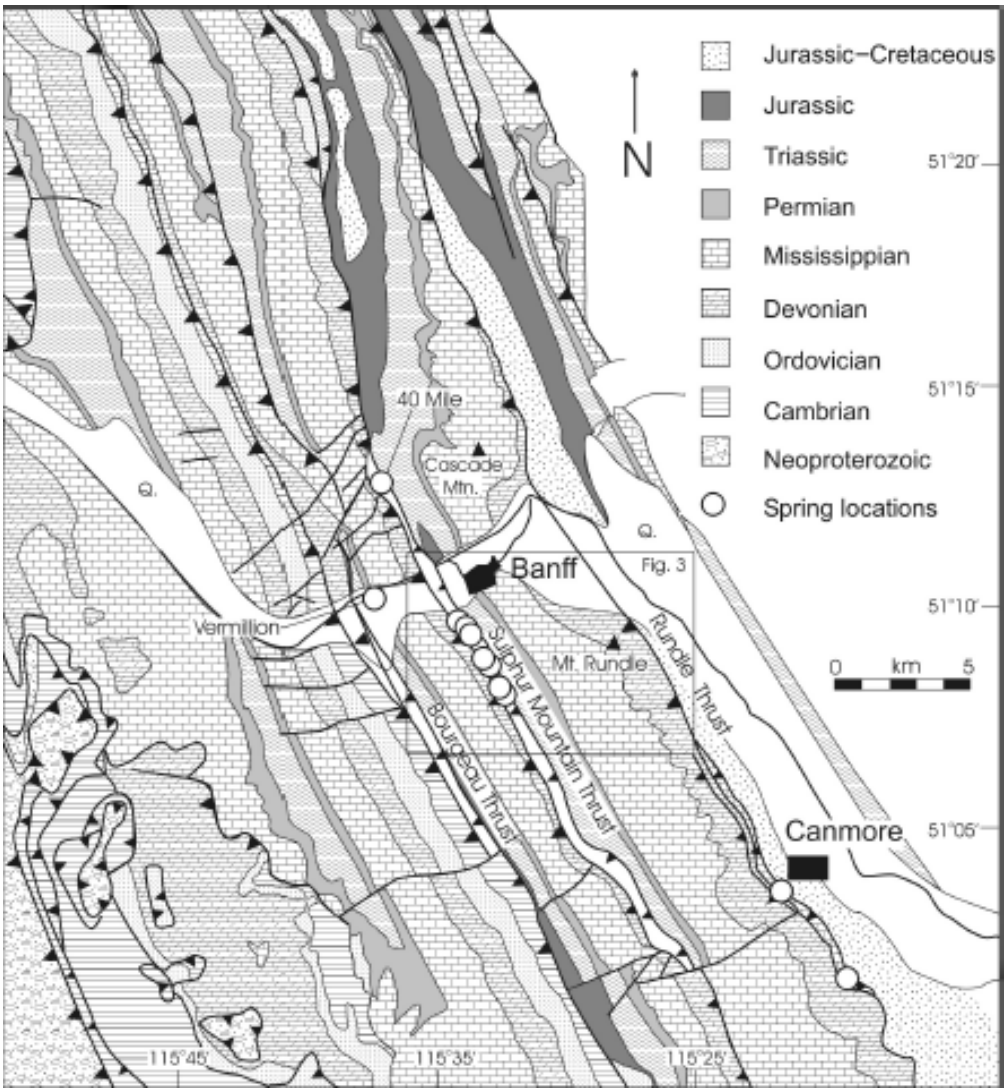

Figure 3: Geological map of Banff showing the locations of thrust faults (Borgeau, Sulphur Mountain, and Rundle) and thermal springs (Grasby and Lepitzki 2002; website 4).

The sites visited

The information presented below is from Benn and Pistolesi (2012), Mussieux (1998) and the listed websites. Tourist information pamphlets of Parks Canada on Lake Louise, Lake Louise Gondola and Cave and Basin National Historic Site too provided some information.

Lake Louise and Victoria Glacier

This glacial lake located 1,731m above the sea level is 2.4 km long, 0.5 km wide and its maximum depth is 90 m (Figures 5 and 6). It was named in 1884 after Princess Louise Caroline Alberta, the fourth daughter of Queen Victoria. This lake is famous for its stunning emerald green water and lies below the Victoria Glacier. This glacier is named after Queen Victoria which sits on the slope of over 3460 m high Mount Victoria. The lake water reflects the surrounding mountains, evergreen forests and glaciers that formed it. The glacial silt or 'rock flour' suspended in the melt water from the Victoria Glacier absorbs and reflects sunlight that gives its distinct emerald green colour. During the last Ice Age glaciers had covered whole of this valley which subsequently retreated due to the Holocene warming trend depositing terminal moraine which acted as a dam for the melt water forming this lake.

Figure 4: Formation of thermal springs on the Sulphur Mountain (website 4).

Figure 5: Lake Louise and the Victoria Glacier (Photo: the author (right) with Paresh and Anita with Diya in the foreground, taken by a fellow tourist)

Figure 6: Tourist information about Lake Louise. (Photo: The author)

Lake Louise Gondola

This gondola ride takes tourists up to a height of 2136 m and this location offers grand panoramic views of the surrounding mountain peaks of the park including a stunning view of Lake Louise and the Victoria Glacier (Figure 7). The gondola reaches the summit of Mount Whitehorn from where one can enjoy spectacular views of Lake Louise and across to the Valley of the Ten Peaks.

Figure 7: An aerial view of the Lake Louise from the top of a mountain taken by the Lake Louise Gondola. (Photo: Paresh Maisuria)

Moraine Lake

Moraine Lake is about 15 km away from Lake Louise in the Valley of Wenkchemna Mountains (Figure 8). Several talus cones (Figure 9) and a good view of the 'U shaped' valley carved by the movement of the glacier can also be seen (Figure 10). This lake was not formed by damming of melt water by terminal moraine as is the case of Lake Louise; instead this lake was formed by damming of water run-off from the surrounding mountains by falling rocks forming debris hill from the 'Tower of Babel' (Figure 11).

Figure 8: Moraine Lake showing talus cones and transported logs and huge boulders by snow and ice. (Photo: The author)

Figure 9: A talus cone at the base of the cliff on the shore of the Glacial Lake. (Photo: The author)

Figure 10: A U-shaped valley carved by the movement of glaciers (Photo: Paresh Maisuria)

Figure 11: Outcrops around the Glacial Lake and talus deposit at the foot of the cliffs. The 'Tower of Babel' is in the background. (Photo: The author)

Cave and Basin National Historic Site

This cave and nearby hot springs (water temperature 34^0C) are credited to be "discovered" in 1883 by three railway workers, although aboriginal peoples of this region had known about it for millennia before and bathed in its curative and sacred waters. As mentioned above this cave and basin area is the source of the creation of Canada's first national park, Banff National Park. The Cave and Basin Centennial Centre opened in 1985 to honour the 100^{th} anniversary of Canada's national park system (Figure 12).

The geology and origin of these hot springs and caves have been described above; the inside of the cave is almost totally covered by tufa which could be few to several meters thick (Figures 13 and 14). Tufa are sponge-like rocks made-up of Calcium Carbonate and are formed by the hot water that travels from Earth's interior to the surface through layers of limestone that dissolves and picks up Calcium Carbonate and precipitates as tufa inside the cave.

Figure 12: Mount Rundell as seen from Cave and Basin Centennial Center near Banff (Photo: Paresh Maisuria)

Figure 13: A hot spring pool near Cave and Basin. (Photo: The author)

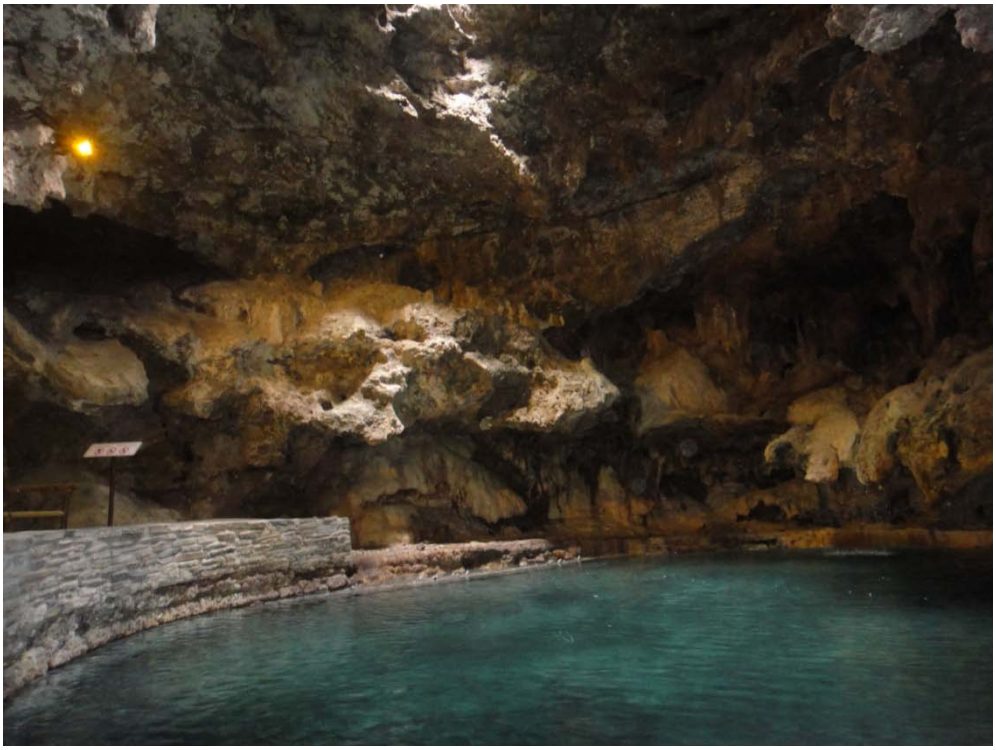

Figure 14: Cave and Basin near Banff town in the park. (Photo: The author)

Figure 15: A rare and endangered species of a tiny Gastropod (*Physella johnsoni*) that inhabits this pool is protected by law. (Photo: The author)

Figure 16: Close-up of a Banff Springs Snail (*Physella johnsoni*) through a microscope. The black eyes can be seen at the base of the long and thin tentacles. (website 3)

In the year 2000 the Banff Springs' snail (*Physella johnsoni*) was designated as an endangered species (Figures15 and 16). This tiny snail, 5 mm long, inhabits the warm

mineral springs of Sulphur Mountain feeding on algae, bacteria and other microorganisms in and around the Cave and Basin. Scientists have determined that the cessation of water flow in the thermal springs is one of the biggest threats to the continued survival of the Banff Springs Snail. Furthermore, it is believed that climate change is the ultimate cause of the increased frequency of thermal springs drying (Website 3).

Castle Mountain

This mountain appears like a medieval fortress that rises to 2766 m above the mean sea level and is a prominent land mark (Figure 17). It is located within Banff National Park approximately half-way between Banff and Lake Louise. The upper sections of this mountain, including its cliff faces consists of late Pre-Cambrian and Cambrian age limestone and shale along with some quartzite. Originally deposited in an ancient shallow sea, these deposits were later thrust over younger rocks of late Paleozoic and Mesozoic age which now form the forested, gently sloping base of the Castle Mountain. Erosion has shaped this castellated mountain in which a series of flat or gently sloping terraces are composed of softer shale and sharp cliffs by harder layers of quartzite, dolomite and limestone (Website 5).

Johnston Canyon

Johnston Canyon is located about 25 km north of Banff on the Bow Valley Parkway and is approximately 30 m deep and as narrow as 6 m at some places. Four hours long walk from the parkway to a group of six springs also known as ‘Inkpots’ are deep aquamarine waters due to the presence of glacial sediments in the springs. There are seven water falls in this valley, but two main waterfalls are known as the ‘Lower Waterfall’ and the ‘Upper Waterfall’. The ‘Lower Fall’ is just a 1.5 km long walk from the parkway through several catwalks that overhang right out into the gorge (Figures 18, 19, 20, 21).

Figure 17: Castle Mountain as seen driving on the Canada Highway-1 between Calgary and Banff National Park. (Photo: The author)

Figure 18: The lower falls of the Johnston Canyon in the park. (Photo: The author)

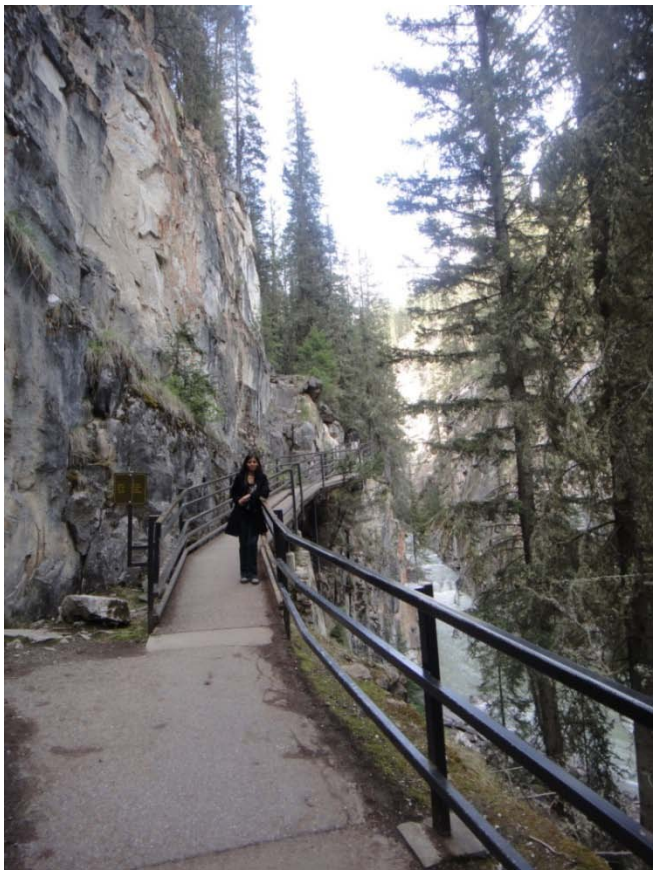

Figure 19: The Johnston Canyon in the park, notice catwalks that overhang right out into the gorge (Photo: The author, Anita is in the foreground)

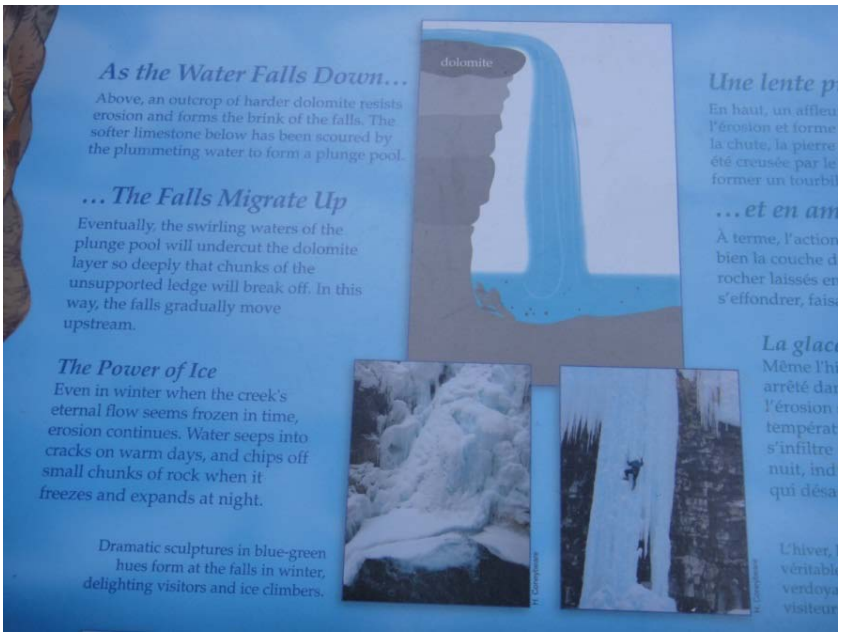

Figure 20: Some geological information about the canyon and the water falls. (Photo: The author)

Figure 21: Geomorphological details about the Johnston Canyon in the park. (Photo: The author)

Wildlife

The park has 56 mammal species and the Grizzly (Figure 22) and Black Bears are major attractions. Common predatory mammals of the park include cougars, lynx, wolverines, weasels, northern river otter and wolves. Moose, elk (Figure 23), mule deer and white-tailed deer also occur in the valleys and plains. Mountain goats, bighorn sheep, marmots and pika inhabit the alpine regions. Smaller mammals like beavers, porcupines, squirrels, chipmunks and Columbian ground squirrels are also common (Website 3).

The park has few reptiles and amphibians because of harsh winters. Over 280 species of birds are found; they include bald and golden eagles, red-tailed hawk, osprey, and merlin, all of which are predatory species. Water bodies like rivers and lakes are frequented by over a hundred different bird species that include loons, herons and mallards who spend their summers in the park. Endangered species in this park include the Banff Springs Snail (*Physella johnsoni*) which is found in the hot springs and Woodland caribou (Website 3).

Figure 22: A grizzly bear of the park. (Photo: The author)

Figure 23: An Elk in the park. (Photo: The author)

Figure 24: Mount Baker (right) and Glacier Peak (left) volcanoes seen from the left side airplane window while flying from Calgary to Seattle. (See their locations in my article Kumar, 2010) (Photo: Anita Maisuria)

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Suggested Readings

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Website 3: http://en.wikipedia.org/wiki/Banff_National_Park
Website 4: http://www.bowvalleynaturalists.org/page24/page25/page25.html
Website 5:http://en.wikipedia.org/wiki/Castle_Mountain

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