Waterton Resource Guide
Geology & Landforms

The Rocks That Form Our Mountains

- Waterton has some of the oldest exposed sedimentary rock in the Canadian Rockies - about 1500 million years old. These rocks were formed at a time before the development of complex animal life on earth, so only fossils formed by primitive cyanobacteria (blue-green algae) are found.
- Some cyanobacteria developed into impressive cabbage-like fossils called stromatolites. As various types of cyanobacteria lived and died, they changed the water chemistry, causing calcium carbonate to precipitate on and in their mucous-covered cells. Layers of these precipitated crusts, sometimes with trapped sediments, formed laminated mounds which were preserved as fossils. Although rare, large stromatolites only exist today in areas where aquatic invertebrate competitors can't live and calcium carbonate precipitation occurs readily (e.g. Shark Bay, Australia). Rocks with stromatolites are easily seen at Waterton at Red Rock Canyon. They resemble cabbages cut in half.
- Most rocks seen in the park are sedimentary; a small proportion is igneous.
- Red rocks are shaly siltsones, often called argillite - with up to 3% oxidized iron. Green rocks are the same - except with unoxidized iron. Beige/grey/brown rocks are limestone or dolomite. A black band of rock is intrusive igneous rocks called the Purcell Sill which are sandwiched between bands of white marble (cooked limestone).
- Around 1500 million years ago, most of the continents came together at the equator to form a supercontinent called Rodinia. As the continents slowly drifted apart, a depression formed and became a shallow sea. Present-day Alberta was next to this sea, called the Belt Sea, and most of Waterton's rocks formed in it.
- The region was a balmy, but barren, place. Changes in the area's climate, water depth and rate of deposition are all recorded in the rock. It was a time of flourishing microscopic marine life. For some forms, day-to-day life involved consuming hydrogen sulphide as their energy source. Much earlier, some bacteria evolved the process of photosynthesis as a means of obtaining food. Cyanobacteria (previously called blue-green algae) use the sun's energy to split carbon dioxide into carbon and oxygen. Life as we know it did not yet exist; there were no plants or animals.
- For about 100 million years, sediments accumulated at the bottom of the Belt Sea. The sequence of rocks deposited in this sea reach a total thickness of about 15 km, which is remarkably thick. Estimates of the time involved suggest deposition was quite rapid, perhaps taking only about 100 million years. The source for most of the sediment is thought to be a now-vanished mountainous area to the west and southwest.

- Layer upon layer of sand, silt, clay and iron-rich mud were buried, compressed and cemented to form sandstone, shale and limestone. Some deeply buried layers were changed (metamorphosed) by additional pressure and heat. For example, shale changed to argillite (red and green rocks) and limestone to dolomite.
- Evidence of the ancient seabed is provided by fossilized ripple marks, salt crystal casts and stromatolites. Earthquakes appear to have shaken the sea bottom frequently, forming distinctive cracks and squiggly veins.
- About 1400 million years ago, molten rock broke through the sedimentary layers and the lava spread onto the surface to cool and form igneous rocks known as the Purcell Lava. About 800 million years ago, near the end of the life of the Belt Sea, molten rock from the mantle squeezed up through cracks in the sea floor, injecting itself between sedimentary layers and cooling to form a distinct dark layer of igneous rock - known as the Purcell Sill. This dark layer is clearly visible on many of Waterton's mountains.

Building Mountains

- Crustal disturbance caused by the North American continental plate moving west over an oceanic plate began about 100 million years ago created the folded and faulted Rocky Mountains.
- In most of the front ranges of the Canadian Rockies, mountains were built of overlapping, tilted thrust sheets. In Waterton, the main movement was a single, flat-lying thrust sheet originating about 100 km/65 miles southwest of their present position. Starting about 75-85 million years ago, it began moving northeast as a unit, sliding over younger 70 million year old Cretaceous rock. This more or less horizontal movement ended about 35-45 million years ago. This fault is called the Lewis Thrust.
- Within the Lewis thrust sheet many smaller thrusts and folds formed. This can be seen on the face of Vimy Peak to the northeast of Waterton's community, and on Crandell Mountain.
- Since, and while, the mountains were built, glaciers and other forms of erosion sculpted them then deposited the pieces at their feet. Glacial and fluvial deposits blanketed the area east of the mountains; creating Waterton's unique 'Where The Mountains Meet The Prairie' landscape.
- Over the last 3 million years, North America experienced several major ice ages; the last major glaciation was 20,000 - 15,000 years ago, with a minor glacial advance 4000 to 2000 years ago, and another 'little ice age' about 700 to 150 years ago.
- A glacier is a flowing mass of hard snow (firn) and ice. Snow patches and snowfields are isolated tracts of snow and firn without the mass or slope to create flow.
- There are presently no glaciers in Waterton, just snow patches. Glacier National Park has several snowfields and about 50 small glaciers, which are retreating rapidly. At current rates of recession, they may be gone by mid-century.
- Mountain (Cordilleran) glaciers sculptured most of the Waterton/Glacier landscape. Continental (Laurentide) ice has only marginally influenced Waterton's landscape.
- The effects of glaciation are still obvious - deep, U-shaped and hanging valleys (e.g. Upper Waterton and Akamina); arêtes (e.g. Citadel Peaks); cirques (e.g. Cameron Lake); kames (e.g.

where the Prince of Wales Hotel sits) and eskers (e.g. in the bison paddock).

- Post-glacial features include the alluvial fans of Blakiston Creek and Cameron Creek (where the community sits); water erosion in Red Rock Canyon; and sediments collecting on the bottom of lakes and ponds.

GLACIATION

- Over the last three million years North America has experienced several major ice ages. These glacier advances were probably initiated by a general cooling of the earth's climate. Although it's common to think of one long ice age, in reality it was interrupted by warmer inter-glacial periods which caused glacial retreats (melt-backs). The last major ice age happened between 20,000 and 15,000 years ago, with a minor advance 4,000 to 2,000 years ago, and another 'little ice age' about 700 to 150 years ago. Much of Waterton was likely ice-free by about 12,000 years ago.
- Glaciers exist where more snow falls in winter than melts in summer. Snow that remains from year to year compacts into hard snow (firn) and ice. Under pressure, the ice recrystallizes, deforms, and given the right conditions, flows like thick molasses. Snow patches and snowfields are isolated patches of perennial snow without the mass or slope for movement. Today, Waterton supports a few snow patches while Glacier National Park supports several snowfields and about 50 small glaciers which are retreating rapidly. At current rates of recession, they may be gone by 2030.
- Mountain (Cordilleran) glaciers sculptured most of the Waterton/Glacier landscape. Continental (Laurentide) ice has only marginally influenced Waterton's landscape. The last and most extensive Laurentide advance was about 18 to 15 thousand years before present, as indicated by erratics found in and near the park. This advance was short. Thin ice may have overridden the margins of retreating cordilleran ice, then quickly melted away.
- The erosive power of glaciers is tremendous. As a glacier flows, it drags rocks, boulders, pebbles, sand and silt across bedrock scraping away at it like a rasp or file. Valleys are broadened and deepened (e.g. u-shaped Blakiston and Upper Waterton valleys). Valleys are left hanging in places where smaller glaciers flowed onto larger glaciers from side valleys (e.g. Cameron Falls). Rock ridges are sharpened (e.g. Citadel Peaks) and cirques are enlargened (e.g. Cameron Lake). The turquoise colour of some mountain lakes results when fine rock dust washes into the water and reflects the sunlight.
- Glaciers also transport and deposit huge amounts of material. Like a conveyor belt, eroded material is carried from one place and dumped (melted out) on another. This material is deposited by glaciers directly as moraines or it is deposited by meltwater on the glacier ice (kames), in the glacier ice (eskers), or away from the ice (outwash plains). In Waterton, most of these features were laid down in the northeast part of the Park, outside the mouth of the Waterton and Blakiston valleys.
- Some features, like alluvial fans, are still active. A good example is the fan on which the community of Waterton sits. It formed when the meltwaters of Cameron Valley glaciers carried sands, gravel and other debris into Upper Waterton Lake. Spring meltwaters still carry large amounts of debris in similar fashion. As water flows past Cameron Falls, its velocity drops. Slower moving water can't carry as much debris so much is dropped out. In heavy runoff years,

creeks overflow their banks and form a new channel. Through consecutive flooding, the creeks move back and forth, depositing material to form the typical fan shape. This process can create floods in the community. As a result, Cameron Creek's banks were stabilized with rock gabions.

- Other creeks and fans are left to natural process, notably Blakiston Creek and Fan. This fan, the park's largest, is the extensive flat area which is seen south of the Entrance Parkway between Lower and Middle Waterton Lakes. The Blakiston fan was created at the same time the fan on which the community sits was formed. Meltwaters from the retreating Blakiston Valley glacier dropped sand and gravels along the west side of a remaining chunk of the Waterton Valley glacier, creating the beginnings of a fan. As the ice melted to become a large lake, sediments in the meltwaters from the Blakiston Valley glacier added to this material. Over time, Blakiston Creek continued to erode materials from farther up the valley then deposit them. As the fan grew, it divided the original large lake into the Lower and Middle Waterton lakes, which are now joined by the Waterton River. The natural process of frequently shifting creek channels depositing eroded sediments continues today. Former creek channels are clearly visible from the air and when walking across the fan. Recent significant changes to the creek channels and flow happened during the 1995 flood and with high waters in 2010.