Montana Geology 2010

Chief Mountain

© Photo by Marc Adamus

Glacier National Park
100th Anniversary

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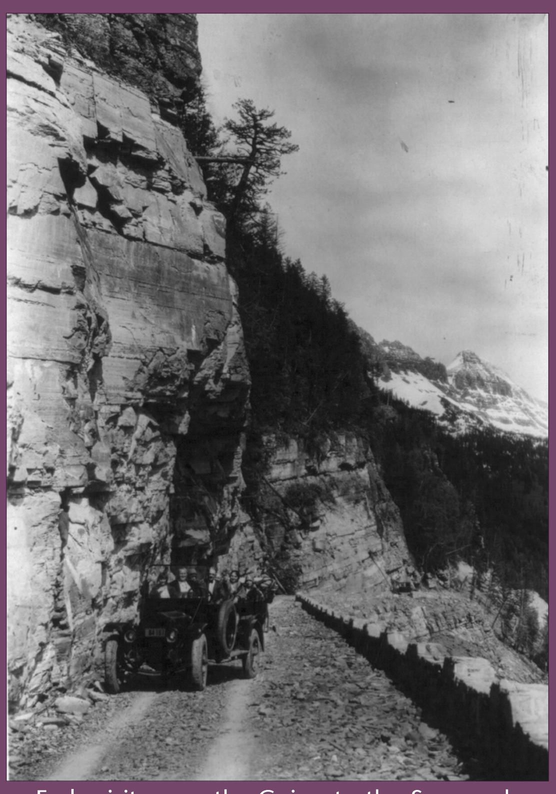
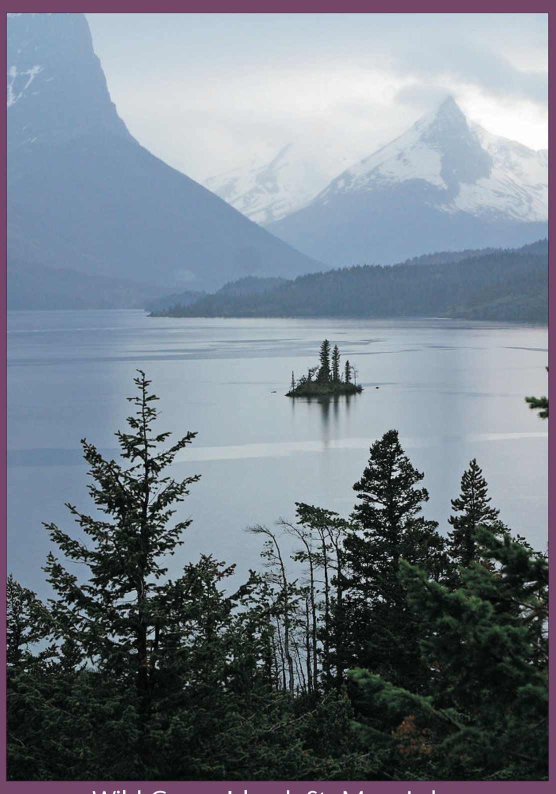


Early visitors on the Going-to-the-Sun road.
Photo from Library of Congress.

Along the Hidden Lake overlook. Photo by David Restivo, NPS.



Wild Goose Island, St. Mary Lake.
Photo courtesy PDphoto. org.

Glacial cirque. Photo courtesy Michael Barth.

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Montana Bureau of Mines and Geology

Chief Mountain and Glacier National Park

Location map

Jutting more than 4,000 feet above the plains, a solitary peak at the front of a massive chain of mountains, Chief Mountain has long played a prominent role in the culture of Montana's indigenous people. The Blackfeet call the peak *Ninaistaki* and hold it sacred as the home of Thunderbird, creator of thunder; Chief Mountain continues to be a site for their vision quests.

To geologists, Chief Mountain is arguably the world's finest example of a *klippe* (German for cliff). A klippe is an outlying remnant, isolated by erosion, of a much larger sheet of thrusted rocks. In other words, fault movement and erosion have left the rocks notably out of place. In 1901, Bailey Willis of the U.S. Geological Survey recognized that the rocks of both Chief Mountain and the mountains to the west had moved tens of miles from their original site, and identified Chief Mountain as a klippe. The geologic history is complex, but four main events produced the spectacular scenery we see today.

The Belt Basin: The rocks that make up the mountains of Glacier National Park are about 1.4 billion years old, deposited in the shallow waters of an ancient basin (the Belt Basin) that covered much of western Montana, the Idaho panhandle, and southern Alberta (fig. 1). As the basin subsided, vast volumes of mud and lesser amounts of fine-grained sand and limy beds were deposited to thicknesses that locally exceeded 40,000 feet—over 7 miles! The absence of burrowing animals in this ancient environment allowed preservation of delicately laminated beds and detailed features like mudcracks, raindrop impressions, and accumulations of fossil algae known as stromatolites. Certain layers record intrusions of molten magma into the sediments; some reached the seafloor to become lava flows. Geologists have divided this enormously thick sequence of rocks into numerous formations, which collectively are referred to as the Belt Supergroup. From 1.4 billion years to about 500 million years ago, the Belt Basin was apparently quiet and stable, but rocks deposited after that time record multiple episodes of sedimentation as seas advanced and erosion as they retreated.

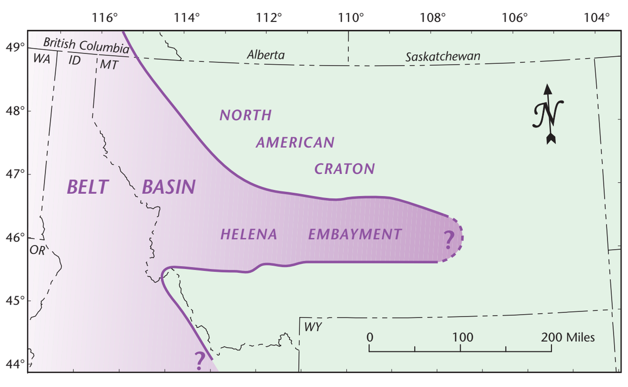


Figure 1. Location of the Belt Basin.

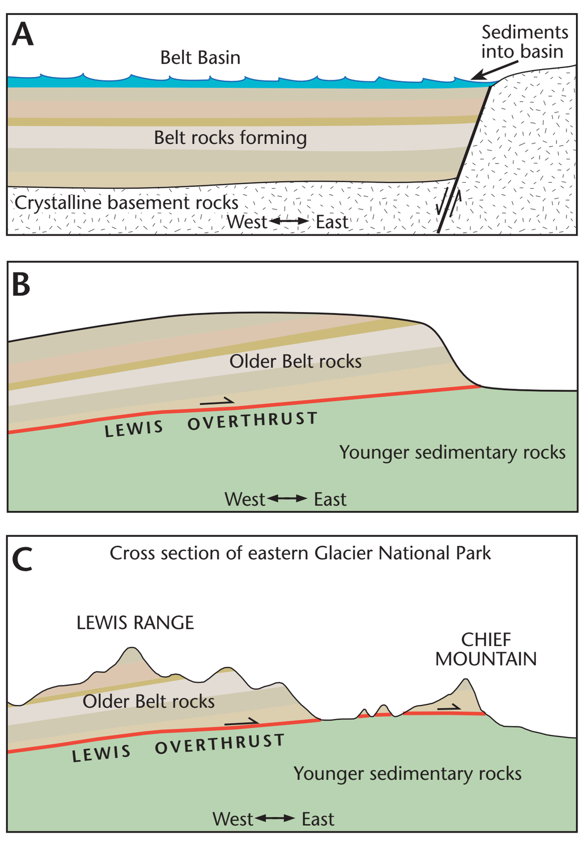
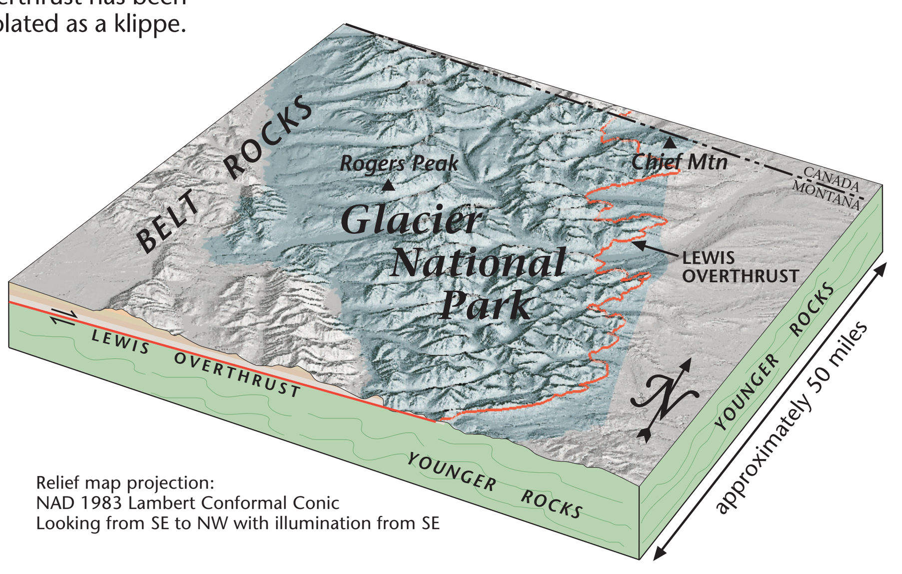


Figure 2. Schematic cross sections showing development of the Lewis Overthrust.
A: At 1.4 billion years ago, the Belt Basin was subsiding and being filled with sediment miles thick; **B**: By 60 million years ago, collision of continental plates had resulted in uplift of the Rocky Mountains, and a huge slab of Belt rock was thrust eastward at least 40 miles along the Lewis Overthrust; **C**: Today the Lewis Overthrust has been eroded, leaving Chief Mountain isolated as a klippe.

Mountain building and the Lewis Overthrust: Around 150 million years ago, crustal plates collided far to the west, initiating squeezing and uplift as the Rocky Mountains began to form. As this uplift culminated about 60 million years ago, in the region that is now Glacier National Park an enormous slab of Belt rocks measuring about 300 miles long and several miles thick was thrust at least 40 miles eastward over much younger rocks. The slip surface was a nearly flat fault plane known as the Lewis Overthrust. Belt rocks at the base of the thrust sheet slid on the younger wet, slippery shales much like kids sliding on a wet plastic sheet (fig. 2).

Erosion: As mountain building slowed, erosion became the dominant force in modifying the landscape. Most of the rocks overlying the Lewis Overthrust have been eroded away, but the remainder is substantial. All the rocks that form the mountains in Glacier National Park are Belt rocks that were part of the thrust block (fig. 3). Erosion has separated Chief Mountain from the rest of the thrust sheet that forms Glacier National Park (figs. 4, 5). Although klippen are found in many mountainous areas of the world, few rise so dramatically and stand in such isolation as Chief Mountain.

Figure 3. The present-day leading edge of the Lewis Overthrust is exposed along the eastern and southern parts of Glacier National Park and is marked by the boundary between resistant Belt rocks that form the mountains and the weaker, easily erodible shales beneath that form the plains. The cross section in figure 4 goes from Rogers Peak to Chief Mountain.



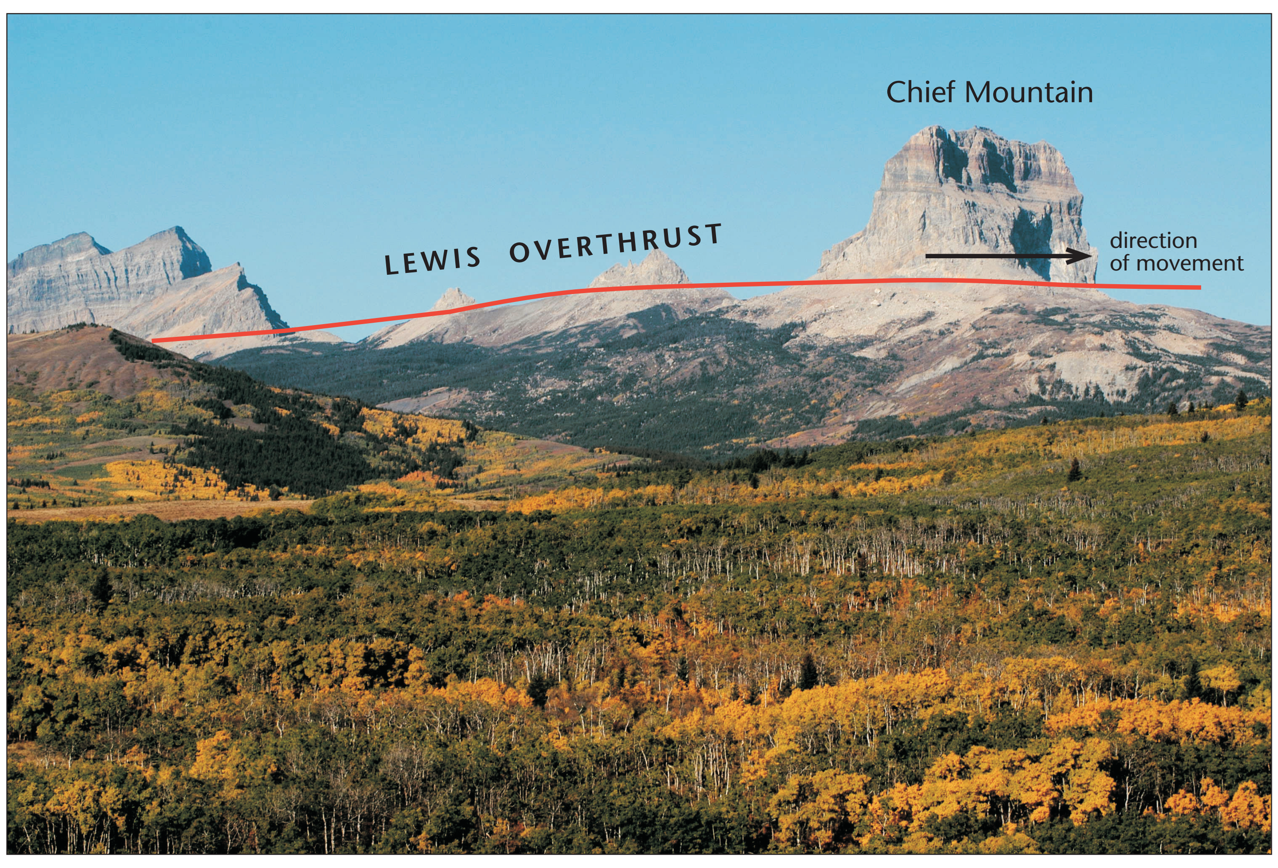
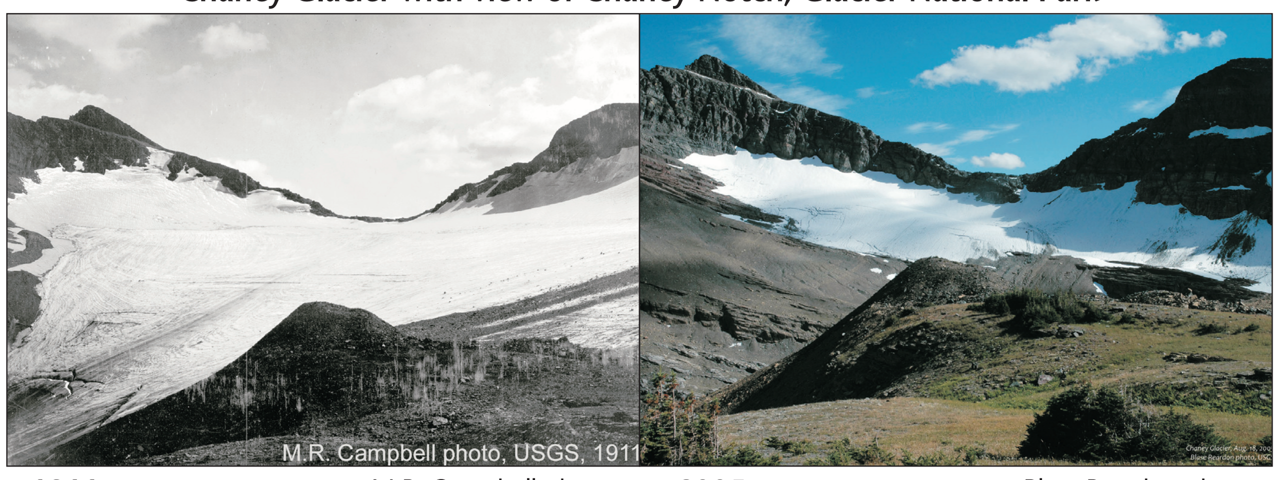


Figure 5. Photo of Chief Mountain with Lewis Overthrust drawn in, showing direction of movement. Photo courtesy of National Park Service. View looking northwest.

Glaciers: A more recent event carved Glacier National Park's ancient rocks, creating the sharp peaks and scenic lakes we see today. Some 2 million years ago, earth's climate cooled and the most recent Ice Ages commenced. As huge ice sheets advanced and retreated multiple times across much of the Canadian and north-central U.S. plains, smaller glaciers filled Glacier National Park's valleys until only the highest peaks remained exposed. Glacial ice flowed down mountain valleys, plucking, bulldozing, and grinding away at the underlying bedrock to create the Park's rugged landscape. Earth's climate gradually began to warm again, and by 12,000 years ago those enormous glaciers had all but disappeared. Some scientists have speculated that eventually all glaciers in the Park melted and the 50 to 60 small glaciers still found in the uppermost drainages are the remnants of glaciers that grew during the "Little Ice Age," from roughly 1600 to 1850. Regardless, the advances and retreats of these smaller glaciers did not approach the sculpting capacity of the immense Ice Ages glaciers. As our climate constantly changes, the continued existence of the present glaciers seems unlikely (fig. 6).

Chaney Glacier with view of Chaney Notch, Glacier National Park



1911 — M.R. Campbell photo, USGS Photographic Library
2005 — Blase Reardon photo, USGS

Figure 6. A few of the Park's glaciers have not shown appreciably visible changes during the past century, but many, such as Chaney Glacier shown above, have shrunk drastically.

Chief Mountain's destiny: Chief Mountain continues to erode today. Although imperceptible to the human eye, each year freeze–thaw cycles, rock falls, and other erosional processes slowly continue to reduce the mountain. The younger shales that underlie Chief Mountain are weak and prone to landslides, further undermining the mountain. Like the rocks of the thrust sheet that originally surrounded it, Chief's fate is to gradually disappear—not in our lifetime, nor our children's, but eventually the great peak will be gone. And somewhere west of where it stands today, a new klippe may exist.

Acknowledgments

Front photo by Marc Adamus, with permission. Other photos by MBMG and National Park Service staff, or as noted. Text and figures by Bruce Heise, National Park Service; Trista Thornberry- Ehrlich, Colorado State University; and Montana Bureau of Mines and Geology staff Edmond Deal, Bob Bergantino, Susan Smith, Paul Thale, and Ken Sandau. Contributions by Dr. Rob Thomas, University of Montana Western; Jeff Kuhn, Montana Department of Environmental Quality; and Kassandra Hardy and Mark Wagner, Glacier National Park. Editing and layout by Susan Barth and Susan Smith, MBMG.

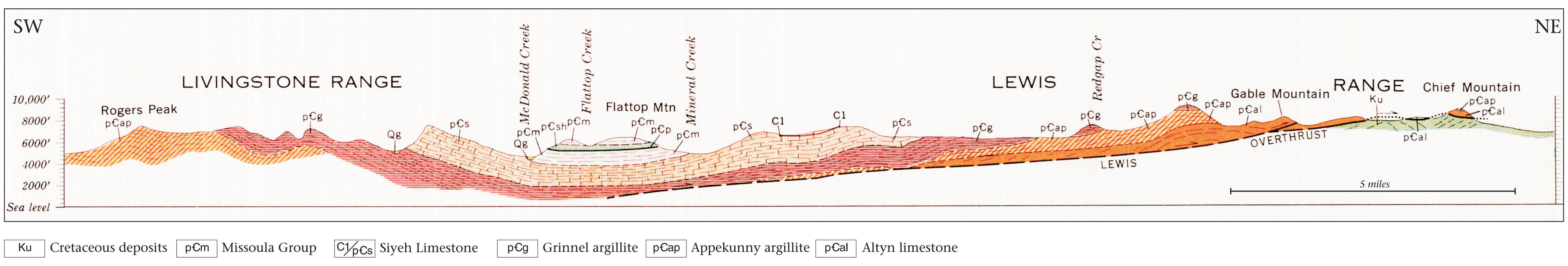


Figure 4. Part of cross section B from Ross, Clyde P., 1959, Geology of Glacier National Park and the Flathead Region, Northwestern Montana: U.S. Geological Survey Professional Paper 296, 125 p., 2 plates, scale 1:125,000.

Glacier National Park History and Centennial Celebration

Glacier National Park was established May 11, 1910, by President Howard Taft, but its attraction to humans extends much further back. Archeological surveys have found evidence of use dating back over 10,000 years. The indigenous Blackfeet, Salish, and Kootenai Indians were attracted by the region's bountiful plant and animal resources. In the early 1800s European trappers came in search of beaver and in 1806 Meriwether Lewis' exploration party lingered four nights at Camp Disappointment, about 42 miles southeast of Chief Mountain. The completion of the Great Northern Railway over Marias Pass in 1891 opened the area to more settlers. Homesteaders settled in the valleys west of the Park and miners came seeking copper and gold, though little was ever found. Natural oil seeps in the northwest corner of what is now the Park prompted drilling of the first oil well in Montana.

By the early 20th century, however, focus shifted to the value of the region's spectacular scenic beauty. A movement to preserve the area gained momentum, culminating with President Taft signing the bill establishing Glacier as the country's 10th National Park. Increasing numbers of park visitors led the railroad to construct a series of lodges and chalets, and ultimately the Going-to-the-Sun Road was completed in 1932. The same year, the U.S. and Canadian governments established the Waterton–Glacier International Peace Park. In 1995, the area was designated a World Heritage Site.

2010 marks the centennial of this spectacular park. The National Park Service is celebrating this event with a wide range of activities, from educational programs and commemorative events to legacy projects. The story of Glacier National Park's past, present, and future is one shared by many diverse cultures and people. It is a story that has many deeply rooted personal connections. The centennial provides all Americans and the world a chance to increase our understanding of and dedication to the rich history and preservation of this pristine treasure. The Park is truly the Crown of the Continent.

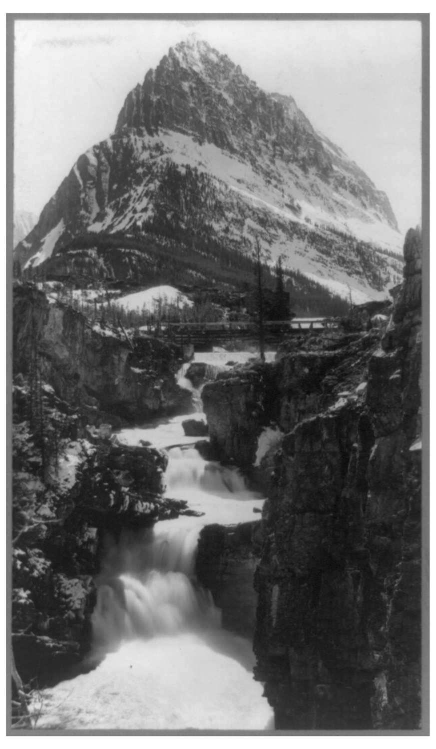


Photo from Library of Congress.

Montana Bureau of Mines and Geology

Montana Tech of The University of Montana

Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a public-service and research agency for the State of Montana, to conduct and publish investigations of Montana geology, including mineral and fuel resources, geologic mapping, and ground-water quality and quantity. In accordance with the enabling act, the MBMG conducts research and provides information but has no regulatory functions.

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