MONTANA GEOLOGY

Larry Ulrich©

Mt. Gould—*Glacier National Park*

January

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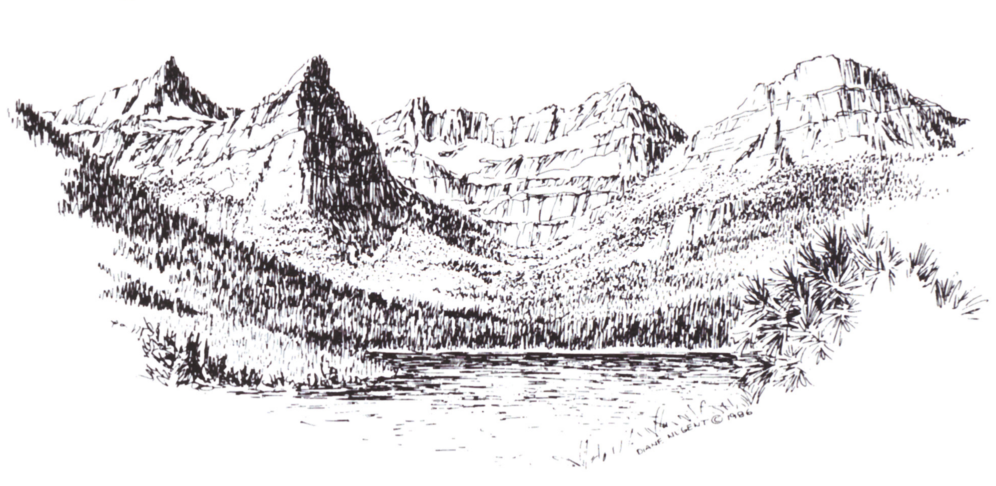
A Department of Montana College of Mineral Science and Technology

Glorious Glacier



I have been in the Alps of Switzerland and the Himalayas in India, but in neither of those ranges have I seen any setting of lake and mountains that can compare with this before us.
Colonel Robert Baring, 1889

Mountain scenery on an exceptional scale gives Glacier National Park its unique appeal. Here are found splendid Swiss-like peaks with sharply chiseled faces; canyons separated from each other by narrow, intricately carved ridges; and waterfalls, lakes and glaciers tucked away in the higher hanging valleys. Most often, the grandeur of such scenic highlands also affords an opportunity to observe and study interesting geology. Sometimes referred to as the "Crown of the Continent", Glacier National Park was established on May, 11, 1910. It is a place of such magnificence that ultimately two national parks, one in Canada and the other in the United States, were formed in 1932 to protect a shared ecosystem and to promote a symbol of friendship. Sitting astride the Continental Divide, the Park also exhibits a rich variety of flora and provides a habitat for a diverse wildlife community.

The geologic story of Glacier National Park begins about 1,600 million years ago, at a time when there were no mountains in the region—only a vast shallow sea bordered by desolate plains. The sand, silt, clay and mud, in part very limy, that were laid down in this sea eventually became partly metamorphosed quartzite, siltite, argillite, and recrystallized limestone and dolomite. In the Park area, this vast sequence of sedimentary rocks is estimated to be 18,000 feet thick. It is divided into eight formations of Middle Proterozoic age (1,600-800 million years). Similar rocks also occupy parts of present eastern Washington, western Montana, the panhandle of Idaho, and bordering areas of Alberta and British Columbia in Canada.

In the photograph of Mt. Gould, the shear, massive rock face is composed mostly of dolomite and limestone of the Helena Formation. The unit is about 1,400 million years old and was deposited in a shallow sea that was relatively free of clay, silt and mud. It is 3,000 feet thick and contains abundant stromatolites (fossil algae). In the upper part of the cliff face (concealed by the cloud bank in the photograph), the formation was intruded by an igneous sill of diorite, estimated at 750 million years old. This distinctive plutonic intrusive is conspicuous in many places throughout the Park as a dark-colored horizontal band, in some places 300 feet thick. As the molten rock invaded along bedding planes of the Helena Formation, it produced narrow white borders (bleached zone), where the intense heat of the injection altered the limestone to marble.

After the Middle Proterozoic rocks were laid down, seas slowly advanced and retreated across what is now Glacier National Park, burying the rocks under successive younger ones. Between 100-65 million years ago, the rocks of western North America were uplifted, forming the present Rocky Mountains. Included with this great upheaval, a detachment now termed the Lewis thrust fault, caused the dislocation of a mass of rock that was thousands of feet thick and hundreds of miles long and moved it eastward approximately 40 miles. This spectacular feature, well exposed on Summit Mountain at Marias Pass, resulted in older rocks being transported over and stacked on younger rocks.

When sediments of the region emerged from the sea, they began to be attacked by erosion. As periods of uplift, faulting, and erosion continued, the younger rocks were slowly stripped off of the older rocks.

The final episode in the Park's geologic past was the "Ice Age", beginning about 2 million years ago and ending approximately 10,000 years ago. This interval of geologic time is called the Pleistocene Epoch, and was characterized in the northern hemisphere by snowfalls that exceeded melting. This resulted in vast sheets of ice that originated in the area now occupied by Canada. These *continental glaciers* moved outward in all directions from centers of accumulation and advanced hundreds of miles into what is now the United States. In present-day Montana, they approached, but never quite reached what is now Glacier National Park *(see map)*. Smaller glaciers, however, formed near mountain crests and ultimately gouged their way down previously cut stream valleys. Glaciers of this type are termed *alpine glaciers*. Repeated advances and retreats of the glaciers sculptured the mountain terrain and developed the splendid scenery that is now Glacier National Park. It may be argued by some that the area is still in the "Ice Age", for some glaciers still exist. Glacial erosion that characterized the Pleistocene, however, is no longer a process. The more than 50 glaciers that are so identified within the boundaries of the Park today, reflect current climate conditions and are slowly receding.

Glossary of selected glacial terms

Arête—Narrow, serrated mountain crest or sharp-edged ridge that was sculptured by glaciers and resulted from the continued backward growth of the walls of adjoining cirques.

Cirque—Steep-walled, amphitheater-like hollow, variously described as crescent shaped or semi-circular in plan, situated at the head of a glacial valley, and produced by the erosive activity of an alpine glacier.

Glacial trough—Deep, steep-sided, U-shaped valley leading down from a cirque, and excavated by an alpine glacier that has widened, deepened and straightened a preglacial stream valley.

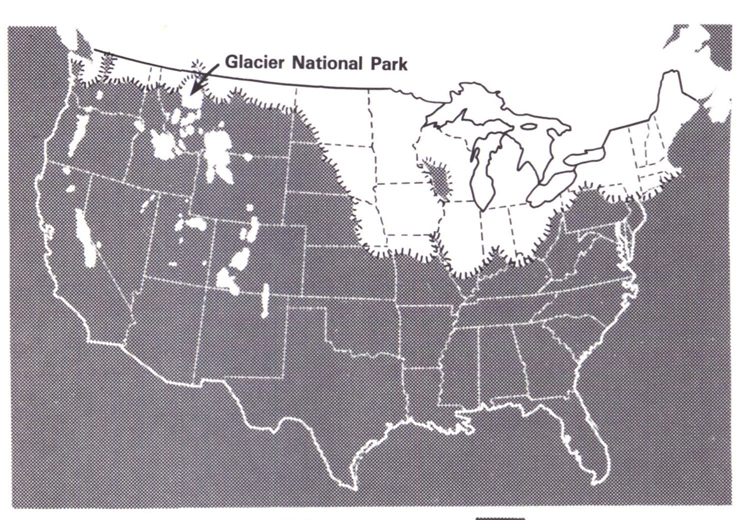
Glacier—Large mass of ice formed on land by the repeated accumulation, compaction and recrystallization of snow. Its movement is generated by stress of its own weight: two types, alpine and continental.

Hanging valley—Tributary glacial valley whose mouth is at a higher level on the steep side of a larger glacial valley.

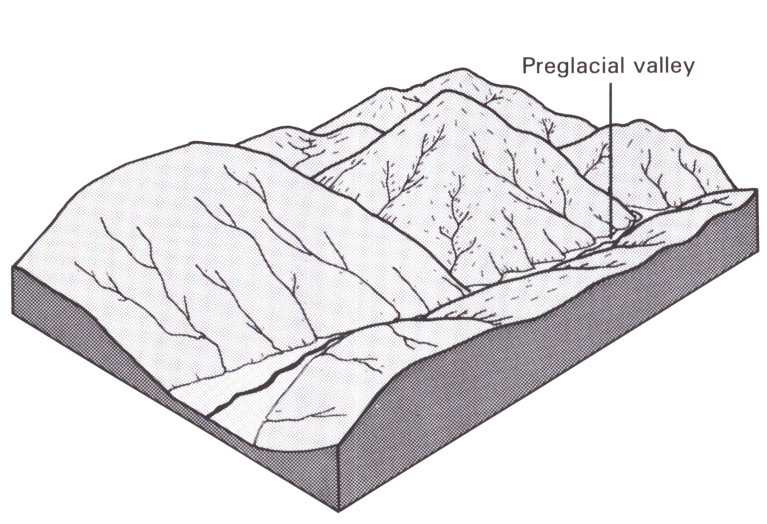
Horn—High, sharp-pointed mountain peak with prominent faces and ridges, bounded by intersecting walls of three or more cirques that have been cut back by the headward erosion of glaciers.

Moraine—Mound, ridge, or other distinct accumulation of unsorted glacial till that was deposited by the direct action of glacier ice: *terminal*—deposited at the farthest advance of a glacier; *medial*—an elongate feature that develops in the middle of a glacier, usually formed by coalescing valley glaciers; *lateral*—ridge-like feature along the sides of a glacier.

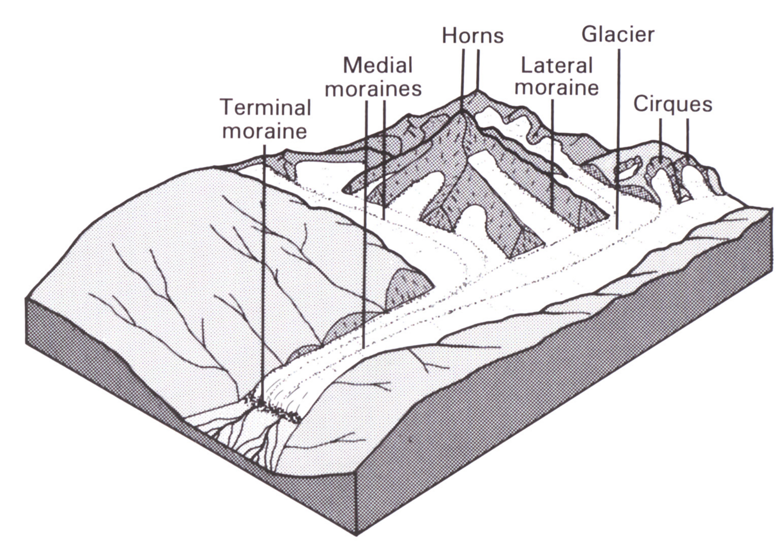
Tarn—Relatively small, steep-banked lake or pool amid high mountains, especially one occupying an ice-gouged rock basin or cirque.



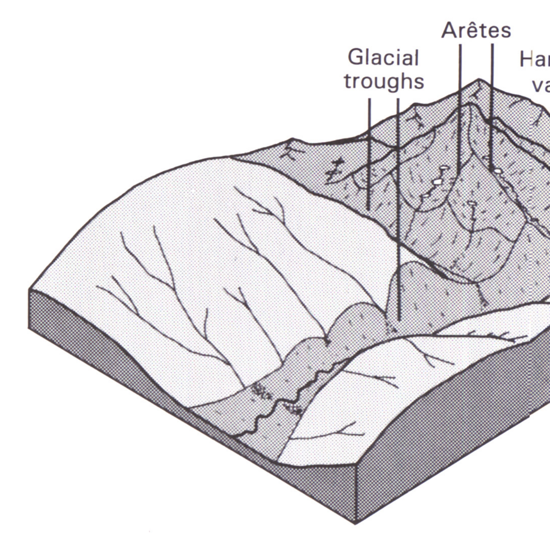
Extent of Pleistocene glaciation in the contiguous United States.



Phase 1
Before glaciation



Phase 2
During glaciation



Phase 3
After glaciation

Cartography: Pat Tamarin
Composition: Tracy Holmes

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Charter, Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a public service agency and research entity of the Montana College of Mineral Science and Technology. The Bureau director serves as the State Geologist and represents Montana in the Association of American State Geologists.

Enacted by Legislative Assembly of the State of Montana (Section 75-607, R.C.M., 1947, Amended), the scope and duties of the agency are summarized as follows:

- To collect, compile, and publish information on Montana's geology, mining, milling, and smelting operations, and ground-water resources.
- To maintain collections of geologic and mineral specimens, photographs, models, and drawings of mining and milling equipment, and literature on geology, mining, and ground water.
- To conduct investigations of Montana geology, emphasizing economic mineral resources and ground-water quality and quantity.

In accordance with the enabling act, the MBMG conducts research and provides information, but has no regulatory functions. To carry out its duties most effectively, the Bureau operates in four divisions: Research, Administration, Analytical and Publications.

Selected Publications on Montana Geology

Special Publication 89—Profiles of Montana geology: A layman's guide to the treasure state, David D. Alt, 1984, 168 p., 180 figs $12.00

Special Publication 94—Belt Supergroup: A guide to Proterozoic rocks of western Montana and adjacent areas, Sheila M. Roberts *(ed.)*, 1986, 311 p., 175 figs. 11 tables, 10 color plates $25.00

Special Publication 95—Guidebook of the Helena area, west-central Montana, compiled by Richard B. Berg and Ray H. Breuninger *(eds.)*, 1987, 64 p., 20 figs., 1 table $5.00

Geologic Map 27—Glacial features of the upper Swiftcurrent valley, Glacier National Park, Montana, H.L. James, 1982 . . $2.50

Special Publication 102—Coal geology of Montana, Mark A. Sholes *(ed.)*, 1992, 157 p., 134 figs., 5 tables, 1 appendix, 2 sheets $25.00

Reprint 6—Gold placers of Montana (2nd edition, revised), Charles J. Lyden, 1987, 120 p., 23 figs, 22 maps $10.00

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