Trapper Peak, Bitterroot Mountains

Montana Geology 2020

Trapper Peak. Photographer Mike Anich, 2019. Purchased from Alamy Stock Photo.

January

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South face of North Trapper Peak.

Summit view looking west.

Alpine lake in fall colors.

Como peaks.

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TRAPPER PEAK AND THE BITTERROOT MOUNTAINS

Trapper Peak (center) is the highest (10,157 feet) point in the Bitterroot Mountains, but its lesser sibling on the right, North Trapper Peak (9,801 feet), is perhaps the most spectacular. These peaks are on the south end of a rugged chain of mountains that form 60 miles of the Montana–Idaho border (fig. 1). No roads cross these remote mountains, and most of the range has been preserved in the Selway–Bitterroot Wilderness, accessible only by foot or on horseback. The Trapper peaks are underlain by granitic igneous rocks of the Idaho batholith emplaced more than 10 miles beneath the earth's surface. They were brought to the surface through a long and complex series of geologic events outlined below.

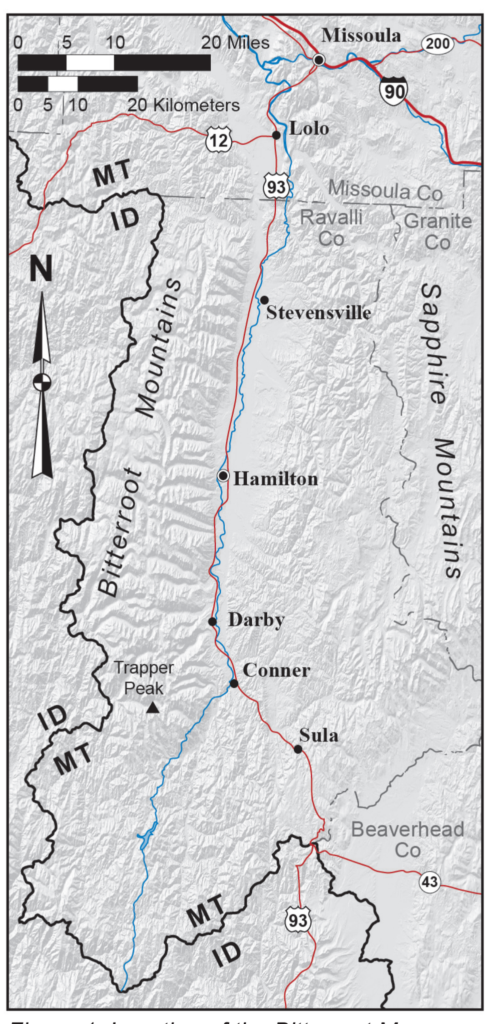

Figure 1. Location of the Bitterroot Mountains, Trapper Peak, and the Sapphire Mountains.

The geologic history of the Bitterroot Mountains began over 1.4 billion years ago with the accumulation of a thick succession of sedimentary layers deposited first in a vast inland lake, and then later along the shores of an open ocean. These sedimentary deposits had reached a thickness of 10 miles by the time plate tectonic forces began to build the Rocky Mountains about 120 million years ago. At that time, compressive forces shoved these deposits eastward along great thrust faults (see fig. 2). The faults stacked slices of rocks on top of one another, thickening the earth's crust (fig. 3A), and forming high mountains similar to the Andes and Himalayas today.

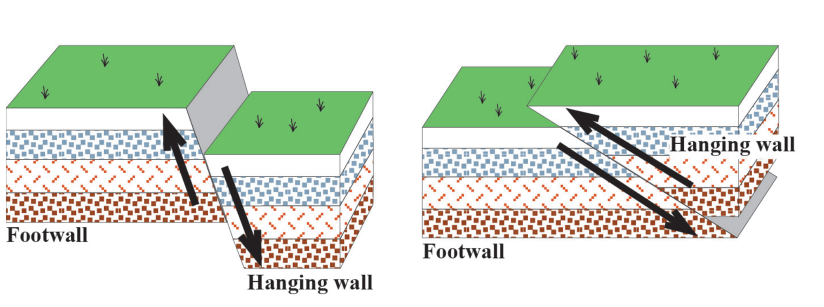

Figure 2. Explanation of fault terminology. (A) On a normal fault, the hanging wall moves down with respect to the footwall. The fault can be either steep as shown or gently sloping like the Bitterroot detachment fault. (B) On a thrust fault, the hanging wall moves up and over the footwall at a low angle.

The sedimentary rocks that were deeply buried by these thrust faults were then changed by heat and pressure into metamorphic rocks such as schist and gneiss. Some melted, forming magma that invaded the metamorphic rocks and sedimentary layers (fig. 3B). This magma cooled and solidified deep underground about 80 million years ago, becoming the granite intrusions of the Idaho Batholith. The granite that makes up the Trapper peaks and most of the Bitterroot Mountains cooled and crystallized more than 10 miles beneath the surface.

About 53 million years ago, the tectonic forces reversed and the earth's crust in this region began to be pulled apart, or extended, instead. The extension allowed the emplacement of more granite intrusions, but most importantly it broke the crustal rocks with a gently east-sloping normal fault (see fig. 2) called the Bitterroot detachment fault (fig. 3C). Because the Bitterroot detachment fault initially formed at great depth where it was very hot, the rocks along it sheared plastically, changing the granite along the fault plane to very hard, layered gneiss (fig. 4). The rocks of the Bitterroot Mountains were pulled out from under the overlying rocks that now make up the Sapphire Mountains to the east. The rocks above the Bitterroot detachment fault were therefore moved many miles eastward relative to the Bitterroot Mountains (fig. 3D). It is common to hear people talk about how "the Sapphire Mountains slid off the top of the Bitterroot Mountains," which simply describes the relative movement along the Bitterroot detachment fault.

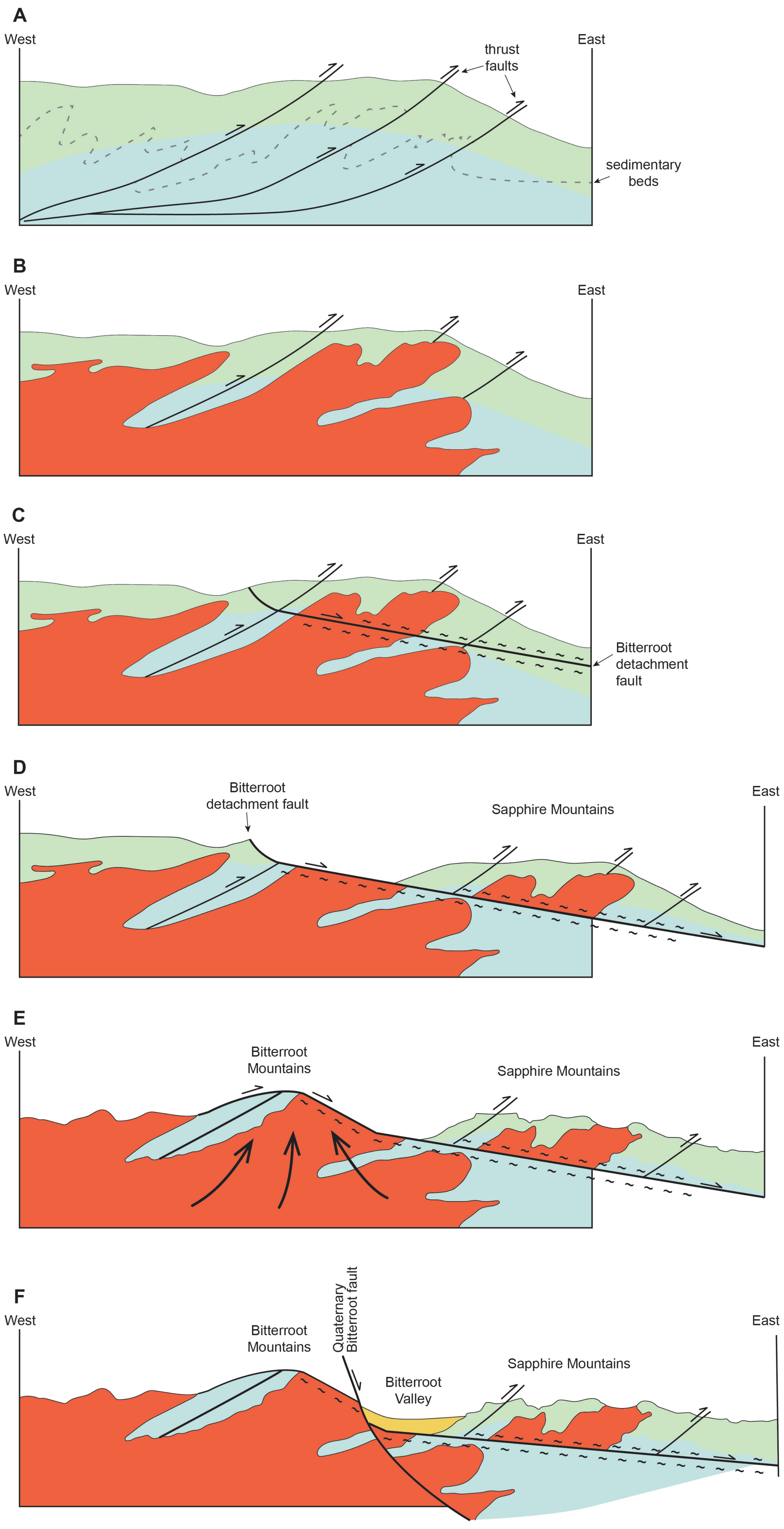

Figure 3. Schematic cross sections showing the geologic history of the Bitterroot region.
(A) 100–80 million years ago. Compressive tectonic forces shove the sedimentary rocks (green and blue) eastward and stack them along thrust faults, forming high mountains. The deeply buried rocks are changed by heat and pressure into metamorphic rocks (blue) such as schist and gneiss.
(B) 80–65 million years ago. Under great heat and pressure, rocks deep in the crust melt, creating magma that then rises into and intrudes the overlying sedimentary and metamorphic rocks. It then cools and crystallizes, forming the granite (red) that underlies the Bitterroot Mountains today.
(C) 53 million years ago. The earth's crust begins to pull apart, and a gently sloping normal fault, the Bitterroot detachment fault, forms and begins to move the rocks above the fault in its hanging wall, eastward. Along the fault plane, shearing turns the rocks into very hard resistant gneiss (denoted by squiggles).
(D) 53–30 million years ago. Movement on the Bitterroot detachment fault continues, moving its hanging wall rocks into the position of the present-day Sapphire Mountains.
(E) 53–30 million years ago. As the great weight of the Sapphire Mountain rocks is removed from atop the Bitterroot Mountains, they rebound upward to form a dome capped by the resistant gneiss (squiggles) of the Bitterroot detachment fault plane. The ancestral Bitterroot Valley forms and begins to fill with unconsolidated sedimentary rocks.
(F) 26 million years ago to present. Steep normal faults develop along the east side of the Bitterroot dome and further elevate the mountains. These faults are still active.

With the great weight of the Sapphire Mountains rocks removed, the Bitterroot Mountains rose up in a broad, elongate dome (figs. 3E, 5). Because it is so resistant to weathering, the gneiss of the Bitterroot detachment fault plane now forms the top of this dome. The resistant gneiss on the east side of the dome creates the very planar slope of the eastern front of the Bitterroot Mountains (fig. 6). It caps all of the highest Bitterroot peaks, including the Trapper peaks (fig. 7). The detachment fault separates the rocks of the Bitterroot Mountains, which were derived from deep within the earth's crust, from the rocks of the Sapphire Mountains, which were from shallower levels and so are less metamorphosed. These features—the metamorphic core of the Bitterroot Mountains, the detachment fault, and the less metamorphosed carapace of the Sapphire Mountains—together constitute a unique geologic feature called a metamorphic core complex.

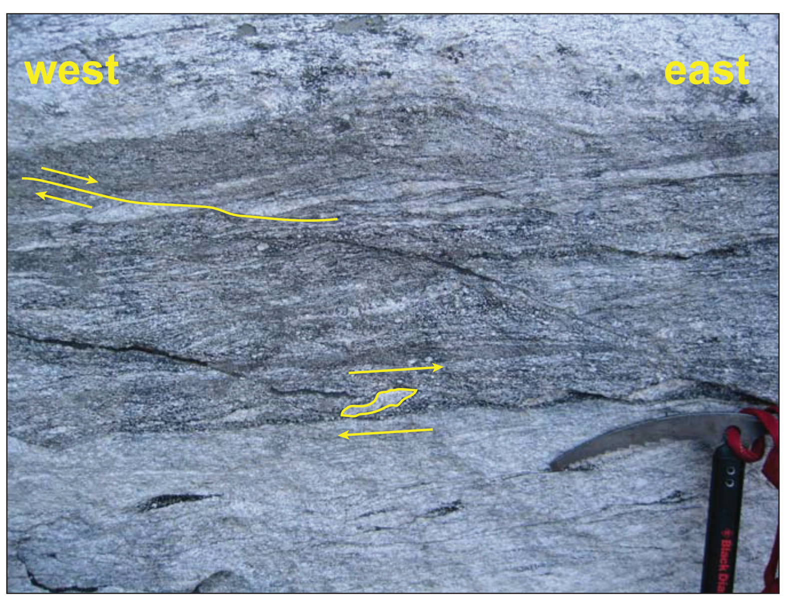

Figure 4. Cross section (edgewise) view of the resistant gneiss developed by shear along the Bitterroot detachment fault plane. Geologists can use the features exposed here to determine the movement direction of the fault as shown by the arrows. They show that the top (hanging wall) moved to the right, that is, to the east into the Sapphire Mountains.

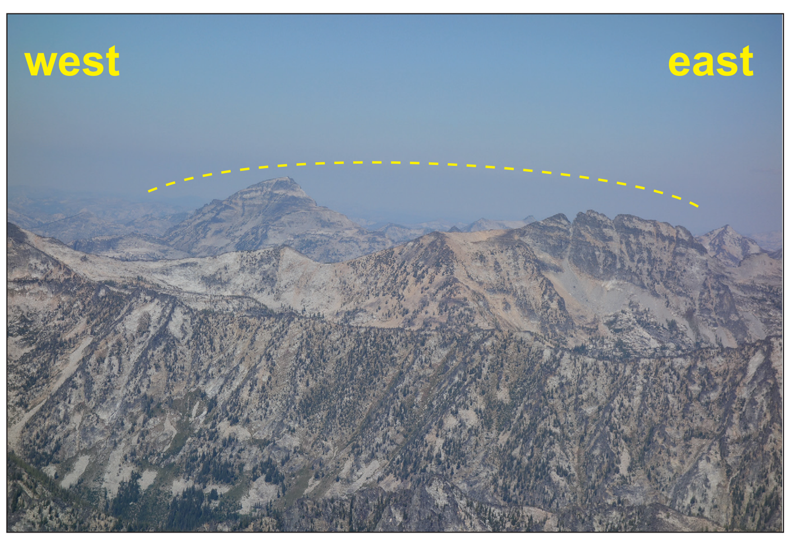

Figure 5. Northward view from the Trapper Peak summit showing the apex of the Bitterroot dome. The gneissic layers visible on the two highest peaks parallel the shape of the dome drawn above, sloping to the west on the left peak, and to the east on the right peak.

With the rise of the Bitterroot dome, the Bitterroot Valley came into existence about 30 million years ago; it is therefore one of the oldest valleys in Montana. It immediately began filling with unconsolidated sediment derived from both the Sapphire Mountains to the east and the Bitterroot Mountains to the west; near Hamilton these gravels and clays are more than 2,000 feet deep. Although movement ceased along the Bitterroot detachment fault 30 million years ago, the rise of the mountains continued. Steep normal faults became active along the eastern base of the Bitterroot Mountains and further elevated the mountains (fig. 3F). This fault system, called the Quaternary Bitterroot fault to distinguish it from the older detachment fault, is thought to be active today because fault scarps (fig. 8) cut across the most recent glacial deposits (about 14,000 years old). The Montana Bureau of Mines and Geology is studying these fault scarps to try to assess earthquake hazards in the Bitterroot Valley.


Figure 6. Northwestward view of the Bitterroot Mountain front near Hamilton. The flatirons are resistant gneiss developed along the Bitterroot detachment fault plane. The gneiss outlines the east side of the Bitterroot dome and forms the eastern front of the modern Bitterroot Mountains.

It was the glaciers, though, that finally sculpted these peaks into their spectacular forms. Despite the Bitterroot Mountains' relatively low elevation, the influence of the snowy Pacific maritime climate drove extensive glaciation during the several ice ages that occurred over the past 200,000 years. During these ice ages, snow persisted through hundreds of summers until it was eventually compressed into ice. When the ice attained sufficient thickness, it began to flow down the mountain valleys, carving the mountains into sharp peaks, plucking out the steep-walled cirques, excavating lake basins, and plowing U-shaped valleys. The bowl-shaped basin between the peaks on the main photo is a glacial cirque plucked out by the ice (fig 7). An arête is a knife-edged ridge carved by two valley glaciers, one on each side of the ridge. North Trapper Peak is a horn sculpted by glaciers that completely surrounded the peak, cutting steep walls on all sides. The Matterhorn in the Swiss Alps is the most famous example of a glacial horn, but similar jagged peaks abound in the heavily glaciated Bitterroot Mountains (see photos on front). The mountain glaciers around Trapper Peak extended well into the Bitterroot Valley, depositing moraines and outwash. At times, Glacial Lake Missoula filled the valley and must have created an incredible scene: the glaciers were probably calving icebergs directly into the lake. The last ice age ended about 14,000 years ago, and the deposits left behind are the ones cut by fault scarps along the active Quaternary Bitterroot fault (fig. 8).

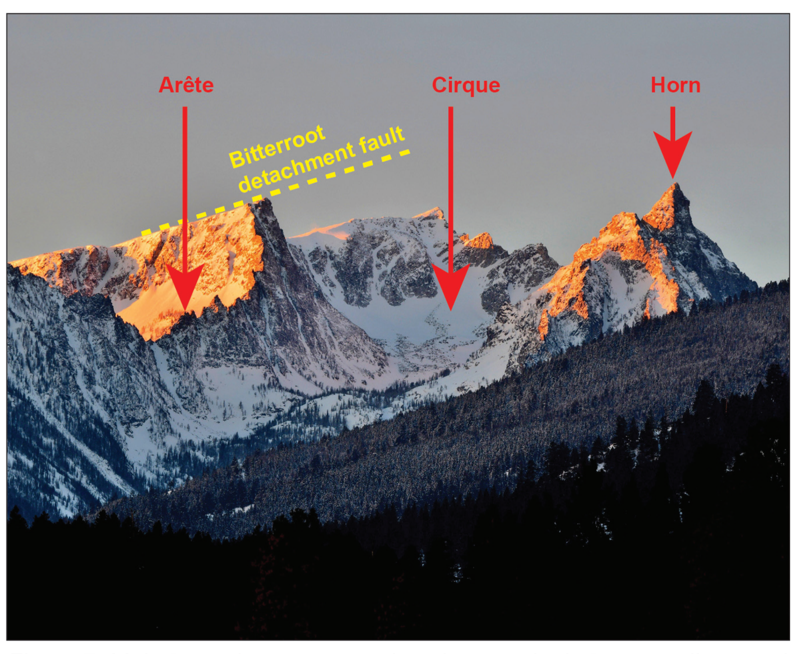

Figure 7. Main front photo annotated to show geologic features discussed in the text.


Figure 8. The hill on the left is the fault scarp formed by the still-active Quaternary Bitterroot normal fault. The left (west) side moved up relative to the right side. The scarp here cuts through young (14,000 years old) glacial deposits.

Additional Information

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Acknowledgments

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Stormy North Trapper Peak.

MONTANA BUREAU OF MINES AND GEOLOGY
Montana Technological University

Scope and Organization

The Montana Bureau of Mines and Geology (MBMG) was established in 1919 as a non-regulatory 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 groundwater quality and quantity.

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