Glacial Lake Missoula

Missoula, Montana

Glacial Lake Missoula Chapter truly covers the area where the incredible Ice Age Floods began, the entire area of impoundment of the Clark Fork River from just southeast of the ice dam to the furthest extent of the lake, including the waters of the Flathead, Bitterroot, Clearwater, and Blackfoot tributaries.

J.T. Pardee, the geologist who identified the source of the floods that swept down the Columbia, lived in this area. It is also home to David Alt, University of Montana geologist, and others who continue to contribute to our understanding of this cataclysmic event.

The chapter maintains an exhibit in Missoula in cooperation with the Montana Natural History Center, 120 North Hickory Street (call 406-327-0405 for hours) where you can watch videos about the great floods, view artifacts from the life of JT Pardee, pick up a map of a driving route of flood features in this area, and find other related books and brochures.

The Glacial Lake Missoula chapter sponsors speakers and field trips several times each year. To contact us, visit Facebook, or the chapter page on the Ice Age Floods Institute website (IAFI.org), or contact the Montana Natural History Center.

GLACIAL LAKE MISSOULA CHAPTER
ICE AGE FLOODS INSTITUTE

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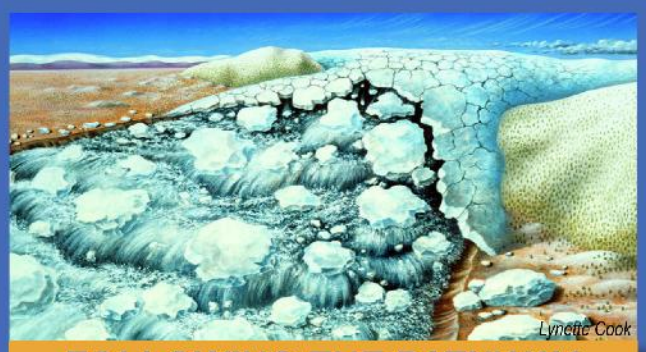

FOLLOWING THE PATHWAY

During the last glacial cycle of the Ice Age some 80,000 to 14,000 years ago, repeated ice dam collapses released cataclysmic floods from massive Glacial Lake Missoula, creating many of the distinguishing features of the interior Northwest's unique landscape.

This is your guide to the dramatic evidence of these incredible floods, from wave-cut strandlines to spectacular canyons and cliffs to waterfalls and vast, flood-eroded pathways, that can be witnessed in a short road trip.

It is our hope that you will use this guide to explore the fascinating geological flood features in our region, and want to learn more about the dramatic Ice Age Floods story.

OF THE GREAT FLOODS

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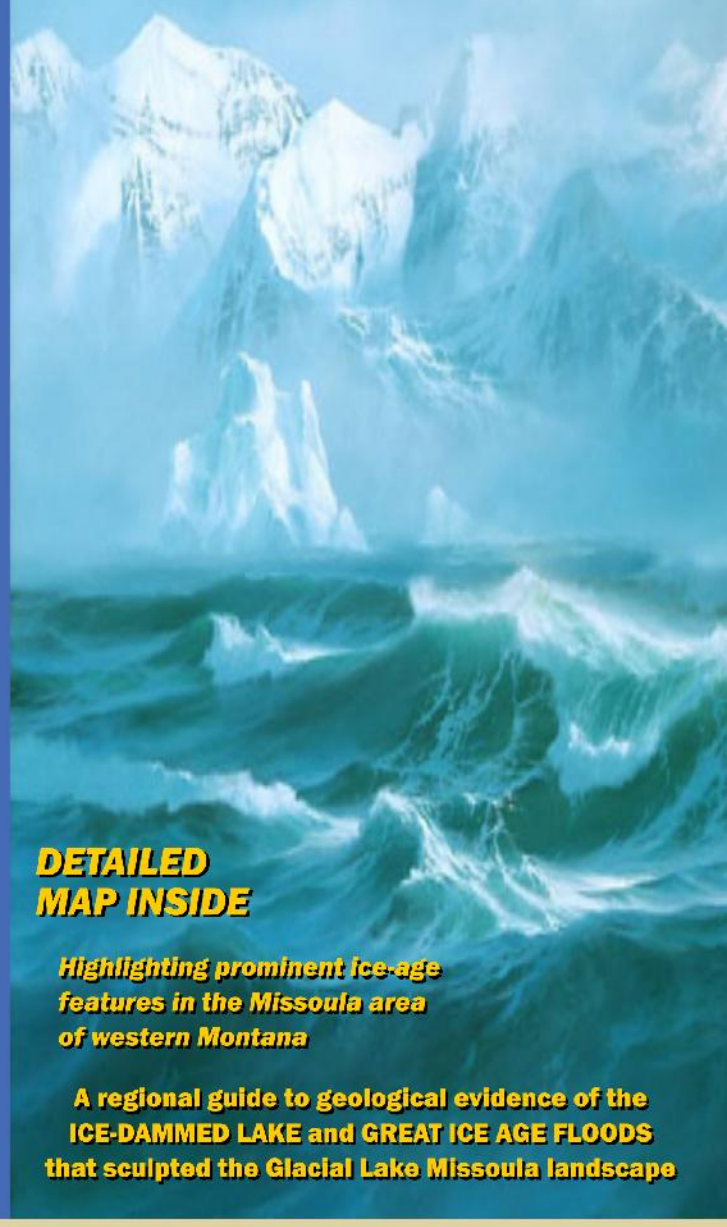
Learn MORE at IAFI.org or facebook.com/IceAgeFloods/

A GUIDE TO THE INCREDIBLE ICE AGE FLOODS "WHERE IT BEGAN"-GLACIAL LAKE MISSOULA

Our Cataclysmic Floodscape

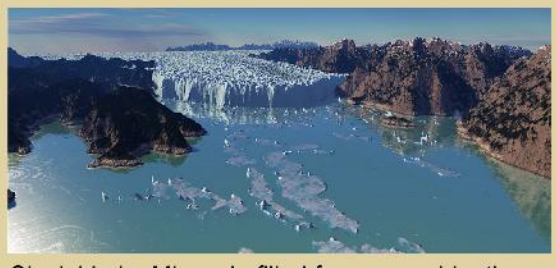


DETAILED MAP INSIDE

Highlighting prominent ice-age features in the Missoula area of western Montana

A regional guide to geological evidence of the ICE-DAMMED LAKE and GREAT ICE AGE FLOODS that sculpted the Glacial Lake Missoula landscape

Interesting Flood Facts!



Glacial Lake Missoula filled from a combination of rainfall, meltwater draining south from the continental ice sheet and from drainage of alpine snow from surrounding mountains.

Because of repeated flood cycles and harsh conditions, there were no fish in this lake nor many mammals in the valleys. Soils left behind were poor and vegetation sparse.

The underlying rock in most of this region is very hard, erosion-resistant metamorphic rock with distinctive minerals.

Flathead Lake was gouged out by a lobe of the continental ice sheet and today is the largest lake in the US west of the Great Lakes.

Glacial Lake Missoula contained over 500 cubic miles of water and ice. The lake covered 3000 sq mi, and was up to 2000 feet deep. It was 16 times the size of Flathead Lake and at Missoula it was 6 times Flathead Lake's average depth.

The period between Ice Age Floods in this area ranged from 58 years to as little as 9 years.

The roar of a coming flood could have been heard at least ½ hour before it struck.

J Harlan Bretz, originally a Seattle school-teacher, first presented his theory of the floods in 1923, and J.T. Pardee, a USGS geologist working near Missoula, published his findings on a glacial lake in 1942, but there was not general acceptance of the idea until the 1970s.

No human relics have been found yet in the floods areas, but native oral history suggests there possibly were witnesses to these events.

The Story of the Great Ice Age Floods

During the peak of the last Ice Age, a vast Cordilleran continental ice sheet covered southwestern Canada and the northern parts of Washington, Idaho and Montana. An eastern Purcell lobe of the ice sheet descended into the Idaho panhandle, blocking the Clark Fork River with an ice dam thousands of feet thick.

Water rising behind the ice dam flooded the valleys of Montana creating Glacial Lake Missoula – a great inland lake stretching over 200 miles to the east with a volume of water greater than Lake Erie and Lake Ontario combined.

The rising lake waters periodically caused the ice dam to fail, resulting in sudden, cataclysmic floods that rushed across northern Idaho and the Channeled Scablands of eastern and central Washington, through the Columbia River Gorge, and into Oregon's Willamette Valley, before emptying into the Pacific Ocean at the ancient mouth of the Columbia River. Glacial Lake Missoula would have drained in just a few days as a volume of floodwaters greater than all the rivers of the world combined roared across the landscape at up to 60+ mph.

Now imagine this happening not once but dozens, perhaps even hundreds of times as the advancing continental glacier rebuilt new ice dams!

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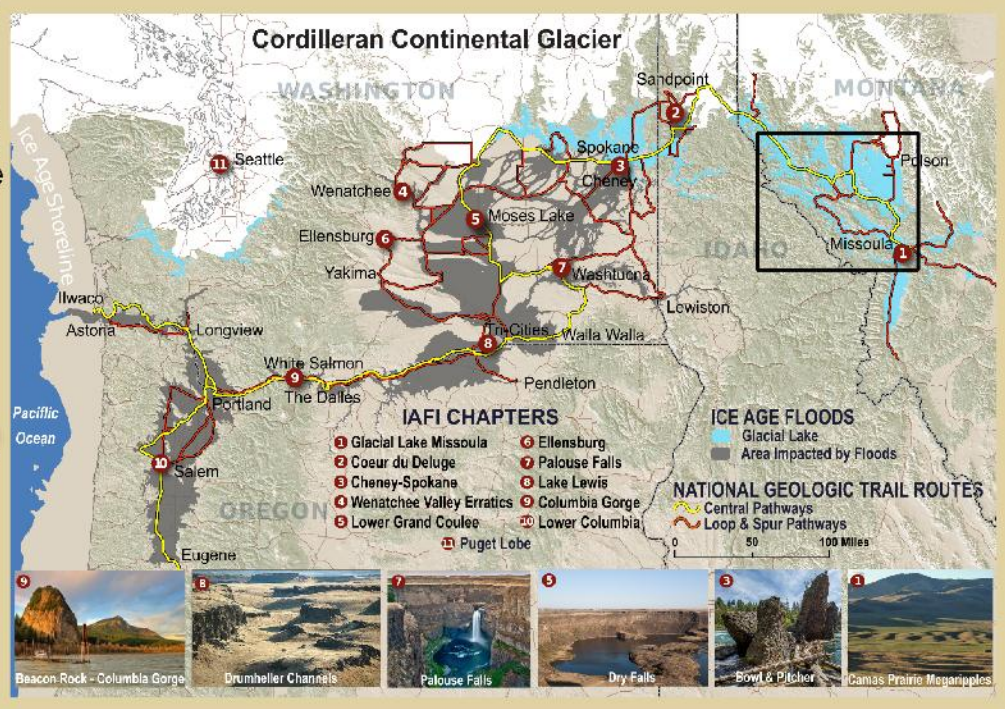
ICE AGE FLOODS
NATIONAL GEOLOGIC TRAIL

Ice Age Floods National Geologic Trail

Since the 1990's the Ice Age Floods Institute (IAFI) has worked to create and to build support for the Ice Age Floods National Geologic Trail.

The Ice Age Floods National Geologic Trail is essentially a network of marked touring routes extending across parts of Montana, Idaho, Washington, and Oregon, with several special interpretive centers located across the region. Many interested parties are being brought together in a collaborative and effective interpretive program at a remarkably low cost, despite the extraordinary size of the region. The Trail is being developed under the National Park Service on existing public lands, with no changes in jurisdiction and no threats to private property rights. The role of the National Park Service is to coordinate and manage the planning of the project and the telling of the story, without taking custodianship of public and private lands.



1 Glacial Erratic

Located on the Main Oval, University of Montana campus.

As ice-age glaciers moved through the landscape they picked up large boulders which became embedded in the ice. These boulders were rafted in chunks of ice in glacial lakes or floodwaters, then deposited as the waters receded and the ice melted. Erratics such as the one the UM campus can be found throughout Missoula neighborhoods and dotting the hillsides.

2 Strandlines

Strandlines can be seen on the slopes of both Mt. Jumbo and Mt. Sentinel looking east from many locations in the Missoula valley.

Ancient shorelines or strandlines of Glacial Lake Missoula are visible as perfectly parallel horizontal benches ground into hillside slopes around Missoula. During the last ice-age, ice dams repeatedly blocked the Clark Fork River, the only drainage outlet for much of interior Montana, and the impounded water formed Glacial Lake Missoula. As the lake level rose, benches were cut into the surrounding hillsides by wave action until the pressure of the impounded water caused the ice dam to fail and the impounded water emptied. As the ice-age waned each successive ice dam that reformed was smaller and failed under less pressure from a lower lake level than the one before, leaving behind its bench as a record of the successively lower ancient lake shorelines. Snow and low evening light emphasize the horizontal lines marking these ancient strandlines.

3 Little Money Creek Gulch Fill

Directions: From Missoula, take Exit 96 from I-90, travel north on US 93 to Ravalli, turn west on MT 200 to pullout at Mile Marker 91 for best view.

The coarse materials filling the side gulches along the narrow valley in this area were described by geologists Joseph T. Pardee and David Alt as the result of deposition by currents eddying into tributary gulches along the path of escaping Glacial Lake Missoula floodwaters, filling the gulches with debris scoured from valley walls.

The power of these floodwater eddies in these gulches was tremendous. J.T Pardee estimated the flow of floodwaters through this narrow valley at between 8 and 10 cubic miles per hour– more than the combined flow of all modern rivers in the world. Similar gulch fill can be seen in many locations along this river.

4 Rainbow 'Dog' Lake

Directions: Continue on MT 200, turn N on Hwy 28E at Plains, travel 9.2 miles to the end of the lake for an open view from the highway.

Rainbow Lake is now thought to be a cataract retreat lake, formed by the erosion and upstream retreat of a 100 ft waterfall. As the level of the ice-age floodwaters along the Clark Fork River dropped over 1700 ft near the present town of Plains, the sudden change in elevation created flows of up to 60-70 mph through the Boyer Creek spillway. Any weak spots in the underlying resistant rock were torn apart and a recirculation current created in the plunge pool of the waterfall continuously undermined the lip of the waterfall, causing the lip to collapse and the waterfall to retreat upstream. As this process repeated with each flood the deep Rainbow "Dog" Lake was left behind marking the entire migration path of the retreating waterfall and plunge pool. The debris from this erosive action was dumped in the valley downstream.

5 Markle Pass Kolks

Directions: Continue on Hwy 28, then turn south on Hwy 382 and drive about 8 miles to a pull-off at the top of the pass

In areas adjacent to the road here are deep rocky holes and circular ponds, called kolks, that are carved out of the bedrock by intense underwater vortices in the floodwaters that act like an underwater whirlpool or "tornado". The vortices are caused by water churning in intense, tight circular eddies in areas where the water flow is restricted.

When these vortices extend to the bed of the flow they can pluck rocks out of the underlying surface by the water's surface friction with the bedrock and the buoyant sucking action of gas bubbles. Numerous kolks are found in the passes near Camas Prairie including Burgess Lake. The chunks of rock plucked out of a kolk are transported and deposited downstream.

6 Camas Prairie Megaripples

Directions: Take Hwy 382 through the prairie to an informational sign pull-out at mile marker 13.

In Camas Prairie there are numerous visible long ridges of sediment that are as much as 35 ft. high and 100 ft. apart. In 1942, Geologist Joseph T. Pardee identified these unique parallel ridges found in the Camas Prairie as "giant" ripple marks. With an average height between 13-30 feet, these current ripple marks would dwarf any ordinary ripple mark you might find on a beach or in a river today. The Camas Prairie ripple marks were formed as the deep and swift flowing floodwaters from Glacial Lake Missoula raced through the area of the failed ice dam at speeds up to 65 miles per hour.

Directions for this tour:

The entire route is about 225 miles following either return option and takes at least 4 hours. From Exit 96 to Stop 3 is about an hour, and from St. Regis to back to Exit 96 is about an hour. To use this map on your phone even where there is no cell phone coverage: Download the free Avenza Maps app from the app store, then go to ***http://iafi.org/Missoula-Glacial-Lake-Route/*** *and store the map on your phone in Avenza Maps. The blue dot on the map will show your location.*

7 Nine Mile Rhythmites

Rhythmites can also be seen from I-90 on both sides of the road near the Ninemile exit 82.

Directions: Take Exit 82 from I-90, travel N on Ninemile Rd uphill for 1.2 miles to a vehicle pullout on the left across from the northside roadcut.

The layers of light pink sand and silt sized materials at this location were deposited on the bottom of Glacial Lake Missoula. The silt deposits are mostly found in areas where the basin was wide and not touched by the high-energy draining of the lake. These deposits are called 'rhythmites' due to the cyclic pattern of layers.

Series of these layers may represent a sequence of lake draining and filling, while layers within these series mark seasonal depositional variation as seen in modern day glacial lakes. These paired layers are like 'varves', in which darker layers represent winter deposits of slowly settling finer particles and the lighter layers represent summer deposits of more actively transported coarser particles. By counting these varves geologists have estimated the lake collected at least 1000 years worth of sediment at this location.

SIDE TRIPS

Glacial Lake Missoula High Water Markers

Since 2010, The Glacial Lake Missoula Chapter of the Ice Age Floods Institute has installed several engraved stone monuments near popular hiking trails and attractions. These monuments are placed at 4200 ft elevation, approximately the high water mark of Glacial Lake Missoula at capacity. To date, you can discover these markers at (lat°, long°):

Mt. Sentinel - on Ridge Line Trail above the "M" (46.8858255°, -113.973079°) and on the Pengelly Ridge Trail from the gravel pit trailhead in Pattee Canyon (46.836878°, -113.977126°)

Mt. Jumbo - on the Backbone Trail from the Lincoln Hills Trailhead (46.888506°, -113.949691°) and on the "L" trail above the "L" (46.874024°, -113.965679°)

Lake Como - just east of the swimming area parking (46.068252°, -114.239542°). It marks the furthest extent of Glacial Lake Missoula.

Gold Creek - I-90 pull-offs about 60 miles east of Missoula are planned to have high water markers by 2020.

Eddy Narrows

The walls of this narrow, 10 mile long canyon are bare of talus and soils up to the level estimated to be the highest level of the lake (1000 ft), and there are polished grooves in the bedrock on a bench 340-400 feet above the Clark Fork River that run parallel to it. Since there is no evidence of glaciation in this area, the only explanation is the rapid draining of Glacial Lake Missoula. In 1942, J.T. Pardee was able to calculate the speed and volume of water which could flow through this restricted area..

Follow St Hwy 200 past where Munson Creek intersects the Highway, 11 mi west of Plains. A Forest Service trailhead marks a good viewing spot.

St. Regis Notch

A prominent notch cut in the bedrock north of St. Regis marks a channel cut where the flood waters rushing down the Clark Fork River failed to make the sharp right turn to the north where it meets the St. Regis River and were forced back over the adjacent hills.

Located at Exit 33 from Interstate 90.

Ninepipes Pingo Scars

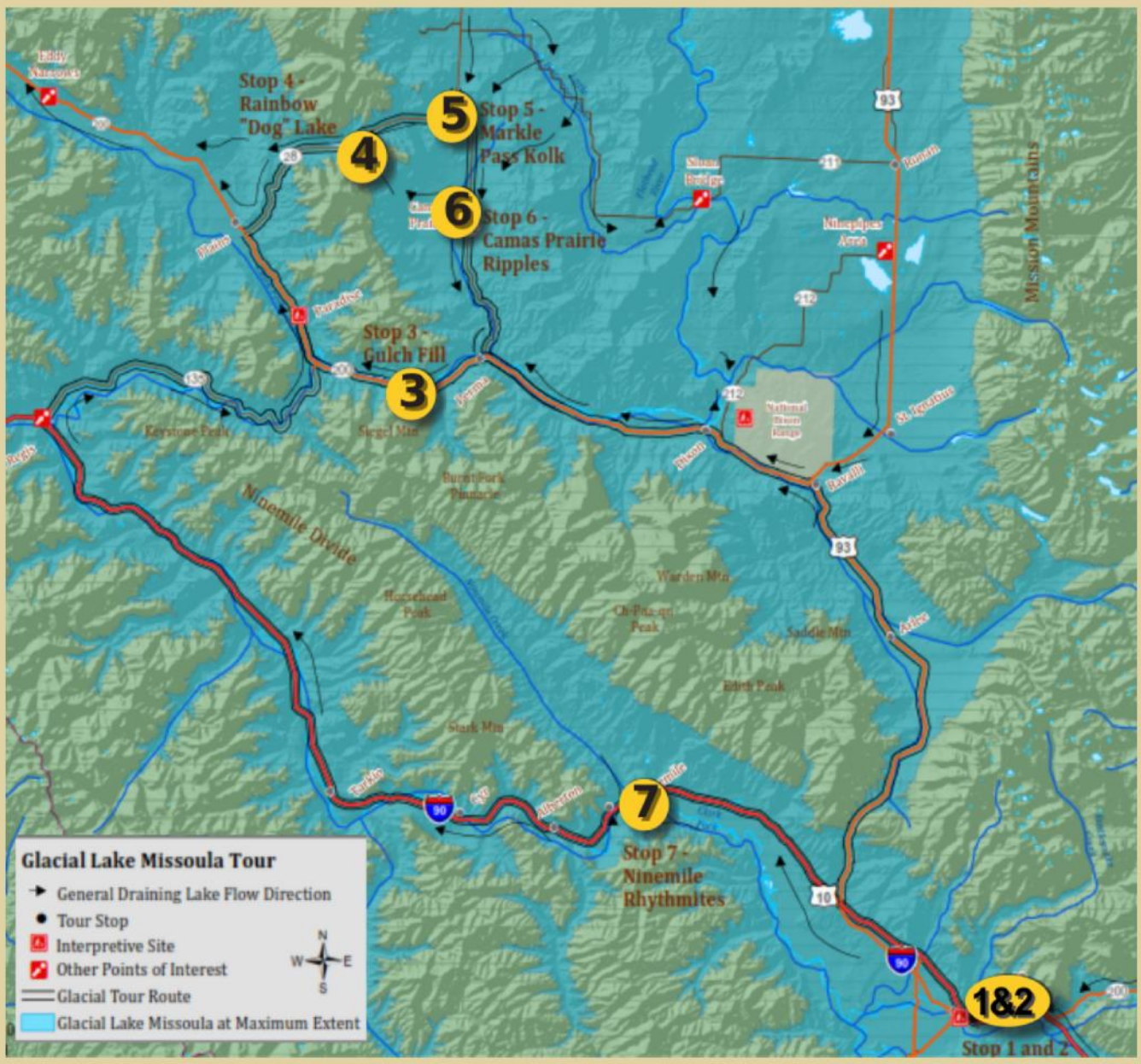
Pingo scars found in this area are places where permafrost type ice formed beneath exposed lake bottom sediments and freeze/thaw cycles resulted in the formation of small round depressions enclosed within a rampart-like rim or edge. A national wildlife refuge and a local museum are also found in this area.

Located on Hwy 212 west of the intersection with US 93.

Paradise Center

Boasts an exhibit which includes an interactive topographic relief model of the entire Glacial Lake Missoula area in Montana.

Turn right off MT 200 in Paradise, onto 1st Street. Go 4 bocks and turn right onto North Avenue and continue uphill to the school. Call 406-826-0500 for hours.



National Bison Range

This area was set aside for the preservation of bison in 1908 and remains largely undisturbed prairie. There are several erratics and strandlines visible near the Bison Corrals, and there is an interpretive sign near the summit. The Mission Mountains across the valley were sculpted by alpine glaciers above the highest level of Glacial Lake Missoula. There is a visitor center with some ice age flood materials.

Take US 93N from Missoula through Arlee to MT 200E, turn left (west) and continue to MT 212N, turn right and travel about 4 miles to the entrance. For hours call 406-644-2211.

Sloan Bridge Sediments

The white bluffs to the north record the sedimentation at the bottom of Lake Missoula. The continental ice sheet was only 18 miles away, and this is the rock flour washing off the ice, making the lake near the ice this color. There are no gaps or soil horizons to indicate much time passing between each filling of the lake in the waning stages of the ice dam sequence.

Located where a partially unpaved road between Hwy 382 and US 93 crosses the Flathead River; take 211/Round Butte Rd at the Dairy Queen north of Ronan.