The Story of the Great Ice Age Floods

During the peak of the last Ice Age, the vast Cordilleran continental ice sheet covered south-western Canada and the northern part of Washington Idaho, and Montana. The 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 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 Lakes Erie and 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 backed up 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 flood-waters greater than all the rivers of the world combined roared across the landscape at up to 60+ mph. This happened dozens, perhaps even hundreds of times as the advancing continental glacier rebuilt new dams.

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GLACIAL LAKE MISSOULA CHAPTER
ICE AGE FLOODS INSTITUTE

Glacial Lake Missoula Chapter

This chapter studies 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 the home of University of Montana geologists 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 and also assisted with the development of the display and large interactive topographic relief map of the entire Glacial Lake Missoula at Paradise Center in the heart of the driving tour route. Another partner is the Ravalli County Museum in Hamilton.

The Glacial Lake Missoula chapter sponsors speakers and field trips each year.

To contact us, visit our website at:
GlacialLakeMissoula.org
our chapter page at IAFI.org
or Facebook.

A GUIDE TO THE INCREDIBLE ICE AGE FLOODS

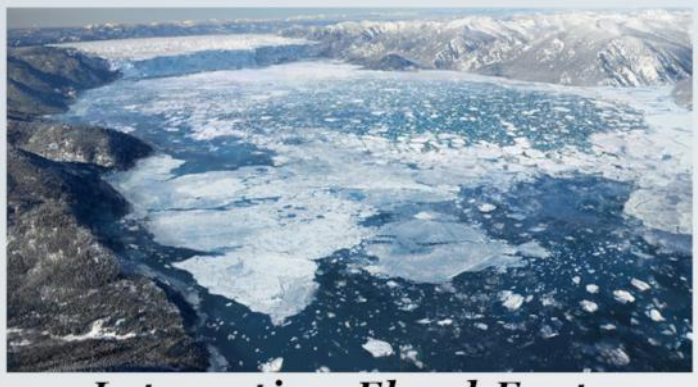
"The Source of the Floodwater"

GLACIAL LAKE MISSOULA

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. PUBLISHED 2024



Interesting Flood Facts

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

Because of repeated flood cycles and harsh conditions, there were no fish in this lake nor many mammals in the valleys. Soil left behind were poor and vegetation was 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 natural freshwater lake in the United States, West of the Mississippi River.

Glacial Lake Missoula contained over 500 cubic miles of water and ice. The lake covered 3,000 square miles, and was up to 2,000 feet deep. It was 16 times the size of Flathead Lake, and at Missoula, it was 6 times Flathead Lakes 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 Ice Age Flood could have been heard at least 1/2 hour before it struck.

J Harlen 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 first findings on a glacial lake in 1942, but there was not general acceptance of the idea until the 1970's.

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

Ice Age Floods National Geologic Trail

The National Park Service manages a network of touring routes that mark the distinctive geologic features left along the path of the floods from Missoula across Idaho and Washington to the mouth of the Columbia River. The Ice Age Floods Institute supported the development of the Trail and coordinates the efforts of more than 10 local chapters to tell the story each step of the way. Extensive information about the activities of the chapters, including a detailed interactive map of flood features, is available at IAFI.org or Facebook.com/Ice Age Floods. A comprehensive map of the trail with many spectacular points of interest highlighted is available in a print brochure and at nps.gov/IAFI.

FIND THESE POINTS OF INTEREST ON THE MAP INSIDE

St. Regis Overlook

The tremendous volume of Glacial Lake Missoula water in the Clark Fork River draining through the Alberton Gorge along I-90 met the St. Regis River flowing the opposite direction in this valley. The waters churned around, making a sharp right turn to scour a path along what is now a scenic route (MT135) to join the Flathead River at Paradise.

Located at Exit 33 from Interstate 90. Go east from the stop sign, then left onto Mill Creek Rd after crossing the bridge. Go about 3 mi to clearing at top of hill.

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 that all of the water from Glacial Lake Missoula east of this point drained through this restricted area, allowing J.T. Pardee to calculate both the speed and volume of water involved.

Follow Hwy 200 from about 11 mi west of Plains thru Eddy and pull off at the KooKooSint Big Horn Sheep site for an interpretive sign.

Sloan Bridge Sediments

The white bluffs to the north record the sedimentation at the bottom of Lake Missoula. The continental ice sheet is 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. Such sediments are found throughout the floods area.

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

Thompson Falls Cataract

The floodwaters of Glacial Lake Missoula created a cataract waterfall here, which has since been dammed, leaving a magnificent gorge.

Turn off Hwy 200 on Gallatin Street at the west end of town. Park near the walking bridge and cross to the island. Walk straight ahead to get to the views of the gorge, or turn right or left to view the dams.

Montana Natural History Center

Watch videos about the great floods, study the display of information about Glacial Lake Missoula, view artifacts from the life of J.T. Pardee, pick up a map of the National Ice Age Floods Geologic Trail, and collect an official NPS passport and/or Junior Ranger stamp. This center also has wildlife displays.

Located in Missoula close to downtown across from the baseball stadium on Cregg Lane at 120 Hickory Street. Call 406-327-0405 or go to montananaturalist.org for hours.

Paradise Center

This former schoolhouse has an interactive topographic relief model of the entire Glacial Lake Missoula area in Montana, as well as related information about the ice age floods. A model railroad and other historic items are also displayed, both in the building and outside.

Turn right off MT 200 in Paradise, then right onto 1st Street, Go 4 blocks and turn right onto North Avenue and continue uphill to the schoolhouse. Call 406.826.0500 or visit paradisecentermt.org for hours

The Bison Range

This area was set aside for the preservation of bison in 1908 and remains largely undisturbed prairie. Several erratics and strandlines are visible near the Bison Corrals and elsewhere, 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. The CSKT Tribe now manages the range, including a visitor center with Glacial Lake Missoula materials and displays on indigenous history and culture.

Take US93 N 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 or visit bisonrange.org

Ninepipes Pingo Scars

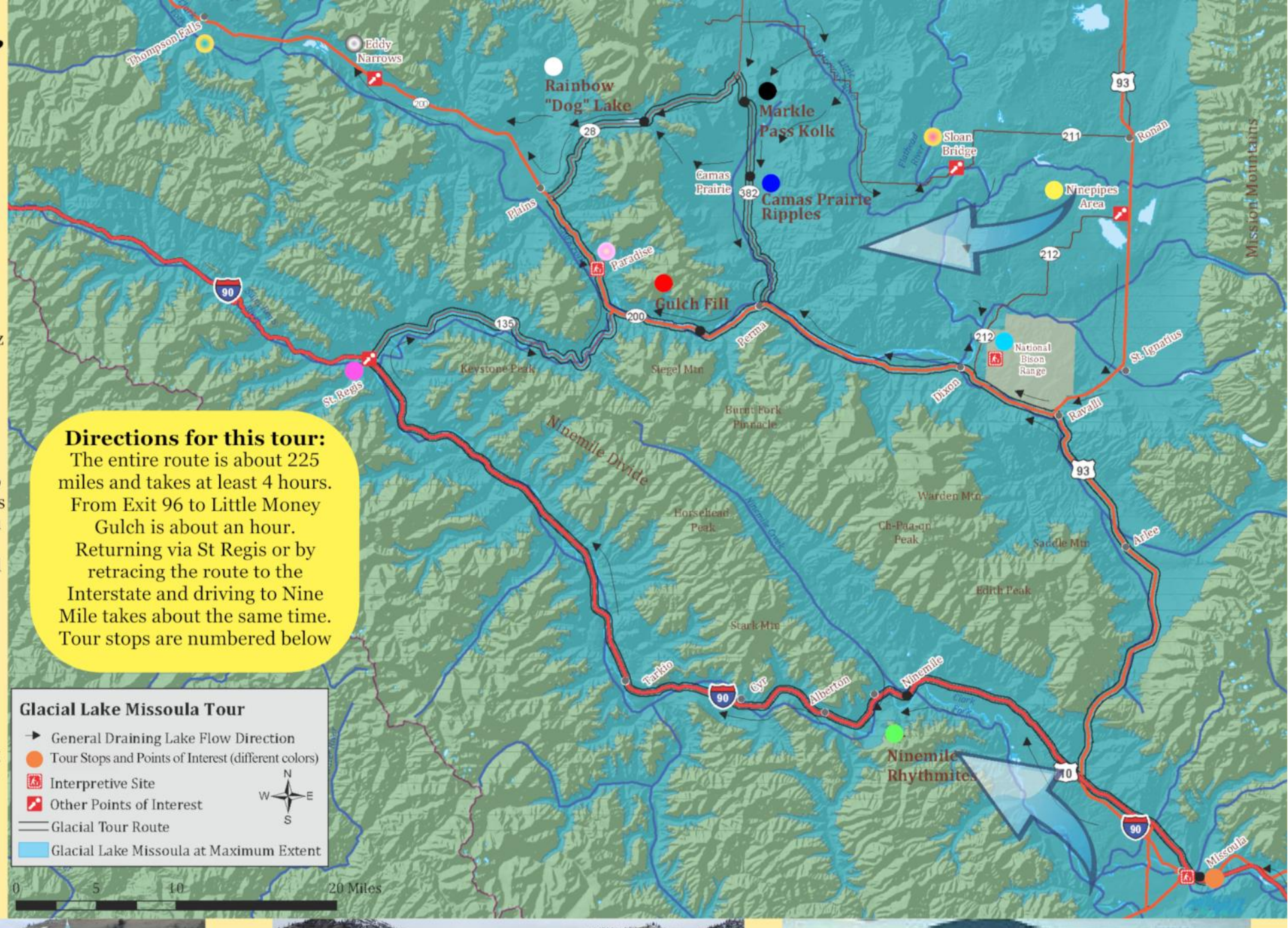
Pingo scars are found in this area, places where permafrost type ice formed beneath exposed lake bottom sediments and freeze/thaw cycles resulted in the formation of small round depressions enclosed within a rampart-like rim or edge. Other circular depressions may be kettles, formed when a chunk of ice melts, leaving coarse materials behind. A national wildlife refuge and a local museum are also located here.

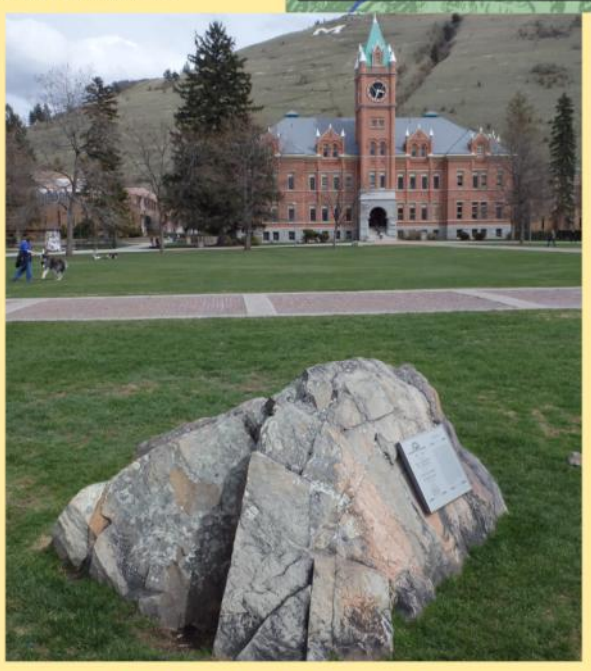
Located on Hwy 212 west of the intersection with US93

OFF THE MAP

Large erratics can be found at several locations in the Bitterroot Valley. One has been moved to become part of an outdoor kiosk exhibit at the **Ravalli County Museum**, 205 Bedford Street, Hamilton MT. This museum also has information on the Lewis and Clark and Nez Perce National Historic Trails, which intersect the geologic trail at this point.

The furthest extent of Glacial Lake Missoula up the Clark Fork tributaries from Missoula have been marked with engraved stone monuments placed at about 4200 ft, the highest elevation of Glacial Lake Missoula at capacity. These can be found at **Lake Como, Ovando, and Gold Creek**. High water markers have also been placed on popular hiking trails in Missoula on Mts Sentinel, Jumbo, and Dean Stone. Location details can be found on the GLM website and on the interactive map of the IAFI website.





● *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 flood waters receded and the ice melted. Erratics such as the one on the University of Montana campus can be found throughout Missoula neighborhoods and dotting the hillsides.

● *Strandlines*

Strandlines can be seen on the slopes of both Mt. Jumbo and Mt. Sentinel.

Ancient shorelines or strandlines are visible as perfectly parallel horizontal benches ground into the 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 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 horizonal lines marking these ancient strand lines.

● *1-Little Money Gulch Fill*

Traveling on I-90 take US 93 N to Ravalli, Turn West on MT 200 to the pullout at Mile Marker 91 for the 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.

● *2-Dog Lake*

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

Dog 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 the process repeated with each flood, a deep 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.

● *3-Markle Pass Kolks*

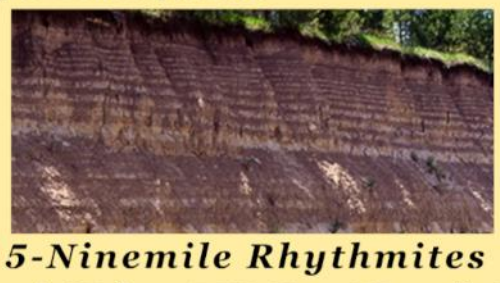
Travel N on Hwy 28, turn South on Hwy 382, travel about 8 miles to a pull-out at the top of the pass.

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 waters' 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.

● *4-Camas Prairie Ripples*

Travel South on Hwy 382 to a pullout with an informational marker 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 water from Glacial Lake Missoula raced through the area of the failed ice dam at speeds up to 65 miles per hour.



● *5-Ninemile Rhythmites*

Take exit 82 from I-90, N on Ninemile Road for 1.2 miles to a pullout on the left.

The layers of light pink sand and silt sized materials at this location were deposited on the bottom of Glacial Lake Missoula. Such 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. These layers may represent a sequence of draining and filling, while layers within these series mark seasonal depositional variation as seen in modern day glacial lakes. These paired layers are called "varves," in which darker layers may 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.