# GeoNote 26

## Glacial Lake Missoula and the Spokane Floods

Ice Age floods have left their signature on the landscape of the Pacific Northwest. Catastrophic flooding during the Pleistocene Epoch from Glacial Lake Missoula swept more than 500 miles across the Columbia River basin to the Pacific Ocean. The prehistoric tumult produced erosional and depositional landforms over a 16,000 square mile area in Montana, Idaho, Washington, and Oregon. Cities in the region that would have been under water include Coeur d'Alene, Spokane, Lewiston, and Portland. The floods were spectacular beyond modern experience. They created unique and distinctive geologic features still visible today in northern Idaho and the Spokane Valley.

### Channeled Scabland and Uniformitarianism

In 1923, Professor J Harlen Bretz of the University of Chicago published the first in a series of research papers on the Channeled Scabland in Washington. He attributed the dry channels, coulees, and falls to one cause — an episode of flooding on a scale larger than geologists had ever recognized on earth. This so-called "outrageous hypothesis" was disputed by prominent contemporary geologists, and the resulting controversy is one of the most famous in geology.

Bretz's ideas for such large-scale flooding also challenged the classical uniformitarian doctrine then ruling the science of geology. This concept held that the geologic agents of construction and destruction observed today acted similarly in the past and with the same intensity: hence, the adage — "the present is the key to the past." Bretz nevertheless persisted in his thinking and, after additional evidence revealed a source for the flood, found his explanation for the Scabland finally accepted. Today, most scientists support the idea that while earth processes are at work throughout geologic time, most of their energy is released in episodes rather than at a constant rate, much as a river is more powerful at flood stage or a volcano during eruption.

### Glacial Lake Missoula

J.T. Pardee of the U.S. Geological Survey first studied Glacial Lake Missoula in 1910, but it was not until the early 1940s that he finally presented evidence for rapid drainage of the large lake dammed by a glacier. Pardee's explanation of unusual currents and features of flooding in the lake basin provided Bretz with the long-awaited source for flooding in the Channeled Scabland.

The cause of the immense "Spokane Floods," or Missoula Floods, was attributed to the rapid drainage of Glacial Lake Missoula. A great lobe of the Cordilleran ice sheet in Canada had advanced south down the Purcell Trench into the basin of Pend Oreille Lake and dammed the Clark Fork valley in northern Idaho. The resulting glacial lake covered about 3,000 square miles in western Montana. The collapse of the 2,000-foot-high ice dam released a torrent of water down the Clark Fork valley, about ten times the combined flow of the worlds' present-day rivers.

Pardee calculated the water volume in Glacial Lake Missoula at 500 cubic miles based on an elevation of 4,150 feet against the ice dam. He also estimated the lake drained at a rate of 9.46 cubic miles an hour through Eddy Narrows in Montana. More recent calculations by other scientists have reestimated the lake volume as large as 600 cubic miles and the maximum rate of discharge at 16 cubic miles an hour. With further evidence for multiple flood releases from Lake Missoula, geologists continue to debate the number, size, and timing of flood events.

### The Ice Dam

One of the most intriguing questions about the catastrophic flooding is how the ice dam failed. Various mechanisms for glacial outburst floods, or jökulhlaups, have been proposed: ice erosion by overflow water, subglacial failure by flotation, deformation of ice by water pressure, and erosion of subglacial tunnels by water and ice bergs.

Recent work has modeled the mechanics of ice dams. One popular model suggests a self-dumping phenomenon. In this mechanism, flood waters are released when the lake water reaches nine-tenths the depth of the ice. At this depth the increasing hydrostatic pressure makes several things happen: the ice seal becomes buoyant, subglacial tunnels form and enlarge, and drainage occurs until hydrostatic pressure is decreased and the glacier flow again seals the lake. The self-emptying model is used to explain the numerous rhythmite sequences of the region and to interpret each cycle as a separate flood. Even so, some geolo-

IDAHO GEOLOGICAL SURVEY

Main Office At Moscow
Morrill Hall, Third Floor
University Of Idaho
PO Box 443014
Moscow, ID 83844-3014

Branch Office At Boise
Math-Geology, Room 223C
Boise State University
Boise, ID 83725-1535

Branch Office At Pocatello
Physical Science, Room 235
Idaho State University
Campus Box 8072
Pocatello, ID 83209-8072

www.idahogeology.org 208-885-7991 email: igs@uidaho.edu
Since 1919, Serving The State Through Geologic Research

gists argue that only the total collapse of the ice dam can explain the largest of the catastrophic floods.

Studies of flood sediment now show that there were several episodes of multiple outburst floods and that these episodes may represent glacial advances. The last ice lobe advanced down the Purcell Trench between 13,000 and 25,000 years ago. Based on the age of volcanic ash deposits from Cascade volcanoes that erupted during this time, scientists have determined that the latest flooding episode happened 12,000 to 15,000 years ago and was preceded by an earlier and larger epidode of floods 35,000 to 40,000 years ago.

## The Flood Path

The major pathway of the Lake Missoula Floods started from the end of Pend Oreille Lake and ran through the Rathdrum Prairie and Spokane Valley. Another main flood route followed the Pend Oreille River, crossed divides, and flowed down the Little Spokane River. Other ice-dammed lakes existed in the valleys near the Cordilleran ice sheet. Flooding from these sources must also have coursed down the Columbia River system and through the Channeled Scabland.

## Flood Features

The onrush of water from Glacial Lake Missoula poured through the Spokane Valley on its way to the Channeled Scabland, the Columbia River, and ultimately the Pacific Ocean. The upper level of effective erosion is over 3,456 feet at Round Mountain in Idaho (which is directly in the flood path from Lake Pend Oreille) and descends to about 2,630 feet in the Dishman area. The maximum flood height exceeded the effective erosion elevation and is best determined by finding the upper level of ice-rafted debris. The elevation of the Spokane Valley floor is 2,080 feet at the Idaho-Washington border. Evidence of outburst flooding near the state line extends as high as 2,720 feet. Thus, most of the valley was under more than 500 feet of water. Water levels exceeding 2,350 feet would allow flood water to spill south into the easternmost part of the major scabland channel systems, the Cheney-Palouse scabland tract.

The flood waters engulfed the existing river channels, flowed back up the major rivers, like the Snake, and inundated sites like Lewiston and Clarkston. Thus, in the same event, a flood could deposit gravels while traveling up the valleys during the initial surge and then deposit finer silt and sand while traveling back down the valley. The resulting deposits, the rhythmic cycles of coarse and then finer beds, called slack-water deposits, are used to count the number of flood events or surges.

Some earlier researchers rejected the catastrophic flood hypothesis and attributed the deposits and landforms near the ice margin in Idaho and the Spokane Valley to glacial processes. The deposits holding Liberty Lake, Newman Lake, Coeur d'Alene Lake, Twin Lakes, and others were considered lateral moraines or glacial outwash. In fact, Bretz did not recognize them as flood gravels. Later work has supported a flood origin for the gravel and boulder deposits in the valley center.

Many geologists now believe that the valley deposits were all flood produced, although some may be local glacial deposits reworked by the floods. In some places, the unusual concentrations of large boulders may represent flood-swept moraines. During the floods, locally streamlined, flood-produced landforms, called pendant bars, trailed downstream of bedrock obstructions and eddy bars concentrated at the mouths of tributary valleys. Most of the lakes along the Spokane Valley are impounded by the sand and gravel of eddy bars.

The "giant current ripples" are also an important piece of evidence for catastrophic flooding. These large-scale bedforms appear as patterns of parallel ridges and swales on aerial photos. They escaped recognition on the ground because of their large size. Fields of current ripples are visible near Spirit Lake and Rathdrum.

The present-day landscape of the Spokane-Coeur d'Alene-Rathdrum area is directly related to Ice Age floods. Perhaps, the biggest feature is unseen, the Spokane aquifer — one of the most productive in the United States. Other depositional features that can be seen are the flood bar at Liberty Lake golf course and the rhythmites exposed at Hangman Creek. Features showing flood scour are Grand Coulee, Dry Falls, Palouse Falls, scabland lakes like Sprague Lake, rocks at John Shields Park, and the Bowl and Pitcher Park.

Prepared by Roy M. Breckenridge
05/93