

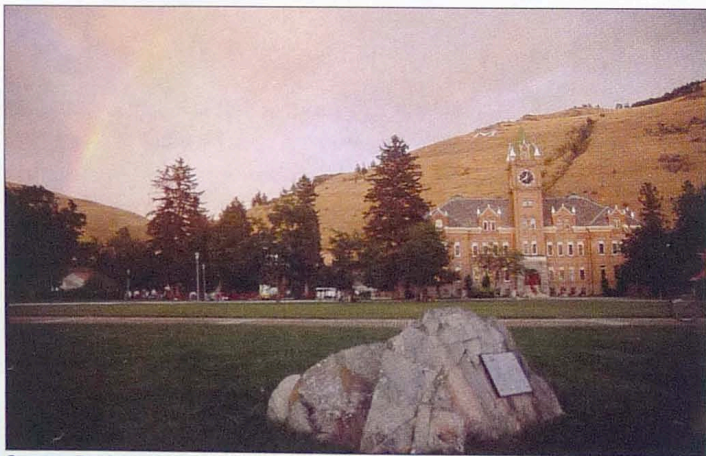
CORDILLERAN ICE SHEET



SEDIMENTAL JOURNEY

Following the path of Glacial Lake Missoula's flood waters

S T O R Y & P H O T O S B Y P A T I A S T E P H E N S



Spooky Rock and the horizontal shorelines and vertical mudflow scars on Mount Sentinel and Mount Jumbo are remnants of Glacial Lake Missoula.

There's nothing like geology to put one's life into perspective. For all our worries and passions, we are but tiny specks on the timeline of the human race, smaller still in the life span of this planet we call home.

In Missoula, we blithely carry out our lives at the center of what was once geologic ground zero for a cataclysm that shook and shaped the northwestern United States. Some 12,000 years later, the scars of Glacial Lake Missoula remain on the mountains around the University campus.

While many people know the Missoula Valley once held an ancient lake, few are aware that Glacial Lake Missoula transformed the terrain from western Montana to the Oregon coast. Helping to tell this phenomenal story is UM geology Professor Dave Alt, author of *Glacial Lake Missoula and Its Humongous Floods*. The book, a successor to his popular *Roadside Geology* series, was my guide last summer, when I followed in Alt's footsteps through the glacial leavings that form a substantial part of the states of Montana, Idaho, Washington and Oregon.

Glacial Lake Missoula was created when a massive ice dam — a southern lobe of a glacial ice sheet that once covered much of Canada — blocked the flow of the Clark Fork River where it crosses the Montana-Idaho border. The lake's icy waters filled the valleys of western Montana, from Darby to St. Regis to Garrison to Polson to beyond Noxon. When the ice dam broke, Glacial Lake Missoula drained catastrophically in a process that repeated at least forty times over the course of nearly 3,000 years.

The lake's brute force tore the once-rounded northern edge of Sentinel down to ragged bedrock as it ripped through Hellgate Canyon. Its beaches left a litany of horizontal lines on the mountainsides of Sentinel and Jumbo. Its receding waters created soggy, vertical mudflow scars on Missoula's slopes.

Buildings, bridges and trees now sprout out of earth that was once, twice, many times under nearly a thousand feet of water. Rocks the size of household furniture decorate campus and neighborhoods across the valley. The very water we drink bubbles up through layers of gravel laid by Glacial Lake Missoula.

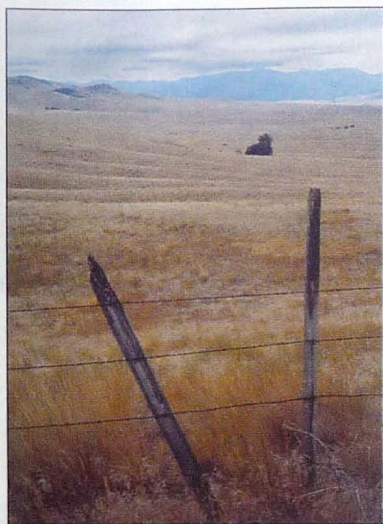
Missoula to the Ninemile Valley

At its fullest, Glacial Lake Missoula “held approximately 500 cubic miles of water,” Alt writes, “about half the volume of Lake Michigan. It was, truly, an inland sea.”

My journey begins on the northwestern side of Missoula, where the flat valley floor starts to curve and swell in gentle hills near Mullan

Road, the Wye and the airport. Like ripples on a sandy stream bed, these hills were formed by rushing water of a nearly unthinkable scale. West of Missoula, the rushing flood waters scrubbed the Alberton Gorge down to bedrock, creating popular rafting rapids.

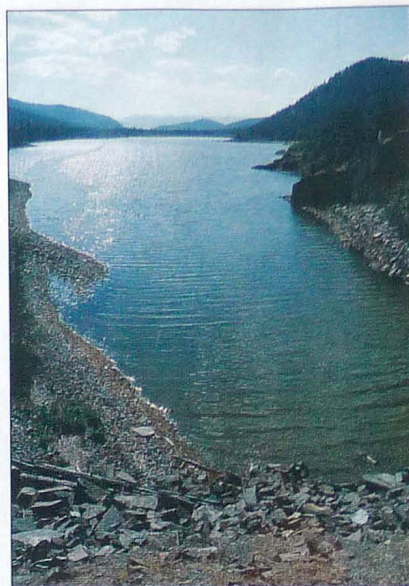
Taking the Ninemile Road exit off Interstate 90, I soon see a large, bleached cliff cut into the road. Here, the lake dropped a load of sediment in which geologists can read a tale of successive fillings, drainings and even seasons by counting “varves” — the light-dark layers left by deposits of



Camas Prairie's giant ripples were formed by fast-moving water and are similar to those on a stream floor.

pale rock flour, a powder ground by moving glaciers and released in summer meltwater. “Glacial Lake Missoula surely became a splendid

Rainbow Lake was drilled out ▶ of bedrock by a tornado-like current.



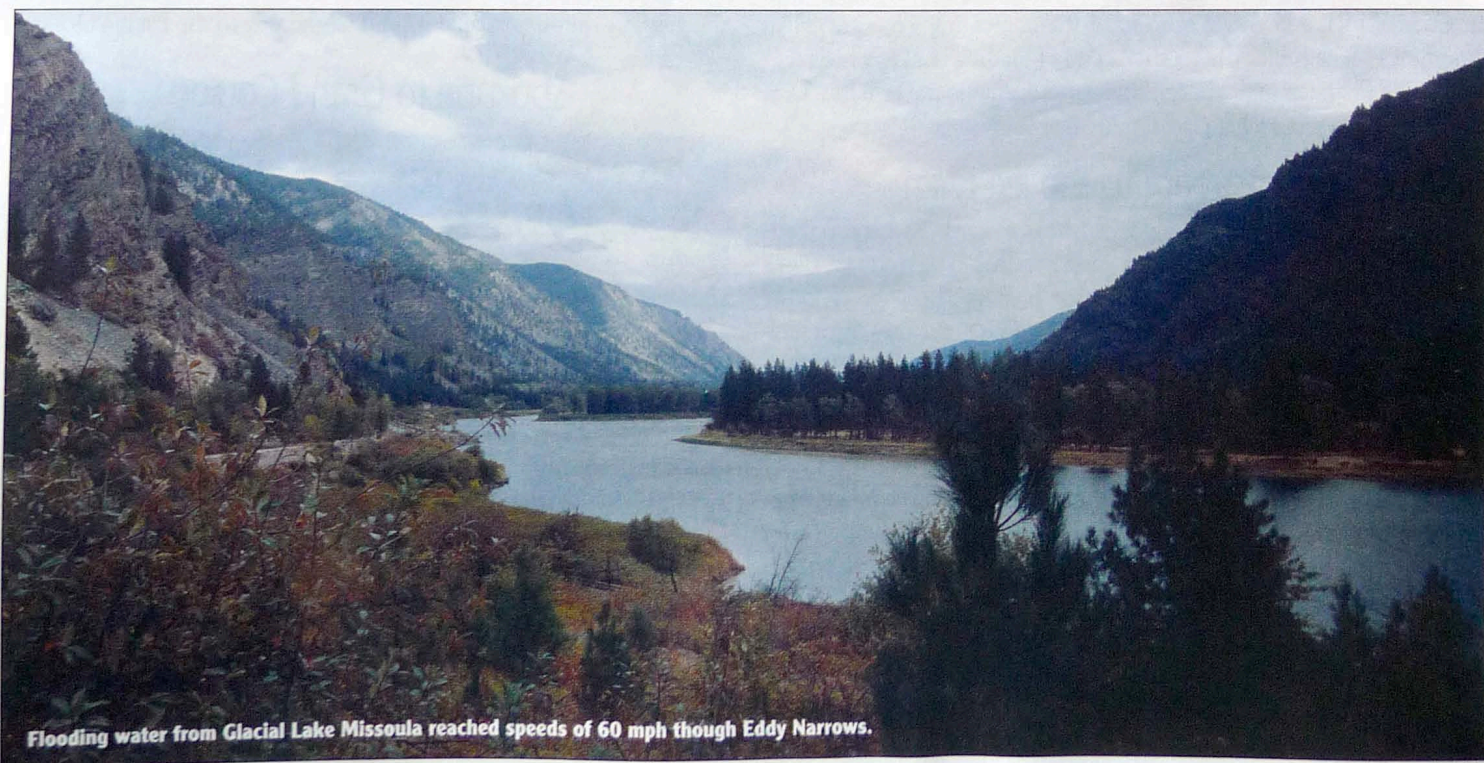
and brilliant greenish blue,” Alt writes, “as the last of the summer rock flour settled and the larch trees blazed yellow in the deepening chill of the coming winter.”

The record left by the Ninemile roadcut is echoed in sediment deposits all along the flood path, from the Touchet beds in southeastern Washington to Oregon's Willamette Valley. Surprisingly, none of these sediment dumps has revealed a human presence. Although existing fossil evidence — such as Kennewick Man — postdates the floods, most experts agree that there probably were humans in the Northwest at the time.

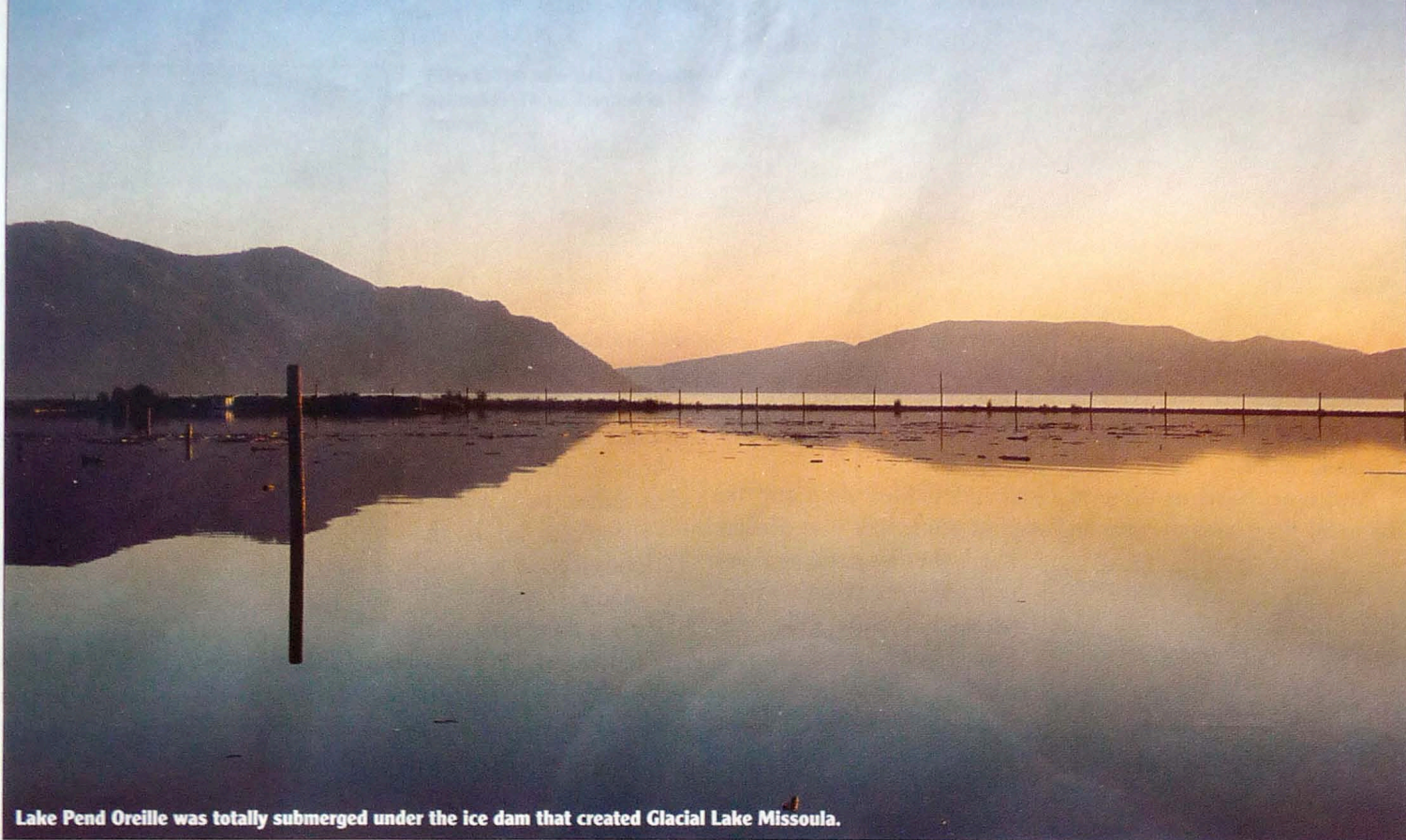
North to Camas Prairie and Rainbow Lake

It took an aerial photograph of Camas Prairie for geologist J.T. Pardee to recognize its ripple pattern in the late 1930s. Pardee, who in 1910 was among the earliest to identify Glacial Lake Missoula, was the first to even conceive of such a thing as giant ripples. But standing at the north end of Camas Prairie, a few miles south of Hot Springs, I am suddenly struck by their blatancy. The small hills undulate up the valley floor like ripples on a mountain stream.

East of Camas Prairie, just inside the western edge of the Flathead Indian Reservation, lies Rainbow Lake, or Dog Lake as it is known locally. An oval basin of glittering water, Rainbow Lake was carved out of black bedrock by an extraordinary current, Alt explains, called a



Flooding water from Glacial Lake Missoula reached speeds of 60 mph through Eddy Narrows.



Lake Pend Oreille was totally submerged under the ice dam that created Glacial Lake Missoula.

“kolk.” Like an underwater tornado, a kolk drills out chunks of rock and hurls them downstream.

Other lakes, such as Flathead, Pend Oreille and Coeur d’Alene, were formed by the slower forces of glacial ice. Alt later explains this astonishing process to me. During the close of the last ice age, he says, lobes of the Cordilleran Ice Sheet slowly receded northward. As they melted, these mountains of ice developed streams and rivers of surface runoff, which carried dirt, gravel and rocks formerly trapped in the ice. This sediment was deposited all around the ice sheet, forming what is now lakeshore. “What’s low was high and vice versa,” Alt says. “It’s a landscape turned inside out.”

Another fascinating fact: When they grew, ice sheets pushed mounds of rock and gravel in front of them, creating what are called “moraines.” The hill at the southern end of Flathead Lake, which separates the Flathead and Mission valleys and now is traversed by U.S. Highway 93, is just such a glacial moraine.

Downstream to the Ice Dam

The Clark Fork River flows northwest toward Thompson Falls through the visual contradiction of Eddy Narrows. The narrow valley’s walls are often barren rock — on which bighorn sheep precariously perch — while its floor holds a lush layer of soil that nurtures thick hayfields and nursery trees. The answer to this conundrum is that the fast-moving waters, estimated at nearly sixty miles an hour here during drainages, scrubbed the valley down to bedrock, while later, slower flows deposited layers of sediment.

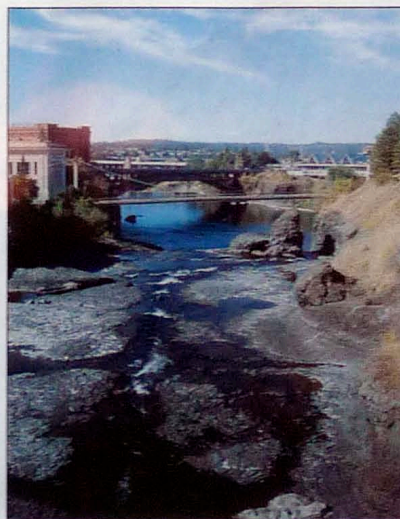
“The peak discharge through Eddy Narrows was approximately ten times the combined flow of all the rivers in the world,” Alt writes. “The drainages of Glacial Lake Missoula were thumping great occasions.”

Still, it’s possible for us non-geologists to be blind to the cues around us. I approach the state border alert for the open skyline that signals the trench once traveled by the ice dam. But all I see is mountains and trees and then the silky surface of Lake Pend Oreille. My imagination simply can’t conjure up an ice dam big enough to block the Clark Fork.

I return to the area weeks later and slowly the thought dawns on me: I haven’t been thinking big enough. The Purcell Trench lobe of ice spread nearly across the entire Idaho panhandle. The ice dam, merely a small section of the lobe, was three miles long, ten miles across and 2,000 feet tall. When the water behind the dam became deep enough, this southern finger of the vast ice sheet popped up like ice cubes in a glass of lemonade.

The breaking ice dam would have let loose a sound to rival a sonic boom. The ground would have trembled like an earthquake as the lake roared onto Rathdrum Prairie south of Sandpoint, Idaho, and then spilled into the much smaller Glacial Lake Columbia, which covered Coeur d’Alene Lake and the Spokane Valley. It would have been like the gunshot start of a race, downhill all the way to the Pacific Ocean.

Spokane to Grand Coulee



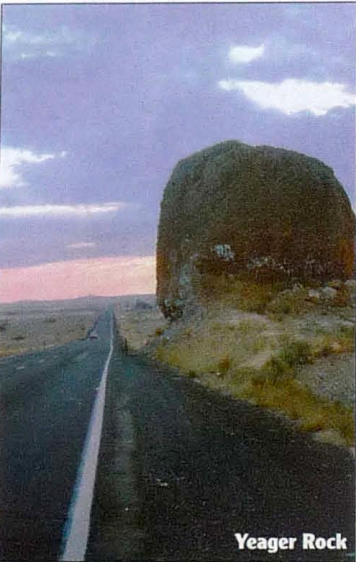
Spokane is built on a thick layer of volcanic basalt rock, much of which was washed away by floodwaters. Here the Spokane River trickles past knobs of basalt.

In Spokane, volcanic basalt rock joins the story. Glacial Lake Missoula filled and drained between 12,000 and 15,000 years ago; the layers of lava that erupted from vents in the earth near Moscow, Idaho, were laid down some fifteen million years ago. These layers blanketed most of eastern Washington and Oregon with volcanic basalt, an extremely hard rock that contracts into columns and chunks. These chunks are easily plucked off by raging flood waters.

While the Missoula

floods carried off much of Spokane's basalt, scoured black knobs remain scattered across the valley. And as the floodwaters rushed across the thick, windblown Palouse silt of eastern Washington toward the Columbia River Basin, they left islands of rich soil surrounded by barren basalt channels. These formations, called "channeled scablands," were crucial to the geologic discovery of the Lake Missoula floods.

In 1923, a University of Chicago geology professor named J Harlen Bretz posited an extraordinarily controversial theory: Eastern Washington's scablands had been formed by torrential floodwaters. At



Yeager Rock

the time, geologic wisdom held that all earth landscapes were formed by slow uniform processes, such as erosion, and never by catastrophic forces. Bretz's theory earned him the scorn and ridicule of the mainstream geological community.

I can almost understand. All my advance reading couldn't prepare me for the incredible flood features that lay along the highways and back roads ahead of me. I was halfway down Grand Coulee when the size and impact of these floods began to really hit me.

I sat in my car at a pullout,



towering cliffs to my left, a broad expanse of valley, reservoir and more cliffs to my right, and read Alt's book: "Grand Coulee was probably a perfectly ordinary stream valley until it began taking the routine overflow from Glacial Lake Columbia and occasional torrents of floodwater." I looked up at the vastness of Grand Coulee. This, an ordinary stream valley? From then on, my trip was tinged with awe.

About an hour and a half west of Spokane, Grand Coulee is a broad, approximately thirty-mile-long canyon carved out of the basalt of the upper Columbia River basin. A boater's paradise of lakes and sleepy resort towns, the coulee is deeply etched into an arid landscape of wheat fields and sagebrush prairie. In the early 1900s, farmers dreamed of irrigating their crops with the river water but had no good way to haul it up the steep canyon walls. With Work Progress Administrative funding, construction began on Grand Coulee Dam in 1933. By the Second World War, the dam was pumping water as well as vast amounts of electricity to the surrounding region.

Grand Coulee Dam is one of a series of dams that generate electricity and controversy along the Columbia River. The dams' benefits to

Park Service Plan Could Create National Trail

If a National Park Service report currently before Congress is approved, Glacial Lake Missoula and its floods soon will become known as one of the region's most important narratives.

The Ice Age Floods Study of Alternatives and Environmental Assessment suggests establishing a national geologic trail — similar in concept to the Lewis and Clark Trail or the Oregon Trail — along the floods' pathways. The report envisions interpretive visitor centers in Missoula and other locations in the four states along the Ice Age Floods National Geologic Trail, as well as highway signs and wayside exhibits.

Members of the local study team that helped create the park service report excitedly list the possibilities of a Missoula interpretive center: an interactive scale model of the entire lake and floods terrain; a theater recreating the experience of the floods; natural history exhibits of flora and fauna that existed at the time (which included mastodons, giant bison and beavers the size of grizzly bears); hands-on children's exhibits; a gift shop; and concessions.

"The fantasy is that Missoula could get its own interpretive center like the Lewis and Clark one in Great Falls," says Janel Queen,

study-team member and executive director of The Nature Center at Fort Missoula. The UM-affiliated center currently offers Glacial Lake Missoula exhibits and will be a key player in any local visitor center. "We want it to be cutting-edge," she says.

Other members of the study team, which has evolved into a chapter of the nonprofit Ice Age Floods Institute, include representatives of the U.S. Forest Service, the Bureau of Land Management, the Missoula Chamber of Commerce and the Convention and Visitors Bureau. Team co-chair and CVB committee member Larry Lambert points to the economic boon the project could provide.

"The potential economic and tourism impacts are huge," says Lambert, who manages Ruby's Inn in Missoula. "Instead of people going from Missoula to Spokane via I-90, maybe we can send them to Polson and Plains and Thompson Falls. Maybe also they'll stay a little longer or come back."

The Ice Age Floods Study is available at the Missoula Public Library, UM's Maureen and Mike Mansfield Library or online at www.nps.gov/iceagefloods.



◀ Dry Falls was once five times bigger than Niagara Falls.

the Northwest's agriculture and economy are praised, their damaging effects on salmon and American Indian traditions lamented. There are no easy answers.

Moses Coulee to Dry Falls

Just west of Grand Coulee, things start getting weird. Rocks the size of cars and pickups are strewn about the landscape. These alien boulders are called erratics, and they were deposited by both the Missoula floods and the creeping ice sheet.

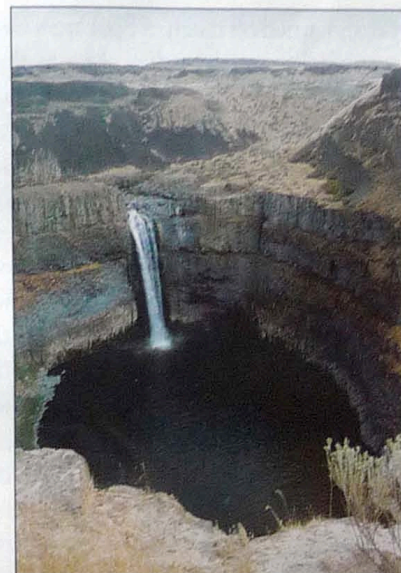
I'd seen pictures of the biggest alien, an ice-sheet souvenir called Yeager Rock. Driving west toward the small farming community of Mansfield, I round a bend and spontaneously blurt out, "Holy Moly." Pictures do not do this monster justice. It's the size of a three-story house, but much more solid. It dwarfs my car and everything else around it.

Yet another twilight-zone scene is Moses Coulee, about ten miles west and roughly parallel to Grand Coulee. Though similar to Grand

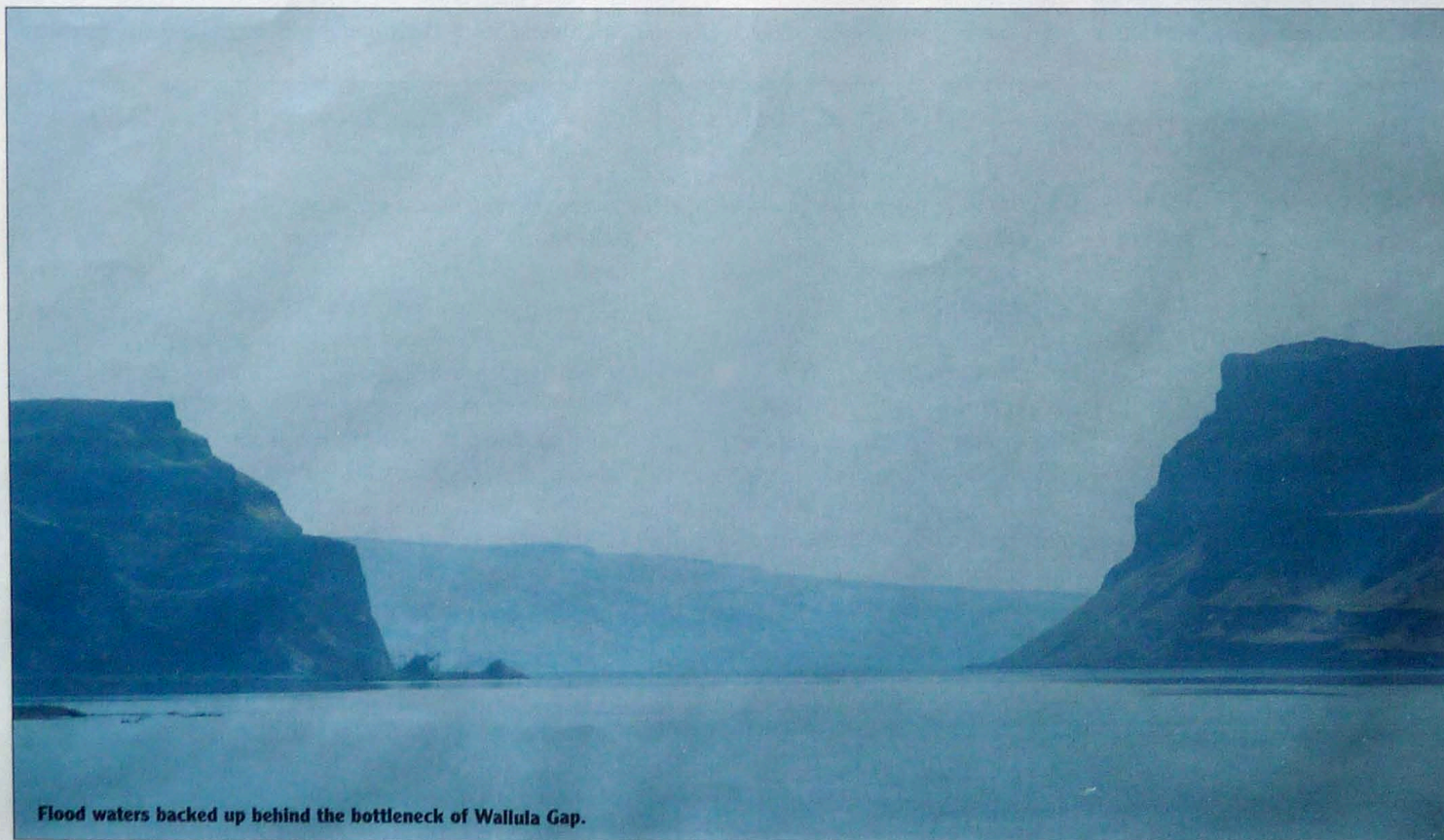
Coulee in size and features, Moses Coulee is oddly dry. After some head-scratching, Alt finally figured that the Columbia River and floodwaters ran through Moses Coulee until its northern end was blocked by a glacial moraine. The waters then changed course and created Grand Coulee.

The next stop is Dry Falls, where the Missoula floods gouged a huge hole in the earth. At more than 350 feet tall and three miles across, Dry Falls at its peak was more than five times the width of Niagara Falls, Alt says. The broadly scattered plunge pools below illustrate how the immense floodwaters did not drop vertically like a traditional waterfall, but sloped like an offramp.

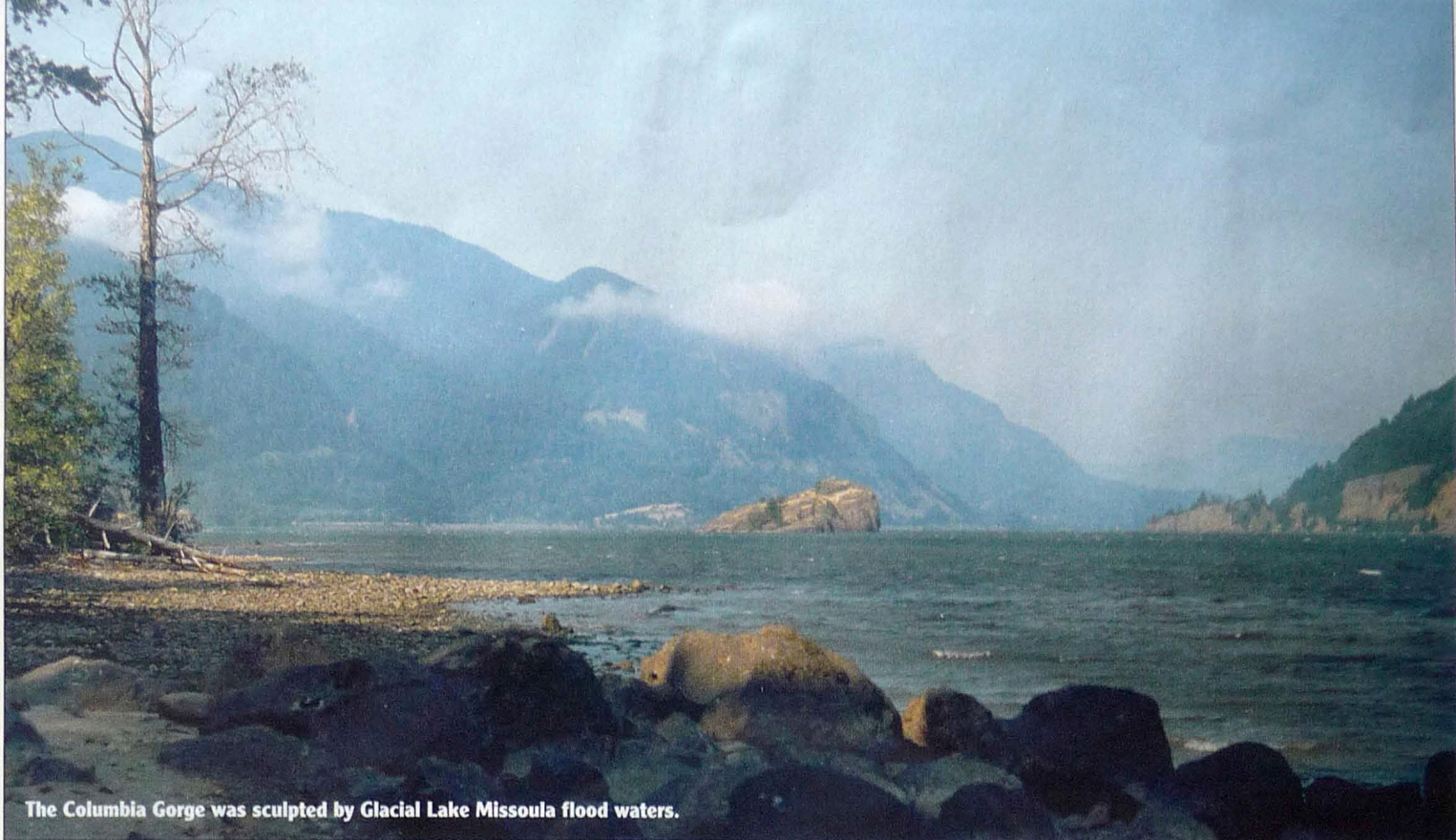
A small but excellent visitor center at Dry Falls pays homage to Bretz with a dedication plaque that quotes him: "Ideas without precedent are generally looked upon with disfavor and men are shocked if their conceptions of an orderly world are challenged."



Palouse Falls



Flood waters backed up behind the bottleneck of Wallula Gap.



The Columbia Gorge was sculpted by Glacial Lake Missoula flood waters.

Palouse Falls

Bretz's vindication came years later at another big hole in the ground some three hours southeast of Dry Falls. One of his most vocal critics, a prominent geologist named James Gilluly, took one look at Palouse Falls and said of himself, "How could anyone have been so wrong?"

The stream now flowing over Palouse Falls is minuscule next to the plunge pool and canyon below it. These absurdly large features clearly were carved out by much bigger flows, and standing at the edge, I can see how the floods knocked out basalt columns like so many teeth.

The floodwaters continued their charge south, following much the same path people take today between Spokane and the Tri-Cities. But where most modern travelers take a shortcut from Kennewick to Hermiston, the Columbia River curves around through a less direct route. The floods took this roundabout, too, only to be stopped short at a narrow space in the hills called Wallula Gap. This dramatic portal created a vast, temporary lake that backed up the flow of the Snake River past Lewiston, Idaho.



Tsagaglialal, or "She Who Watches," is an American Indian petroglyph near The Dalles, Oregon.

The Columbia Gorge to Portland

Beyond Wallula Gap, the floodwaters entered another tight spot.

"Where they squeezed into the narrow bottleneck of the Columbia Gorge, the greatest floods were about 1,000 feet deep, about 500 feet deep as they poured out the western end of the gorge into the Portland Valley," Alt writes. "That steep gradient drove the floodwater through the Columbia Gorge in a ferocious rush." The waters shredded vast amounts of the volcanic rock that lined the gorge, widening it into the scenic landscape we know today.

When the wall of water reached Portland, it was a muddy, rumbling mass that would have submerged most of the city's skyscrapers. Portland's most notable souvenir of the floods is Lake Oswego, a basin scoured out of basalt rock by the rushing waters.

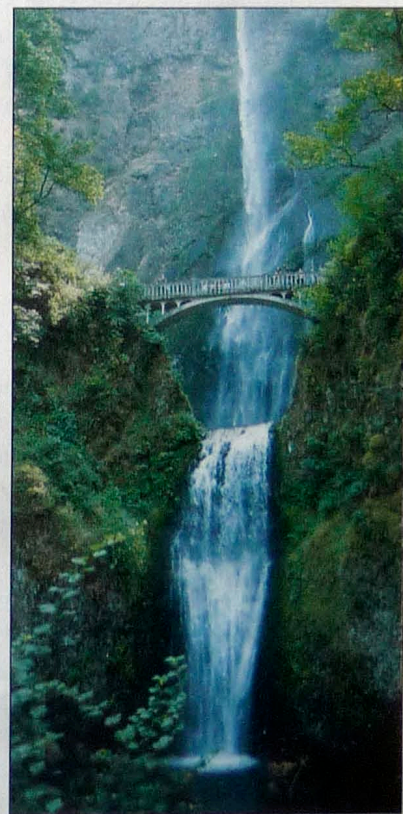
Another flood remnant is the Bellevue Erratic, a sedan-sized rock that rafted in on an iceberg from the Rocky Mountains to just southwest of Portland near Sheridan. As I hiked up the short path to the small state park that surrounds the boulder, I met a man coming down who said, "It's just odd enough to be worth it." The rolling farmland around the erratic contains an abundance of vineyards, pear trees and blackberry vines, evidence of the rich topsoil carried downstream from Washington and Idaho.

The Final Stretch to Astoria and Beyond

While creating a temporary lake that stretched the length of the Willamette Valley to Eugene, Oregon, the flood waters continued widening the Columbia Gorge west. They dumped into the Pacific Ocean near Astoria, Oregon, leaving little evidence except some stray Montana rocks found off the coast as far south as San Francisco and even Santa Barbara, California.

Each time the ice dam broke, the race to the Pacific was over in about two days, a

Multnomah Falls formed after a streambed was sheared off by raging torrents.





The flood waters reached the end of their journey near Astoria, Oregon.

wrecked landscape in its wake. The process repeated every fifty years or so. No one knows exactly how many floods there were, which is only one of many Glacial Lake Missoula mysteries that remain to be unearthed. Geologists disagree on many aspects of the floods, and new discoveries await future scientists.

Back in Missoula, some teachers have integrated Glacial Lake Missoula into their curricula. One is UM geography Professor Jeffrey Gritzner, who recently led a busload of twenty-seven Montana K-12 schoolteachers along the floods' path to Astoria. A summer institute of the UM-based Montana Geographic Alliance, the program explored the geography and history of the Columbia River Basin, focusing on the Missoula floods and the Lewis and Clark expedition, whose paths often overlapped. The teachers went back to their classrooms prepared to share the wealth of knowledge with students.

"They loved it," Gritzner says. "I think that being the largest recorded floods in history, there's a bit of pride connected with it that we Montanans have had this amazing series of floods. They had a tremendous impact on the landscape."

During my journey west, I noticed a thread of awareness about Glacial Lake Missoula and the floods. They were mentioned at interpretive signs and in visitor centers at Lake Pend Oreille, Grand Coulee Dam, Dry Falls, the Columbia Gorge and the Willamette Valley.

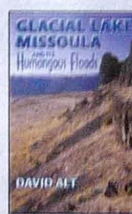
At Multnomah Falls, a popular tourist stop and flood remnant just east of Portland, an Army Corps of Engineers handout describes Glacial Lake Missoula, asking: "Did you know the largest floods to occur on the planet happened here?"

In these challenging times, this is something I can hang on to. If I take any lesson from the incredible story of Glacial Lake Missoula, I hope it is the recognition that in the grand scheme of things, my life and my problems are wonderfully insignificant. 🐾

Patia Stephens is a writer, editor and Web designer for University Relations. She loves her job because it allows her to indulge her obsessions.

RESOURCES

Books



Glacial Lake Missoula and Its Humongous Floods
By UM geology Professor Dave Alt
Mountain Press Publishing Co., 2001

Fire, Faults & Floods: A Road & Trail Guide Exploring the Origins of the Columbia River Basin
By Marge Mueller and UM graduate Ted Mueller
University of Idaho Press, 1997

Cataclysms on the Columbia
By John Elior Allen and Marjorie Burns with Sam C. Sargent
Timber Press, 1986

Videos

The Great Floods: Cataclysms of the Ice Age
Washington State University in cooperation with the National Park Service
www.nps.gov/laro/nwia.htm

Ice Age Flood: Catastrophic Transformation of the West
Oregon Public Broadcasting
(888) 293-1982

Sculpted by Floods
KSPS, Spokane Public Television
www.friendsofseven.org/vidlist.asp

Web Sites

National Park Service
www.nps.gov/iceagefloods
Ice Age Floods Institute
www.uidaho.edu/igs/iafi/iafihome.html

Visitor Centers

(with exhibits related to Glacial Lake Missoula and the floods)

Farragut State Park
Visitor Center
Athol, Idaho
(Four miles east off of Idaho 95 between Sandpoint and Coeur d'Alene)
www.idahoparks.org/parks/farragut.html
(208) 683-2425

Dry Falls Interpretive Center
Sun Lakes State Park
Coulee City, Washington
(Two miles south of U.S. Highway 2 on Washington 17)
www.parks.wa.gov
(509) 632-5214

Columbia Gorge
Interpretive Center
Stevenson, Washington
(On Washington 14, across the Bridge of the Gods from Oregon's Interstate 84)
www.columbiagorge.org
(800) 991-2338