The floods that carved the West.

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Article

FLOODS -- History
GEOLOGY

MISSOULA, Lake
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Discusses the monumental Lake Missoula Floods that repeatedly scoured and shaped the topography of the Pacific Northwest at the end of the last ice age. How geologist J Harlen Bretz discovered the floods in the 1920s through a study of the scablands of eastern Washington; How the discovery changed the discipline of geology.

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THE FLOODS THAT CARVED THE WEST

In a great geological catastrophe, a giant lake exploded through an Ice Age dam, and its waters swept across the Pacific Northwest; awesome signs of its passage are still visible of this day

I live in the edge of catastrophe. It's in the woods above town. It hides along the ridges on the open slopes to the west and south of my Montana home. Down along the river you can see it, if you know what to look for, in shapes of rock and
sand. It is a record of an event--or many events--so enormous that it boggles the mind. In the long haul of time, this happened just yesterday, yet almost no one knows about it.

This catastrophe, referred to by geologists and a few nonscientists as the Lake Missoula Floods, is only now emerging from obscurity. It's about time. We're not talking about a little rising water in the spring here, nor of something as relatively small as the mess along the Mississippi in 1993. These floods ran 60 times the flow of the Amazon. And they happened again and again.

Because the Lake Missoula Floods occurred as recently as 15,000 years ago, at the tail end of the last ice age, the geography they built hasn't changed much. Throughout the Pacific Northwest you can see the dramatic landforms, strange settings and subtle scars they left behind. But after the floods were "discovered" in the 1920s by a geologist named J Harlen Bretz, a furious debate took place over the meaning of all that physical evidence. It was an argument that represented both the best and the worst of the way science works, and it helped to change the discipline of geology itself.

It's odd how peaceful it is now, where this drama once roared. One quiet evening in the late fall I climbed a broad slope in central Washington State with photographer Ted Wood and geologist Richard Waitt of the U.S. Geological Survey (USGS). Waitt has been studying the Lake Missoula Floods since 1971. There seemed nothing remarkable about this slope, but Waitt had something up his sleeve.

Suddenly the land ahead of us dropped away. Where there should have been just a continuous gentle rise was, instead, an enormous hollow far bigger than a football stadium and roughly the same shape. Waitt told us the hole was 180 feet deep, below 340-foot-high cliffs.

Like many features of the landscape between Montana and the sea, it would have been much easier to understand if it had not been so huge. Later, when I flew my small Cessna over the hole, it looked exactly like a place where a seasonal creek had dried up, leaving a pool and a gravel bar--except for its absurd size, one-third
of a mile wide and three-quarters of a mile long.

Without seeing him in the dusk, I knew Waitt was smiling. "Erosional landscape, plunge pool, longitudinal bar," he said. "How can you explain this by anything other than water?"

The trouble is, nobody's ever seen enough water to do something this big. And there are features like this all over this part of the West: isolated heaps of gravel hundreds of feet high where there should only be plains; dozens of parallel lines etched on mountain-sides; enormous holes in the ground; huge canyons dug where almost no water runs; sandbars hidden high up in the hills; ripples so huge and long they can be appreciated only from the air. But until J Harlen Bretz (right) came along, most geologists believed that floods of this size simply could not happen.

The discovery of the floods is like a classic mystery story, and Bretz was a classic geological sleuth. He was born in 1882 in Saranac, Michigan. Raised a Methodist, he went to a religious college, at one time planning to be a missionary. But a skeptical outlook turned him toward geology instead, which led to a long career teaching at the University of Chicago. He had a robust and, as he put it himself, "recurrent earthiness" in his sense of humor and a Socratic method of teaching that included biting rejoinders to students whose answers were sloppy. He had, one colleague said, an "agile and well-disciplined mind" and a hunger for things that were real.

It's ironic that the very qualities that turned Bretz away from his strict religious background helped him kick some pins out from under the geological theory that had undermined the biblical view of creation. This theory of Earth's development was Uniformitarianism--the idea that the same geological processes we see today occurred over extremely long periods of time to produce our present-day landscape. The idea, supported by much evidence, had discredited the theory known as Catastrophism, which explained Earth's shape through a series of upheavals far more violent than any seen today--events like Noah's flood.
In some of his early photographs, Bretz wears a brusque mustache and a stern eye. "He looks like a prosecuting attorney," Richard Waitt said. Looking at these pictures, I can imagine Bretz rigorously enforcing Uniformitarianism. But it was the opposite: his sleuthing shook that doctrine to its roots.

It began with a USGS topographic map of Quincy Basin, which covered an area just east of the Columbia River, near a huge dry canyon that later became well known as the site of a major dam: Grand Coulee. On the USGS map were several cliffs and huge potholes. Unmistakably, they were waterfalls, but there wasn't any water.

Shortly before World War I, Bretz, who was teaching in a Seattle high school, studied the Quincy Basin map out of sheer geological curiosity. He was puzzled by the size and shape of the features, which included two big, round holes like the one Waitt, Wood and I had seen.

"Puzzled" may be too mild a word. "He saw those pot-holes on the map like two big fried eggs," Waitt said. "He must have thought, What the hell is this?"

The map of Quincy Basin was both clue and question. "I had been intrigued," Bretz wrote, understating it. After he began teaching geology at the University of Chicago, he returned again and again to eastern Washington in the summers, driving West with his wife and two children in a Dodge sedan with a grub box on the back, bedrolls strapped on the sides and an umbrella tent and poles on the front bumper. He studied features like the falls and potholes in Quincy Basin; the vast canyon of Grand Coulee, which includes another spectacular dry falls; curious granite rocks--called erratics--that did not match the local basalt rocks; and 30-foot boulders that had been carried far from their source by some mechanism. But the focus of his attention was an area of very strange landscape that marks eastern Washington. It was called the scablands--about 2,000 square miles of raw, peeled ground that stretches from Spokane west to the Cascades and south all the way to the Snake River (see map, opposite).

"Like great scars marring the otherwise fair face of the plateau are these elongated tracts of bare, or nearly bare, black rock," Bretz wrote. "The popular
name is an expressive metaphor. The scablands are wounds only partially healed . . . in the epidermis of soil."

I've walked over small parts of these scablands. The landscape is both bleak and beautiful. It's made up of broken lava, dry grass and sagebrush, and is curiously interrupted here and there by long, isolated mounds of soil up to 500 feet high and several miles long, which remind Richard Waitt of battleships. Only these islands of soil are tillable; the rest of the land is hardscrabble pasture. Only a few ranchers and assorted iconoclasts live here. When I asked one of them why people homestead-ed this tough land, he grinned at me. "Some people came here," he said, "because it couldn't be plowed."

Bretz came because there was a secret hidden in this scalped rock. He went looking for it on foot. There weren't many roads on the scablands when Bretz worked on them, so he walked. Bretz's son, Rudy, remembers that on some days his father would hike as far as 40 miles.

He recorded hill and gravel bar and pothole but did not describe for posterity the moment it all coalesced in his mind and became a story without parallel in his science. It's likely that the idea grew compellingly from his first look at those "fried eggs," overwhelming his own allegiance to Uniformitarianism. "The writer confesses," Bretz wrote in a 1923 paper, "that during ten weeks' study of the region, each newly examined scabland tract reawakened a feeling of amazement." Much later he wrote in his informal memoirs: "I could conceive of no geological process of erosion to make this topography except huge, violent rivers of glacial melt water."

"It was a debacle which swept the plateau"

Bretz's second paper carefully summarized his description of the scablands in 21 succinct statements. But by the end of the 32-page treatise, he had let the dangerous cat out of the bag: "Fully 3,000 square miles of the Columbia Plateau were swept by the glacial flood," he wrote, insisting with italics, "It was a debacle which swept the Columbia Plateau."
If there was an echo of desperation in the assurance of those italics, it was justified. Bretz published another major paper on the scablands in 1925, and after that the floods hit the fan. Two years later he was invited to present his theory to a group of geologists in Washington, D.C., and was clobbered by objections. One critic, James Gilluly, called Bretz’s ideas about the mechanism, magnitude and swiftness of floods wholly inadequate and preposterous. Like one of the floods, Gilluly had dug a big hole for himself, out of which he would later be forced to climb. But in the intervening years Bretz’s theory was, well, uniformly attacked.

Richard Foster Flint, a specialist in glacial geology at Yale, who had once actually been taught by Bretz, became what Bretz called his "most vigorous opponent." To Flint, everything that Bretz claimed was made by a huge flood could also be explained by "leisurely streams with normal discharge."

Bretz's opponents had one great weakness: many of them had not spent much time in the field actually looking at the features Bretz described; they had no gut sense of their size. And Bretz had one great weakness: he did not know where the water had come from. He suggested some vaguely high rates of ice melt due to climatic warming, or ice turned to water by volcanoes erupting under the glaciers, but neither of these theories was satisfactory. He fell back on insisting that the record of the flood was there to be seen and must stand on its own.

The rock's confession had been denied

And there, for a while, the matter rested. In the early 1930s Bretz went through what we might now call a mid-life crisis, a period of apparent despair. Flint's interpretation of the more orderly creation of the scablands was incorporated into textbooks. The Depression came, then World War II, but though the sleuth had wrestled the secret of the great Lake Missoula Floods out of the channeled scablands, the rock's confession had been vigorously denied.

In the past year I've visited the channeled scablands and the surrounding landscape several times and have flown across them often. When you see the expanse of channels it's at first hard to believe your eyes. Then it's hard to believe that so many people rejected the idea of huge floods.
The sights are stunning. Richard Waitt recently led a field trip of eminent geologists through the scablands. Near the end of one day, as the group approached a viewpoint, one of the visitors asked him, almost plaintively, "Is this going to be another 'Wow!' stop?"

The Wow! stops come in two types. First are the scenic splendors. These include the dry falls--far larger than Niagara--midway along the Grand Coulee and a wonderful semicircular plunge pool on the Palouse River, where a thread of water drops into a basalt basin carved by a far larger flow. The second type is made up of more-subtle features that, when you recognize the story in them, amaze you. A huge rock in a field in the Willamette Valley near Portland, Oregon, turns out to be a chunk of granite--an erratic--carried from as far as Idaho by icebergs caught in the flood. Long hills along the Snake River show where floods completely filled the river's canyon and spilled out over the edges, driving gravel up into bars. The bars look just like the little ridges of gravel you'd stand on to fish your local stream--except that they're miles long and hundreds of feet high.

Once during a field trip I attended, Waitt stood with his group on a ridge above the Columbia, staring more than 900 feet down at what looked like a toy barge on the river. Waitt was explaining how the river had risen almost to this level and poured through into the next drainage. It had risen about three feet a minute.

"Would have been a great place to stand and watch," one of the group said.

"Scary, though," said another.

"Yeah," said a third. "You and five million rodents."

Once you see it, the evidence seems overwhelming. How could Flint and colleagues have been so obtuse? Perhaps because things like this look obvious only after someone has the nerve to see them. Scientists stare at chaos, hoping to see a pattern, and when one seems to match reality, it's difficult to see an alternative.

Uniformitarianism was a useful explanation of the world, so it was well defended.
And because science is not a belief but a search for reality, there can be no casual agreement to disagree; with something as tough as truth at stake, arguments, though sometimes courteous, are conducted with knives. So until Bretz had a source for his water, there would be acrimonious stagnation.

On June 18, 1940, that stagnation began to erode. The major breakthrough happened that day at a meeting of the American Association for the Advancement of Science, held in Seattle. Bretz declined to attend, saying that he had already published all he had to say. But another man stole the moment.

He was a USGS geologist named Joseph Thomas Pardee. Not much of a speaker, he gave a short talk about ripple marks in a lake bed.

Many years before, Pardee had written a paper describing a large lake that the evidence suggested had filled several valleys in western Montana during the Ice Age. It was called Glacial Lake Missoula. It had been created when a glacier blocked a river. From the lines of old lakeshores that stand high above the city of the same name, Pardee estimated that the lake had been about the volume of Lake Erie and Lake Ontario combined. This was a lot of water: some 500 cubic miles of it. Lake Missoula began a few miles east--just upstream--of the channeled scablands.

Most geologists knew about Lake Missoula, but there had been many glacial lakes in the West, and there was no compelling evidence that Missoula had ever burst its ice dam. But Pardee offered just that. He delivered his paper quietly, but its message was powerful. The ripple marks Pardee had seen and described were up to 50 feet high and had a wavelength of between 200 and 500 feet. They were enormous. The marks could have been made only by a vast pouring of waters over the slope, which would have happened only if the ice dam that made the lake had suddenly failed. And where would those 500 cubic miles of water inevitably have gone? Into the channeled scablands.

**Here was the source of Bretz's flood.**

"When he [Pardee] stopped speaking," wrote scientist Howard Meyerhoff, "there
were several moments of silence as the significance of his observations sank in. As the first ripples (?) of applause started, a few in the audience rose to their feet and the rest immediately followed, to give the startled speaker a rousing ovation."

So Uniformitarianism had been challenged by, of all things, a flood. A significant story had been added to the history of the world, and geology had been complicated by catastrophe. Today, as scientists increasingly accept ideas of huge volcanic explosions or meteoritic impacts to explain mass extinctions, there's been a general acceptance that grand events are also part of the normal patterns on Earth. Bretz had been a pioneer.

Years later James Gilluly, who had been so critical of Bretz, visited the striking cataract at Palouse Falls with another geologist. Gilluly stood for a few minutes looking out at the vast curve of basalt where hundreds of times the present flow had foamed into the chasm. Then he gracefully climbed out of the hole he had dug for himself years before: "How could anyone have been so gong?" he said.

An unknown bard of the USGS's old Pick and Hammer Club wrote later:

A glacier once 'neath its collar got hot
And out o'er the scablands a mighty flood shot.

Now truly, Gilluly, t'will fool ye,

For Bretz has been there and he says there is not

A shadow of doubt what occurred on that spot.

'Tis true, it has Jim Gilluly's goat got.

But speaks he not truly, Gilluly?

Today the landscape in which Lake Missoula filled and flowed is a quiet place. You can hear the screech of a red-tailed hawk half a mile away and a tractor at two miles. But when a Lake Missoula Flood came through here it was not quiet, and when you know about the floods, the places seem haunted by that ancient
roar. Everywhere you go in this dry, water-carved landscape, you can't help wondering: What was it like?

The "dam" was a lobe of a glacier that moved south and blocked what we know today as the Clark Fork River near the present town of Sandpoint. The land there looked very different from the wooded mountains and grassy scablands of today. It was sparsely vegetated, with dunes of windblown sand and silt, braided gray rivers and low vegetation. There were cliffs and walls and sheets of ice on the northern horizons. In this stark landscape the lake that grew behind the ice dam must have been swirled with dirt in summer and frozen solid each long winter.

If a person had stood on top of the glacial lobe that had dammed the river, no sign of impending floods would have been visible. River water was cutting out a channel, not through the ground below but at the base of the ice. Ever so slowly, taking perhaps weeks, the water cut a channel through the ice. Then the pace picked up.

A small gush emerged from a dirty-looking cave on the downstream side of the dam. Over days the gush grew, eating away the ice, growing larger, moment by moment, swelling exponentially. Finally, the ice roof that had survived collapsed into what was now a torrent. In as little as two days of thunderous cracking, shattering, collapsing ice, Lake Missoula rocketed through a mile-wide canyon in the glacier.

What did it look like? What happens when 500 cubic miles of water are suddenly released down a slope?

There have been several smaller versions in the modern world. In 1976 when the Teton Dam in Idaho burst catastrophically, water blasted through a narrow canyon on its way downriver to Sugar City. From this small hamlet you can barely see the hills where the dam was built, but "homes were swept off their foundations or simply crushed into kindling and rubble," reported the Idaho Statesman. "Farm equipment, pickup trucks and cars were strewn across swamped fields as if tossed about by a child throwing a tantrum."
Such an event only hints at a Missoula Flood. In the Clark Fork canyon, the downstream arm of the lake was abruptly turned into a river. This river was up to 1,500 feet deep and ran with ten times the water of all the rivers in the world combined: more than 600 million cubic feet per second. (The Mississippi flood of 1993 peaked at 1 million-plus cubic feet per second.) In places a car being carried downstream could have earned a Montana speeding ticket: the water coursed at up to 60 miles an hour.

As the flood spread out, it drove west and south in a roaring line. "In places it might have looked like a tidal bore," Richard Waitt said, "but a bore maybe 50 feet high. A muddy, angry front with ice and boulders in it." If the nearly barren Ice Age plains of eastern Washington were dry that season, the advancing flood may have been marked by a boiling cloud of dust as well as foam.

Much of eastern Washington is covered with loess--rich, windblown soil built up over centuries. This is what covered the area that became the scablands. When the flood hit, it dug out the loess and carried it away. Where the flood passed, the water ate right down to the rough basalt, heaping it into gravel bars or grinding it into sand, making rapids and waterfalls and circular pools--some of the holes large enough that rustlers have used them to hide whole herds of stolen cattle. In hundreds of high spots the flood left islands of loess soil--the long mounds that Waitt thinks of as battleships facing upstream.

The flood boomed out of the mountains and scoured the scablands. It crashed into canyons and chewed out waterfalls, then broke them up and moved them upstream. It dug canyons down to both the Snake and Columbia rivers. When the flood reached the Snake it roared upstream, heaping gravel into bars several hundred feet high.

**Like a hole in the bottom of a giant hot tub**

Then, eventually, in its haste to reach the sea, it ran into a tight spot. That constriction is called Wallula Gap. It's a few miles downstream of the confluence of the Snake and the Columbia. It's a mile wide. A mile-wide gap may not seem like much of an obstacle for water, but for a Missoula Flood the Wallula Gap was
like a little drain hole in the bottom of a very large hot tub. You pull the plug, but the water doesn't go away at once.

The flood hit Wallula Gap a half-day or so after it peaked at the dam. It roared through the gap but also backed up behind the bottleneck. For a couple of days it made a huge 3,500-square-mile lake as the water downstream elbowed its way through the Columbia River Gorge, leaving icebergs and rocks up on the ridges.

At last the water reached Portland, where it would have completely inundated the city. It made gravel bars as big as the city itself, then spread and boomed out to sea. In less than a week it was all over but for the mud. The draining of ponds and the melting of the stranded icebergs took longer, but the flood had ended. Yet up there in Idaho, the broken ice front of the glacier was creeping down the valley, building another dam.

How many floods were there? The numbers are still debated. Bretz suggested as many as six or seven. Waitt and colleagues theorized in the early '70s that the evidence might indicate even fewer. But for Waitt all that changed dramatically in 1977.

**From great turmoil to utter peace**

One day Ted Wood and I went to the place where Waitt had had his own moment of insight. It's a canyon near Lowden, in southeastern Washington. We approached it in early morning across newly plowed fields. Once again a place that held evidence of great turmoil was utterly at peace. Mist rose from rolling hills and distant sprinkler systems and swirled past the sun, making it all seem timeless and strange. The canyon is a narrow cut in a hill, about 100 feet deep, dug out when an irrigation canal ran amok in 1926 (ah, catastrophe!). It reveals a 39-layer cake of sediments, cut as sharply as if by a knife. These were sediments laid down when the water pooled up behind Wallula Gap and stopped roaring long enough to drop some of its load of mud.

The many distinct layers in the canyon could be explained by a surging in a flood: a kind of back-and-forth current that would change the character of each layer enough--from gravel to silt and back--to make it look distinct. But in late 1977
when Waitt happened upon the canyon, he found a different kind of evidence. In between the 11th and 12th layers of silt was a layer of ash. Waitt knew it had come from an eruption of Mount St. Helens about 15,000 years ago. It was clear and distinct, yet if all these layers had been put down in the middle of a single surging flood, it should not be there.

"I sat and stared at that horizon for about ten minutes," Waitt said. "It didn't make any sense. I thought about it all winter, and it still didn't make any sense. Then I came out the next spring, and it all fell into place."

To Waitt the layers indicate that there may have been as many as a hundred of these gigantic floods, their volume tapering off as the climate warmed and the recurrent glacier dam thinned. This might explain why there are so many parallel shorelines at different elevations in the hills above Missoula.

I stood among the wisps of mist, staring down into the shadowed canyon. It seemed amazing to stand here, about 200 miles from the parallel lines that mark the old shores of Lake Missoula, looking at the same kind of parallel lines, which told the same story: huge floods that happened over and over.

While I stood there, the irrigation district upstream turned water on somewhere, and a pipe in the bottom of the canyon started to flow. The noise of the water went from a trickle to a rush, and there was a rumble in the pipe. A prickle of apprehension ran through me. I wondered if I should move to higher ground.

But Lake Missoula's been gone a long time. The gush of water quit, the sun came out. As we left I thought of J Harlen Bretz, wandering around on the strangest landscape this side of Mars, looking at evidence nobody else could even see because it was so enormous, putting together a piece of the story here and another piece of the story there, hearing in the desert silence of an empty country a tumult and roar of water. Here he was, prosecuting attorney, putting together the story and laying it out for the jury--People's Exhibit A; People's Exhibit B; right down the line, unmistakably right--a coherent, complete, convincing explanation. And the jury snickered and voted against him, trial after trial.
But at last he won the case. Bretz was awarded geology's highest honor, the Penrose Medal, late in his life. "All my enemies are dead," he lamented to his son, "so I have no one to gloat over."

Now Bretz's work may be further recognized: both a task force of government agencies and the Ice Age Floods Institute, a nonprofit organization, have been formed to explore the possibility of making the scab-lands area a recognizable feature of the tourist landscape, a bit like the Lewis and Clark Trail. Some of the more spectacular sites could be stitched together by guidebooks, making a kind of exhibit for travelers.

One such site has already been dedicated to Bretz. It is the visitors center at Dry Falls in Grand Coulee. A plaque there bears words Bretz wrote in 1928: "Ideas without precedent are generally looked upon with disfavor and men are shocked if their conceptions of an orderly world are challenged."

Reading them, then looking out at the amazing dry cataracts below, I thought of one of the few times Bretz let his enthusiasm for this place show through the austere language of science. He was not just academically intrigued. Like the people who will come, more and more, to see this extraordinary evidence of the power of flowing water, he was in awe:

"Let the observer take the wings of the morning to the uttermost parts of the earth," he wrote, "he will nowhere find its likeness."

PHOTO: Horizontal stripes on the mountains standing above Missoula mark the lake's ancient shorelines, suggesting that there may have been not just one flood, but many.

PHOTO: Rampaging with the force of hundreds of Niagaras, water gouged this mile-wide hole in Washington's Grand Coulee.

ILLUSTRATION: Map shows where ice dam blocked Clark Fork River, backing up water to form Glacial Lake Missoula. When water breached the dam, flood spread over Washington and Oregon and roared down the Columbia River.
PHOTO: In 1923 geologist J Harlen Bretz cracked the mystery of the scablands but was scorned by other scientists.

PHOTO: The ice cream lay in Idaho where the Clark Fork River enters Lake Pend Oreille. All but the highest mountains were bound in ice before Lake Missoula broke through.

PHOTO: In the Washington scablands, the flood scoured down to bar basalt rock, appearing here as dark patches.

PHOTO: The huge potholes on the edge of the Quincy Basin gave Bretz the first clues that an event of catastrophic proportions had occurred. Nothing could have made such topography, he wrote, "except huge, violent rivers."

PHOTO: Layers of silt, created when water backed up behind Wallula Gap, record the many floods that came through.

PHOTO: Palouse Falls, 185 feet high, is a trickle compared with flood, which raged 100 feet above land shown here.

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By Michael Parfit

Photographs by Ted Wood

Michael Parfit's SMITHSONIAN articles have often involved big water, from the Mississippi to the Amazon.

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