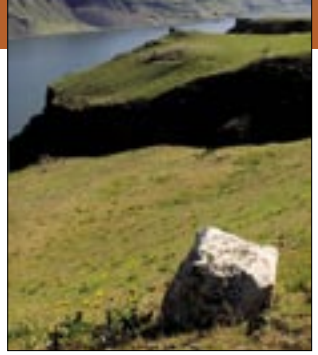


Erratics

Geologists study boulders for clues to ancient floods, icebergs in Eastern Washington

Geologist Bruce Bjornstad examines a granitic boulder in the Rattlesnake Slope Wildlife Area near Richland, Wash. This and other boulders in the area are thought to have been carried by giant icebergs during massive ice age floods. Photo: Ben Raker

Bruce Bjornstad stands on a hill south of Kennewick, Wash., looking out over a wide expanse of parched land that was once almost entirely under water.

The giant, whitish monolith beside him hints not so subtly at some massive force required to put it in its current position. This rock is nearly 15 feet tall, weighs about 100 tons, and blends into the surrounding landscape of dark silt and sparse grass about as well as an elephant would in a penguin colony.

"The only rock type that's around here for hundreds of miles is basalt," says Bjornstad, a senior research scientist at Pacific Northwest National Laboratory in Richland, Wash. "It's a dark, fine-grained rock. So if you see any light-colored rocks, they've got to be from somewhere else."

Bjornstad and his collaborators recently completed the area's first systematic study of these large, transplanted rocks, which geologists call "erratics." Such rocks are believed to have arrived on icebergs from as far away as Western Montana during cataclysmic floods of past glacial periods. They may hold useful information about the nature of those floods, how large they were, and how often they occurred.

The results of Bjornstad's study, presented in November 2003 at the Geological Society of America meeting in Seattle, include plots and descriptions of 1,100 ice-rafted erratics found within a 15-square-mile area on Rattlesnake Mountain in the Hanford Reach National Monument. Much of the fieldwork was done by Elysia Jennett, an undergraduate student at Northern Arizona University, Flagstaff, armed with a GPS unit, tape measure, and notepad.

Data collected about the quantity, distribution, rock type, size, and roundness of the erratics are leading to new theories about the floods that occurred.

by Ben Raker

"They've never really been systematically studied in a local area," says Vic Baker, a University of Arizona professor who has studied Eastern Washington flood deposits since the 1960s.

"Bruce's work documents these ice-rafted erratics in a way that's never been done before," agrees Jim O'Connor of the U.S. Geological Survey, who studies erratics to the south, in Oregon's Willamette Valley.

One of the most significant findings about the erratics is that there are so many of them even in this relatively confined study area. "Up until now, we knew they were here and they were probably from this ice-rafting mechanism," says Bjornstad. "But nobody ever really appreciated how many there actually were."

The distribution patterns of the erratics offer new clues about the way they were deposited. The boulders tend to be concentrated along drainages, which may indicate that the floods slowed while flowing over uneven ground, creating opportunities for bergs to catch in eddies, lodge, and then melt, Bjornstad says.

Groupings of erratics may also be revealing. Lone erratics may be from icebergs that never ran aground but slowed enough to melt; erratic clusters suggest an iceberg that did run aground, allowing all materials to melt out in one place. Finally, there are bergmounds: large hills of deposit that suggest giant, rock-laden icebergs ran aground and dumped their loads.

Bjornstad says the absence of bergmounds above 1,000 feet may be due to the fact that these icebergs were too deep under water to lodge near the sloped shorelines of the highest floods. On Rattlesnake Mountain, the highest recorded erratics were found at near 1,200 feet—marking a high floodwater line nearly 800 feet above the nearby cities of Richland, Pasco, and Kennewick, Wash.

This 15-foot-tall, 100-ton boulder near Kennewick, Wash., may have been rafted here by an iceberg during one of the last ice age floods. The line of snow on the ridge in the background shows roughly where the highest flood may have reached—1,200 feet, or roughly 800 feet above nearby cities. Photo: Ben Raker

The researchers' findings about sizes of erratics and erratic clusters speak to the sizes of the bergs that deposited them. Because it takes a certain amount of ice to float a certain mass of rock, iceberg size may be calculated from its erratic debris. In some cases—depending on the density of the rock—the berg mass can be 10 times the mass of its rock remains. Considering that the biggest erratics get up to many tons, the icebergs required to carry them would have been huge. Bjornstad cautions that this calculation is problematic when a cluster has rocks with different densities.

Rock type was another measurement recorded in the study. "That kind of nails it down as to where they're from," says Bjornstad. "We have a lot of granitic rocks that have source areas at least 100 miles away or more." One particular erratic rock type is characteristic of a rock group found only in Western Montana and Northern Idaho—strong evidence for the theory that floods took them from there.

Although the theory of massive floods washing over Eastern Washington was first proposed in the 1920s, it wasn't until several decades later that it came to be accepted by a consensus of geologists.

The first proponent of the theory, a geologist named J Harlen Bretz, was ridiculed by his contemporaries for suggesting the sudden, epic, short-lived floods. He pointed to erratics as part of his evidence that huge forces had been at work.

Gradually, however, other scientists found evidence for the flood theory as well, including giant ripple deposits in Montana that could only have been made by huge volumes of water flowing over them.

The working model is now this: Glaciers coming down from Canada during a glaciation cut off the Clark Fork River near the Idaho-Montana border, forming an ice dam. As ice built, Glacial Lake Missoula formed behind the dam until suddenly the water floated the ice and rushed across Idaho, Washington, and Oregon. According to some estimates, this damming and flooding process repeated itself from 40 to 100 times within the last glacial period, between 18,000 and 12,000 years ago. The frequency of floods,

The Heretic Hero of Scabland Geology

For a man who staked his reputation on the occurrence of sudden, gigantic events, geologist J Harlen Bretz achieved recognition only slowly and gradually.

It was 1923 when Bretz first proposed his theory of a massive flood or floods to explain scoured Eastern Washington landscapes known as "scablands" and the large, incongruent "erratic" boulders found on the dry, open plains.

But the reigning philosophy of the time said that geologic formations were created only very gradually over many hundreds, thousands, or millions of years. Leaders in the field were simply unwilling to accept Bretz's suggestion that massive floods had streamed through the basin in a matter of weeks. The idea sounded too much like a biblical flood, and they dismissed Bretz's claims as scientific heresy.

Still, Bretz held firmly to his beliefs, even though he could not explain where the floodwaters had come from. Finally, after several decades of defending his theory, Bretz was vindicated when the geologic world saw the connection between flood-source formations discovered by J. T. Pardee near Missoula, Mont., and the formations in Eastern Washington.

In 1979, at the age of 96, Bretz received the Penrose Medal, the Geological Society of America's highest award.

On the Trail of the Great Floods

"I am just madly in love with erratics," says Gary Kleinknecht, a Kennewick, Wash., high school teacher who assisted geologist Bruce Bjornstad with his field-work, and uses lessons about the floods in his classroom. "That sounds weird, but it's true—I'm fascinated by them."

Kleinknecht, Bjornstad, and others are trying to spread knowledge of the work studying floods and flood deposits through the non-profit Ice Age Floods Institute. "It's very gratifying to see people take an interest, because our whole purpose in being is to educate the public," says Kleinknecht.

One goal of the institute is to gather congressional support for a proposed "Ice Age Floods National Geologic Trail"—a semicontinuous network of roadside markers and interpretive facilities that would run from roughly Missoula, Mont., to Astoria, Ore., in the path of the floods.

To learn more about the Ice Age Floods Institute and the proposed geologic trail, visit http://www.iceagefloodsinstitute.org/

when they occurred, and how large they were fuel continuing debate.

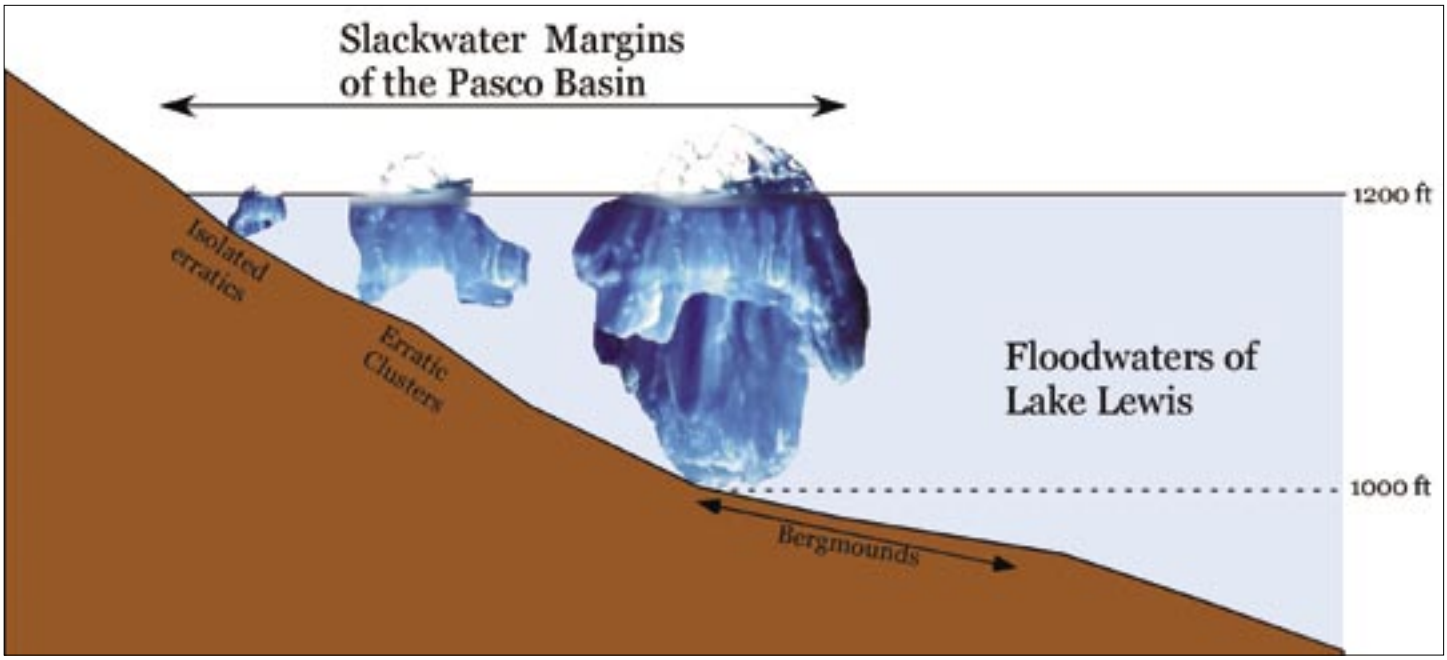
Part of Bjornstad's future research will address the question of when floods occurred by studying the meaning of variations in the shapes of the rocks they found. Roundness and weathering of an erratic may be related to the time it has been sitting exposed since the flood that deposited it. "It should be fairly angular when it starts out," says Bjornstad. "I think that the ones that are rounded and more weathered have just been sitting out there longer—they're probably from older floods."

Bjornstad acknowledges that the rocks may have been rounded before glaciers picked them up, but he says the findings suggest otherwise. "Some rounded rocks may have been rounded at the source, but this doesn't explain why we see so many that are weathered and rounded. Also, the character of the roundness is different. In a lot of the erratics we saw, there was a very uneven surface where more easily weathered minerals were eroded more than the more resistant minerals," he says. "I think the only way you could do that is if the rock was exposed at the surface for a long period of time."

Isotopic dating techniques that measure alterations to a rock made over time by ever-present cosmic rays may make it possible to link certain groups of erratics to dates when specific floods occurred. These techniques are still being tested, according to Vic Baker, who collected the isotope samples with Bjornstad and University of Arizona professor Marek Zreda.

Although the theory of massive floods washing over Eastern Washington was first proposed in the 1920s, it wasn't until several decades later that it came to be accepted by a consensus of geologists.

Further studies of the erratics may also inform research into the containment of wastes at the Hanford Nuclear facility. Says Bjornstad, "Practically all the wastes we have here at Hanford are stored or disposed of in these flood deposits, so the more we understand about the floods, how they've behaved, and what they deposited and where



Although isolated "erratic" boulders are found up to elevations of 1,200 feet on the slopes of Washington state's Pasco Basin, larger clusters of erratics, and the huge piles called "bergmounds," are only found up to 1,000 feet. Researchers propose that the biggest icebergs—those capable of carrying the largest amounts of debris—would have been too deep under water to drift far upslope during even the highest floods. Image: Bruce Bjornstad/PNNL

Geologist Bruce Bjornstad stands on a 15-foot-tall, 100-ton boulder that may have been rafted to its current location near Kennewick, Wash., by a giant iceberg during one of the last great ice age floods. Photo courtesy of Bruce Bjornstad/PNNL

and when, the better we can understand how wastes are moving through."

Proximity to Hanford may have provided an ideal study site. Baker points out that in most areas in the region, boulders have been moved to make way for agriculture. "In the area Bruce is studying, this has been protected—initially as part of the Hanford site and now as a wildlife refuge."

Jenna Gaston, cultural resource manager for the Hanford Reach National Monument, helped with permits to perform the research in this restricted area. "We're very pleased that we can research the resources that we have out there," she says. "Very little geology has been done on the site."

The study site on Rattlesnake Mountain was advantageous for several other reasons, as well. The dark native rock made boulders easy to spot. And the basin edged by the mountain was well situated for trapping icebergs; it was the first place floods would slow as they rushed westward. Water would bottleneck at nearby Wallula Gap, creating the temporary slackwater lake that gave erratics time to drop out.

Bjornstad plans to expand his study area to reach a known erratic field to the west of Rattlesnake Mountain. He and his colleagues also aim to involve the local community in the process of spotting and identifying erratics.

"The story of the floods isn't over," says Bjornstad. "The more we study, the more questions we come up with." ■

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Ancient Forests Exposed by Retreating Glaciers in British Columbia Provide Insights into Climate Change

by Tami Kays and Ben Raker

In the high elevations of British Columbia's Coast Mountains, glaciers are receding at phenomenal rates, literally uncovering the past.

Since the 1920s, the glaciers have been retreating at 25 to 50 meters per year and recently began exposing forests that have been preserved and buried for 2,000 to 5,000 years.

Dan Smith from the University of Victoria (UVic) and his team at the UVic Tree-Ring Laboratory are determining past climates by studying both glacier movement and the uncovered trees. "We are trying to understand the relationship between natural climate variability and the rapid retreat of glaciers throughout the British Columbia Coast Mountains over the last 100 years," says Smith.

Research camp at the foot of the Tchaikazan Glacier, located 250 miles north of Vancouver, B.C., where the remains of a 5,000-year-old forest are being exposed. Photo: Dan Smith

Smith hopes that his research will help researchers decide if the recent warming fits into normal climatic variability or if the climate change is human-induced—or, most likely, a combination of the two.

Other local scientists already fear that humanity has thrown climate here and around the globe into a hotter gear.

For instance, University of Washington professor Edward Miles recently reported that snowpacks in the Pacific Northwest are down 30 percent since 1950. Computer models indicate that snowfall could drop another 30 percent in the next 50 years. Effects on regional water supplies could be disastrous for both city dwellers and farmers. Salmon, said one member of Miles's group, "are toast" if summer droughts dry up streams and rivers.

University of Victoria graduate student Sandy Allen examines recently exposed 700-year-old trees at the Bridge Glacier to find clues about past climates. Photo: Dan Smith

Smith has studied over 40 glacier sites in the last six years as ancient forests become exposed. In the last few years, the glaciers have receded enough to expose much older forests, allowing the scientists to learn about climates older than ever before.

One period of particular interest to Smith occurred between 4,000 and 5,000 years ago. "At around that point something major happened in the climate of the Pacific Northwest," he says. "It either got colder or wetter because the glaciers started advancing. Up until then they had been in a recession, but something sent them back down the valleys."

Contrasting with that glacial advance, today's trend is a massive—and rapid—retreat. "This is the first time in 5,000 years that the glaciers have retreated this far back," says Smith. "If you're looking at the last 10,000 years, this is a very major event. We just don't have any direct parallels in the last 10,000 years." The trees are putting these climate shifts into context, says Smith. ■

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