COLUMBIA GORGE INTERPRETIVE CENTER MUSEUM

EXPLORATIONS

The Bonneville Slide

By Patrick Pringle, Geologist

The great Bonneville landslide, which formed the "Bridge of the Gods" in local tribal oral histories, has been the subject of great interest to the indigenous peoples, early explorers, and to subsequent researchers for centuries. However only recently have investigators been able to accurately estimate the age of this fascinating landform. Research on this landslide, which is ongoing, has been the product of decades of inquiry marked by patience, interdisciplinary teamwork, and even a bit of serendipity. This article discusses some of those studies and describes several more discoveries, some of them surprising.

The Bonneville landslide blocked the entire Columbia River and created a lake that extended for tens of miles upstream. The bridge mentioned in the tribal stories was the pile of rocky landslide debris that allowed people to walk from one side of the river to the other during the time the river was blocked. The lake eventually overtopped the rocky blockage and drained. But the post-landslide Columbia River had been pushed more than a mile farther southeast than its pre-landslide channel and over to the Oregon shore. By the time Lewis and Clark arrived, the Columbia had cut down through rocks to create the "Great Shoot" or rapids mentioned by the explorers.

The big cliff of rock visible at Table Mountain, capped by a thick sequence of lava flows of the Miocene age Columbia River Basalt, is the headscarp or source area of the Bonneville landslide, whose debris trail extends to the southeast toward the Columbia River. The impressive cliffs east of Table Mountain that include Red Bluffs, above Skamania Lodge and the Columbia Gorge Interpretive Center, are the headscarp of what is likely an older, although still-active, slowly moving landslide complex. Underneath the massive looking basalts exposed in the cliffs are fragmental volcanic rocks of the Eagle Creek Formation, which mainly represent volcanic debris flows and floods that spewed forth from a nearby volcano during the Miocene Period. On the south shore of the Columbia River, the petrified tree along the Eagle Creek Trail about 100 yards south of the trailhead is a victim of Eagle Creek volcanism. Radiometric ages on the Eagle Creek rocks show the volcanism occurred roughly 19 million years ago according to US Geological Survey geologist Russ Evarts, who is conducting a detailed study of the geology of the Bonneville Dam 1:24,000 quadrangle.

Some of the cliffs to the northeast of the Bonneville headscarp, along the extreme west margin of Red Bluffs and east of Greenleaf Creek are composed of younger basalt sills and dikes, which squeezed into and cut across the Eagle Creek rock. This volcanism which may have occurred as recently as 100,000 years ago, produced a small cinder cone that blocked Greenleaf Creek and created Greenleaf Falls.

Geologists have classified the Bonneville landslide as a large rockslide-debris avalanche, meaning it represents a complex downslope movement of rocks and soil that probably first slid along joints (fractures) and bedding planes and that then began to tumble and flow chaotically as it moved farther downslope (and rapidly!) toward and into the Columbia River. Was this catastrophic collapse caused by an earthquake or by intense rains that saturated the slide mass, or if not, by what? Geologists can't be sure what the cause was just yet, but they are keenly interested in finding out.

The first written descriptions of the landslide and its effects were by Lewis and Clark. On October 30, 1805, as they were floating along the Columbia River downstream of the Little White Salmon River, Lewis and Clark made a noteworthy observation: "...most singular is that there are stumps of pine trees scattered for some distance in the river, which has the appearance of being dammed from below..." (Coues, v. II, 1893). The puzzle of the dead trees continued to arouse the curiosity of the explorers as they moved downstream and on their return trip. They camped out on a small island slightly upstream of the landslide on October 30th and 31st of 1805. As they talked with their tribal hosts and observed the landslide up close, Lewis and Clark confirmed their hypothesis about the landslide blocking the river and drowning the upstream forest. Their astute observations would later appear as a footnote on p. 216 of Charles Lyell's *Principles of Geology* (1850).

On their return trip, Lewis and Clark continued to mention the tree stumps, noting on April 16, 1805 that the stumps were visible as far upstream as the Chilluckittequaw settlement four miles upstream of the Klickitat River, about 36 miles upstream of the landslide blockage and only about 4 miles downstream of The Dalles.

Most Columbia Gorge researchers agree that some of the most significant discoveries about the Bonneville landslide were made by botanist Don Lawrence, who grew up in Portland and spent summers as a youth at his grandmother's house in the gorge. Don was fascinated by the botany and geology of the gorge,

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Aerial-oblique photo of the Bonneville landslide looking north. Photo courtesy of Derek Cornforth. Mount St. Helens and Mount Rainier are visible in the top left center and right center respectively.

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and soon was investigating the submerged forest of the Columbia that Lewis and Clark had described as well as the Bonneville landslide. Don began sampling the submerged forest trees in 1934 and continued his work for nearly sixty years, publishing papers on the subject in 1936, 1937, and 1958. With his wife Elizabeth, he located more than 3,000 stumps of the subfossil forest, and in 1958 they obtained the first radiocarbon ages on these subfossil trees, which suggested to them that the landslide had occurred about 700 years earlier (~AD 1250).

When the second powerhouse at Bonneville Dam was constructed in 1978, the excavations unearthed trees that had been buried by the Bonneville landslide. Radiocarbon ages obtained on a large Douglas-fir were reported at about 800 years old in a report by archaeologist Rick Minor in 1984. This radiocarbon age appeared to support the dates reported by Don and Elizabeth Lawrence in their 1958 Mazamas magazine article.

In the summer of 1987, a group of researchers, including the author, accompanied Don and his long-time field companion, geologist Ken Phillips, into to the gorge to look for evidence of the lake impounded behind the Bonneville landslide blockage. Don was still doing field work at the age of 86 then, and Ken Phillips was more than 90. On that trip we asked Don about the samples of the submerged forest he had taken in hopes we could examine them, but he sadly reported that they had disappeared. An exhibit containing some of the slabs in the World Forestry Center in Portland was destroyed in 1964 when the building burned down. According to Don, slabs that he had stored at his mother's house also had vanished. For all of us, this was disappointing news, because the key to precisely dating the landslide was locked in the stumps of the submerged forest.

U.S. Geological Survey geologist Bob Schuster had also been fascinated by the Bonneville landslide. In the late 1980's, Bob and I talked about trying once again to determine an age for the landslide because he had remembered that the Skamania County Museum had a specimen of the tree from the 1978 second powerhouse excavation on display. With the cooperation of the staff of the museum (now the Columbia Gorge Interpretive Center), we eventually submitted two small samples of that tree for radiocarbon dating. The results proved to be surprisingly young compared to the original age of about 800 yr BP that Rick Minor had noted in his report. This new results using standard radiocarbon techniques implied an age range of about 300 to 500 years for the landslide. Not long after Bob and I announced our new younger radiocarbon ages, researcher Nathan Reynolds determined that lichens growing atop Bonneville landslide debris probably were about 300 years old. And also about that same time it was discovered that the Cascadia earthquake, a great subduction zone earthquake with a probably magnitude of 9, had happened in the winter of 1700. Was the Bridge of the Gods created by this great earthquake? After all, it was surmised that this 1700 enormous earthquake might have been the largest earthquake in the Pacific Northwest for which there was evidence in more than 1,000 years! And the long period of shaking caused by such an enormous earthquake — as much as five minutes — would have been a good culprit for causing such a rockslide-debris avalanche. There were a few other red herrings in support of this idea as well, and they seemed pretty compelling at the time. For example, Don Lawrence's photo matching of submerged forest trees showed that they were slowly still decomposing in the early-to-mid 1900s, and some of the submerged snags were as much as 25 feet tall. Don observed correctly that dead Douglas-fir trees typically rot away very quickly, becoming quite decomposed after half a century or more. Why were some of these still decomposing? Were they younger than the old dates suggested? Further, one tribal oral history talked of events about 1700, and Lewis and Clark had thought the landslide occurred only 20 years before they arrived in 1805.

But it turned out there was conflicting evidence for this possible younger age interpretation for the Bonneville landslide. Geologists Jim O'Connor and Tom Pierson of the US Geological Survey had discovered evidence for a large flood downstream of the Bonneville landslide. Their evidence included the large rounded boulders in the North Bonneville area as well as deposits on islands in the lower Columbia being studied by US Geologist Brian Atwater. The flood deposits on the islands could be dated, at least in a relative sense, because pumice from the eruptions of Mount St. Helens about AD 1480 was found on top of them. Therefore, the flood and the landslide, had to be older.

The evidence for the younger age of Bonneville slide or it's correlation w/ Cascadia quake would not hold up. In addition to the flood evidence of O'Connor, Pierson, and others, two important milestones happened in 2001-2002. We found a "refugium" of old trees growing on the landslide rubble that had survived past fires, and, most importantly, Nathan Reynolds, who had done the lichen study a few years earlier, tracked down two of the slabs of "the submerged forest of the Columbia" that Don Lawrence had taken back in the mid 1930s!

Russ Weaver and I had received an M.J. Murdock Trust Partners in Science Grant to study the rings of the refugium trees. Russ (with help from Nathan and I) cored nearly 50 of these living trees and found that some of them dated to the mid 1500s! There was no way the slide was younger than that. All the old Douglas firs Weaver studied had fire marks, and it now appears to Nathan Reynolds that the lichen clock must have been reset by fire.

But back to the tree slabs that Reynolds had tracked down in 2001; when that group of us was out in the gorge with Don Lawrence back in 1987, he told us that he thought all the slabs were missing in action, both those he had stored under his mother's house in Portland, and those that were on display in the World Forestry Center, which had burned down in 1964. That is, until fall of 2001 when Reynolds called the WFC and found out they had a crate of slabs in storage that might be of interest to us. So Nathan, Jim O'Connor, Alex Bourdeau, and I went over to the WFC and were flabbergasted to see that a crate that included two slabs of the submerged forest trees and two slabs of modern trees whose rings that Lawrence had been trying to match with those of the subfossil trees. So there is the serendipity of Nathan Reynolds actually tracking down the "missing" slabs as well of the amazing coincidence that these particular slabs had evidently still been in the possession of Thornton Munger down at OSU at the time the WFC burned down. (Munger had prepared the slabs that were in the original exhibit lost in the fire!) Apparently Don Lawrence never knew that, so he thought all his slabs were gone!!!

The helpful staff at WFC assisted us in taking wedge samples of all the trees so we could do radiocarbon analysis and study the tree rings. Jim sent the first set of samples out for AMS dating, and when they came back we processed them in computer program Oxcal for "wiggle-matching" of the dates (finding the best fit of the entire array of dates w/ radiocarbon curve). This finessing yielded an age in the early-to-mid 1400s-finally a date we could have confidence in. Jim O'Connor mentions this in his excellent article in Oregon Historical Quarterly of 2004: *http://www.historycooperative.org/journals/ohq/105.3/index.html*

About this time we compared the rings of Lawrence's slabs with each other and with those of the tree recovered from the second powerhouse that Bob Schuster and I had dated. The trees can be cross correlated, so it appears they died the same year. A tree round on display at the Willamette Locks Interpretive Center also had been taken from the tree recovered in 1978, but had not been sprayed with any preservatives. Nathan Reynolds, Jim O'Connor, and I sampled this wood, as well as more wood from Don Lawrence's samples for additional radiocarbon dates. Nathan Reynolds is currently taking the lead on writing up the results of these ongoing tests for publication in a scientific journal, so some of the details of this latest research will have to wait until the paper has gone to press, but the new work confirms that approximate age in the mid 1400s.

In the meantime, more mysteries have appeared related to the landslide blockage and its effects on the river. Jim O'Connor has found evidence of deltas from tributary streams that were constructed into the lake that had been impounded behind the Bonneville landslide. The size of the deltas implies the lake could have been in existence for a considerable length of time, but for how long? And did the breaching of the lake occur in stages, and if so, when, how, and with what downstream effects?

And Russ Evarts, the geologist who is mapping the geology of the landslide and the areas around it, has been learning a great deal about the rocks composing the landslide as well as the landform itself. The ½ mile-long rockslide from Red Bluffs that occurred in late 2007 or 2008, for example, has resulted in some excellent exposures of rock that Evarts has sampled. Jim Randall, a geologist from Portland State University, is studying some of the more recent ground movements of the Bonneville landslide and of the slide area adjacent to it. Stay tuned for more details on the geologic history of the Bridge of the Gods landslide and its impacts on the Columbia River as well as more details on the geologic story of the rocks and landforms nearby!