Radiocarbon Dating of Some Events on Mount Hood and Mount St. Helens

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THE EXTRAORDINARY smoothness of the southwest quarter of Mount Hood has intrigued us for a number of years. The whole area looks as though it had been swept by a deluge of water. This effect is evident from such a vantage point as the ski slope on Multorpor Mountain (Fig. 1); it is especially notable in vertical aerial photos when examined under a stereoscope, and it can be detected in the smoothly curved and evenly spaced contour lines on the Mt. Hood topographic map prepared long ago by the U. S. Geological Survey. The fan shaped area, indicated on our map (Fig. 2) by arrows and heavy dotted lines, seems to be a much younger surface than most of the rest of the mountain's flanks. General appearances suggest that a great outburst of water issued from the crater and poured down across the slope, making a mud fall across Mississippi Head, filling in depressions, and leaving streamlined curves and swirls across the whole landscape. This sort of waterwashing apparently molded the area which is now so superb for winter skiing, and on which stand Timberline Lodge, Mazama Lodge, and the town of Government Camp. The east boundary of the area is formed by Steel Cliff near the summit, and by the ridge that continues southward just to the east of White River Canyon. The north boundary is formed by Illumination Rock and the ridge below it on the west face of the mountain. Study of the aerial photos suggests that even the steep basin of Reid Glacier just north of Illumination Rock may have received some of the sweeping action by outbreak through the notch behind Illumination Rock.

When buried stumps of trees were exposed by relocation of U. S. Highway 26 and Zigzag River at Twin Bridges a few years ago, it occurred to us that radiocarbon dating of their wood might help to date the deluge. And when many other buried logs were exposed in the summer of 1958 by the digging of ditches south of Government Camp, the thought of obtaining radiocarbon dates became even more intriguing. In early July 1958 we collected wood from both these areas and also from fossil stumps in the West Fork of White River, where Kenneth Phillips had shown them to us in 1940. Quick action by Martha Darcy in obtaining Hardesty Funds and prompt analysis by the University of Michigan dating laboratory have made the dates available for the present article. The methodology of radiocarbon dating was described in our article in the Mazama Annual of 1958.

We collected our samples very carefully with an ax especially cleaned for the purpose. We first cut away outer layers of wood that might have been contaminated with modern or ancient carbon; then while splitting out the sample pieces, we held them with fresh pieces of aluminum foil to avoid contact with our hands so the samples were clean and ready to analyze when wrapped in foil and immediately enclosed within two plastic bags.

We thought when we collected the wood that if the samples were not all of the same age, the logs at the base of Multorpor Mountain at Station 1 on our map (Fig. 2) would be most sure to date the great water-burst from the summit crater because the logs there are jumbled together within a matrix that could be either glacial or volcanic mudflow. As it turned out the three samples were of different ages, and our preliminary interpretation set forth here is merely a framework upon which ideas may be hung. If as time passes other facts come to light which make the framework look rickety, then a sturdier structure will have to be substituted. The purpose of making a framework at all at this early stage of our knowledge is to pose a problem for testing, and to present readers with the facts we have at hand so that they also can begin to think about the problem and watch for other evidences pro or con.

The Great Mudflow

After collecting the sample at the base of Multorpor Mountain (Figs. 3 and 4), at an elevation of 3800 feet, we made ring counts of trees growing on the surface overlying the fossil logs. These showed approximately 500 growth layers which meant that at least 500

Fig. 1. Panorama from northwest slope of Multorpor Mountain showing smooth streamlined southwest face of Mt. Hood remaining after burst of crater wall released great volume of water possibly from a crater lake similar to the one in the South Sister today. Mississippi Head is a prow-shaped cliff above timberline at left. July 6, 1958.

years had elapsed since the great mudflow. At about this stage Dr. Minor Nichols told us he thought he remembered counting 700 rings on some stumps that had been cut behind his house, a half mile west of Government Camp, when the REA power right of way was cleared a few years before. Upon investigating we counted at least 900 rings, all very narrow, in one of the stumps, a cedar *(Thuja plicata)* which was four feet in diameter at breast height where the rings were counted. Since the cedar grew on top of the mudflow that buried the logs at the base of Multorpor, the mudflow must have occurred over 900 years ago. The radiocarbon dating of one of the buried logs, a hemlock *(Tsuga),* shows that it has been lying there about 1670 years (sample M-898: 1670 plus of minus 200 years), or since about year 288 A.D. This we think is the date when the waterburst flowed out across the southwest flank of Mt. Hood, smoothing it off as we see it now.

Where did all this water come from and in what kind of event was it discharged? The only known counterpart in the United States with which we may make comparison is the great volcanic mudflow which swept down the northeast slope of Lassen Peak and into the channels of Lost and Hat Creeks with disastrous consequences to the local residents on the night of May 20-21, 1915. The appearance of the landscape two days later, together with the first-hand accounts of the washed-out residents, were carefully recorded and illustrated by Loomis (1926) who convincingly argued that the great volume of water came from within the mountain and poured out from a great circular hole plainly visible just below the summit in his photo (his Fig. 53), taken May 22, 1915. Loomis' estimate of the amount of water discharged suddenly in this eruption was a million barrels; his friend M. E. Dittmar estimated twice that much (97-194 acre feet).

In Iceland, such events are commonplace and are called "glacier-bursts", *Jokulhlaups* in the Icelandic language. Several have been described in detail by the great Icelandic glaciologist Thorarinsson (1956, 1957). In these events which often last about one week, as much as 1.5 cubic miles (7 cubic km) of water have plunged out from beneath glaciers and into the sea, carrying momentarily as much water as the Amazon River. That author thought that the water originates partly from the volcanic magma, and partly from the ground water, but mostly from lake water stored in basins beneath the glacier ice.

We visualize the summit of Mount Hood in about the year 250 A.D. as circular and rather symmetrical, as the eastern remnant suggests, containing in its crater a lake about one-third of a mile in diameter and 800 feet deep, similar to but much larger than the one now found in the summit crater of South Sister Mountain 100 miles to the south. The Hood crater lake possibly contained about 40,000 acre feet of water. If this water broke out suddenly it would seem sufficient in itself to have smoothed the landscape to the degree that we find today. The peak may have been at that time heavily laden with glacier ice and snow, which seems likely because there appears to have been an advance of glaciers at Glacier Bay, Alaska, at that same time, revealed by age of one of several fossil forests presumably overwhelmed by glacier advance there (Barendsen *et al* 1957). If we imagine the crashing descent of all that water, filled with blocks of glacier ice, as well as rock debris derived from the collapsed south wall of the crater, we can visualize a mixture that seems effective enough to have smoothed the

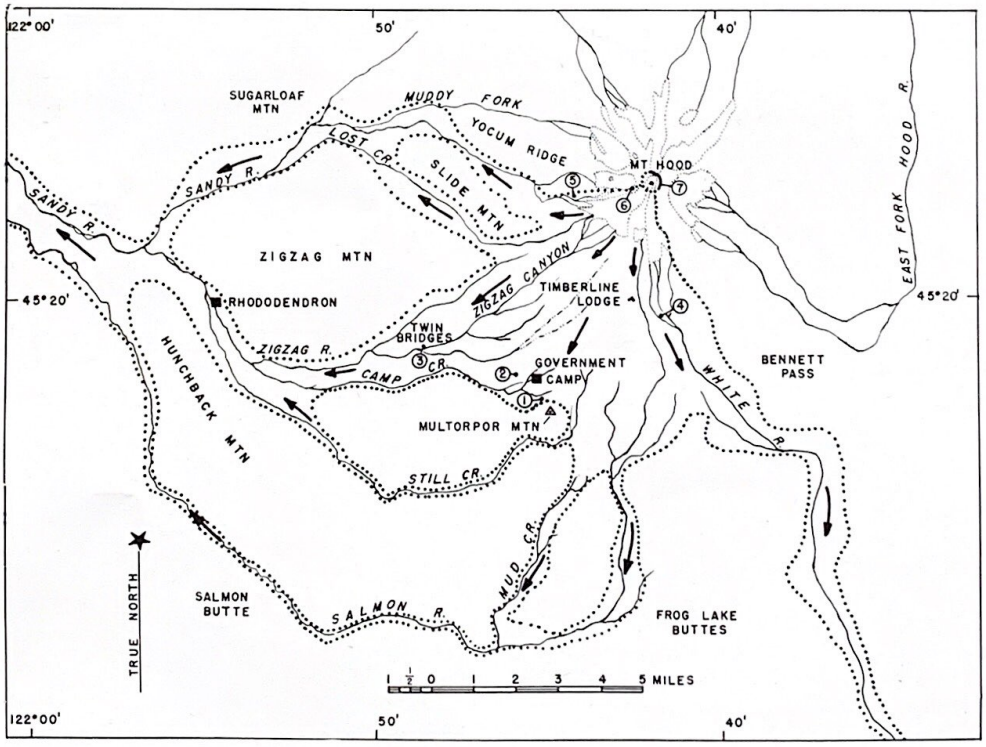
broad mountain flanks over which it tumbled.

In Iceland when a glacier-burst occurs as a result of simple sudden drainage of an overstocked lake basin beneath the ice, volcanic eruption frequently follows immediately. Thorarinsson believed that the sudden reduction of pressure on the volcanic magma stimulates eruption to begin. The same mechanism may have resulted in eruption following outburst of the crater lake over the volcanic throat of Mt. Hood, adding water from other sources within the mountain as there seem to have been at Lassen Peak—magmatic water and ground water stored deep below the floor of the crater lake.

The Twin Bridges and Stadter Buried Forests

At the east end of Twin Bridges Forest Camp on Zigzag River, at 2900 feet elevation, six miles above the town of Rhododendron, an erect Douglas fir stump with bark still attached, rooted in place where it grew among a whole forest of neighbors, was sampled (Fig. 5). Its radiocarbon analysis shows that it was buried in mudflow about 920 years ago (sample M-900: 920 plus or minus 150 years). We were surprised to learn that this wood was so different in age from that at the base of Multorpor Mountain; we rather expected them to be the same. The Twin Bridges Buried Forest turns out to be of about the same age as the Stadter

Fig. 2. Map traced from Mt. Hood Quadrangle USGS topographic sheet, 1927 edition reprinted 1944. Arrows show where burst of water, mud, and rock from what may have been a crater lake centered over Crater Rock swept down across southwest quarter of mountain, smoothing it off. Flow escaped through Sandy, Zigzag, Salmon, and White Rivers covering valley floors with mud and gravel. STATION 1: logs buried in this mudflow, now overlain by as much as three feet of swamp forest peat, have been there for about 1670 years. STATION 2: living cedar (Thuja) forest over 900 years old on top of mudflow. STATION 3: younger buried forest with trees erect where they grew 920 years ago when Stadter Buried Forest was growing at STATION 5. STATION 4: erect remains of still younger forest that grew less than 500 years ago just before White River Glacier advanced down valley overwhelming it. STATION 6: Illumination Rock; Zigzag Glacier lies beneath the label number, and Reid Glacier is immediately to the north. STATION 7: Steel Cliff forming east wall of original crater. North wall of original crater forms present summit of Mt. Hood. Heavy dots continuing circle around central dot marking Crater Rock show presumed outline of original crater possibly containing a lake about 1700 years ago. The crater may have burst as a result of volcanic or glacial causes, or both.



Buried Forest described separately by Carl Richards and by Edwin Hodge in the 1931 Mazama Annual. Wood from the Stadter Forest on the south side of Illumination Ridge had been dated earlier, and the age (950 plus or minus 150 years) was transmitted to us by A. E. Harrison of the University of Washington in his letter of 9 Dec. 1957.

Before discussing these buried forests further we must point out a misunderstanding regarding interpretation of the Stadter Forest, which occurs at an elevation of 6,200 feet. It does not stand above the elevation of the timberline of today. One can plainly see, under a stereoscope in aerial photos that were not available in 1931, living trees growing hundreds of feet higher on the north side of Illumination Ridge. This means that the trunks of Stadter Buried Forest, which lie prostrate, could have been carried down to that level, presumably by the advance of a glacier, from higher up, where they could have grown even had the climate been identical to that of today. We need assume only a more stable mountain slope on which they could have had secure roothold. Discovery of the buried forest of about the same age at Twin Bridges, 3,300 feet closer to sea level, shows that we can no longer continue to believe that the climate was unsuitably hot and dry for forest growth in the foothills and valleys below the mountain flanks at the time the Stadter Forest was living.

It is of great interest to note that another one of the fossil forests at Glacier Bay, Alaska, is of approximately this same age and presumably was also overridden by advancing ice, about 850 years ago.

We believe that the burial of the Stadter Forest and its counterpart at Twin Bridges was related to the growth and shrinkage of Zigzag Glacier in a portion of the "little ice age" that seems to have occurred near the year 1000 A.D. This may well mark the time when Zigzag Canyon was carved in the mudflow surface we have described in the early part of this article. Although the carving of Zigzag Canyon and the deposition of gravels in the forest at the Twin Bridges site may have taken place slowly in the normal course of events along an active glacier outwash stream, they may both have occurred suddenly in an event similar to the Kautz Glacier flood on Mt. Rainier in October 1947.

Fig. 3. New ditch at base of Multorpor Mountain carved through 3 feet of swamp forest peat and into Mt. Hood mudflow. Many fossil logs are here where they were imbedded 1670 years ago in the mudflow material. Hemlock wood sample M-898 was taken from floor of ditch at distant bend to right. July 6, 1958.

The White River Canyon Buried Forest

Wood was also collected from a buried hemlock stump, perfectly preserved with bark still attached, probably mountain hemlock *(Tsuga mertensiana)*, which was rooted where it grew at 5,200 feet elevation on the east wall of the west fork of White River (Figs. 6 and 7). It has been dead too short a time to be dated accurately by the radiocarbon method (sample M-899: 250 plus or minus 150 years). All we can say is that it is relatively modern and has been dead less than about 500 years. We believe that this tree grew immediately before the latest strong advance of White River Glacier, which may have begun as recently as the 17th century A.D. Eliot Glacier on the northeast side of Mt. Hood reached its greatest extent about 1740 A.D. as we showed in our article in the 1948 Mazama Annual, and there are trees of similar age in the youngest fossil forest at Glacier Bay, Alaska, near its mouth,

Fig. 4. Hemlock log in mudflow material at tip of shovel blade was source of radiocarbon sample M-898, which died about 1670 years ago. July 6, 1958.

Fig. 5. Douglas fir stump near Twin Bridges Forest Camp, in place where it grew, with bark still attached, imbedded in glacier outwash gravels deposited about 920 years ago. This is same age as Stadter Buried Forest described in 1931 Mazama Annual.

Fig. 6. Fossil stump horizon in west fork of White River Canyon at 5200 feet altitude. Circle shows location of stump in Figure 7. July 7, 1958.

where it was overridden by the latest glacier advance (Lawrence 1958).

Age of Spirit Lake at Mount Saint Helens

We have asked ourselves repeatedly since we first visited Spirit Lake in 1937, how old is the lake? How long ago was the valley in which it lies dammed by the volcanic growth of Mt. St. Helens? We know that no single answer can be given because the lake grew over a period of centuries as successive eruptions occurred and the mountain base broadened. We said in our article in the 1954 Mazama Annual that we thought the latest important deepening occurred "before 1550 A.D." It appears now that that event occurred only shortly before that, possibly no longer ago than 1500 A.D., or it may even have occurred more recently, possibly as late as the 18th century; it is not possible to distinguish between two such modern dates by the radiocarbon method.

We are indebted to John Leach for assembling data as to the size and depth of Spirit Lake. In a letter of 17 Sept. 1959, J. R. Throckmorton of the U. S. Geological Survey in Tacoma gave him the following information. The area of the lake is 1.87 square miles or about 1200 acres. The lake level is not regulated by a dam now but at one time there was a timber dam (Coes Dam) which has been abandoned. He quoted Washington State Department of Conservation figures of 184 feet as the depth, presumably the maximum measured, with an average depth of about 160 feet. (That same agency gave area as 790 acres.) The steepness of the hills rising from the north shore would suggest much greater depths, of possibly 500 to 1000 feet. John Leach quoted the YMCA camp superintendent's figure of 2,000 feet, and an anonymous article in the July 11th, 1959 issue of the Saturday Evening Post stated 1,300 feet. The

Fig. 7. Fossil hemlock thirty inches in diameter (probably mountain hemlock) with bark attached, imbedded in glacial till or outwash about 100 yards closer to the mountain than foreground of Figure 6. It has been dead less than 500 years. July 7, 1958.

Fig. 8. Douglas fir snag (same as in Fig. 9) near northeast end of Spirit Lake, July 9, 1958. Water depth below tip was 120 feet in 1939, 96 feet in 1958. Boards nailed to tip of snag bear red reflectors to warn boatsmen at night. This seems to be the same leaning snag as that visible in Embody's photo of 1898, then protruding 10 to 15 feet. See Figure 4 of our article in 1954 Mazama Annual.

divergence between these reported values suggests that it would be worth while to attack the problem afresh with sonic sounding equipment and produce a faithful bathymetric chart of the lake.

Our interest in the maximum depth is related to depth of water we have measured around some of the drowned trees standing up from the floor of the lake. In 1939 we measured 120 feet of water below the tip of the one shown here in Figures 8 and 9. The depth measured in 1958 at the same place was only 96 feet. This may mean that 24 feet of sediment accumulated on this part of the lake floor in the intervening 19 years, or that our measurements were in error. Although the heavy forest cover surrounding the lake would suggest a slow siltation rate as Erdmann and Warren (1938) assumed, it would be quite possible near the northeast corner of the lake's east arm, where these measurements were made, for rather heavy contributions of silt to be received from the steep valley to the north. It should be recalled that at least one torrential rain with widespread disastrous erosion and flooding occurred between these years when in early October 1947 the Kautz Glacier flood took place on Mt. Rainier; 24 feet of siltation here could possibly have occurred in a very few severe storms.

Radiocarbon datings of this drowned Douglas fir snag (M-901) and another (M-902), standing up from 58 feet of water, showed that the trees had been dead so short a time (200 plus or minus 150 years) that the radiocarbon method is inaccurate. About all we can say is that they were drowned fairly recently, probably less than 500 years ago. A reasonable estimate of the most recent time when the lake level was raised suddenly by natural means is about 1500 A.D., based on ring counts of an old living Douglas fir growing on the volcanic mudflow slope along the south shore of the lake and sectioned by Murray Miller. But we must leave open the possibility that by 100 years or so after 1500 the outlet stream had carved a channel 60 feet or deeper, that large trees such as the two Douglas firs sampled could have grown up on the shores thus laid bare by drainage, and that the outlet channel could have been filled in again by glacial outwash in the 18th century when glaciers were probably suffi-

ciently enlarged to have enabled that to happen, drowning the trees.

Both snags sampled are leaning and we do not know the angle of the submerged hillside on which they were growing, so the actual depth of water above their roots is not easy to ascertain, but others stand erect in at least 60 feet of water making it safe to say that Spirit Lake is today at least 60 feet deeper than it was a few centuries ago.

Perhaps careful study along the shores of upper Toutle River below its origin at the lake outlet (Fig. 10) would help to solve this problem. Perhaps there are remnants there of forests of more than one age.

In conclusion we may say that although we don't yet know how long ago the lake first began to be formed, we do know now that at least 60 feet or so of depth was added less than about 500 years ago. It may still be possible to learn, from remains of snags now far below the surface of the water, just when the lake was newly formed, and when at other times the dam at its outlet was suddenly raised, but the job of collecting samples of their wood will be very much more difficult.

We wish to express special appreciation to Martha Darcy and the Hardesty Fund for making it possible to have the radiocarbon dating done so promptly, to Dr. J. E. Lodewick for species identification of the wood

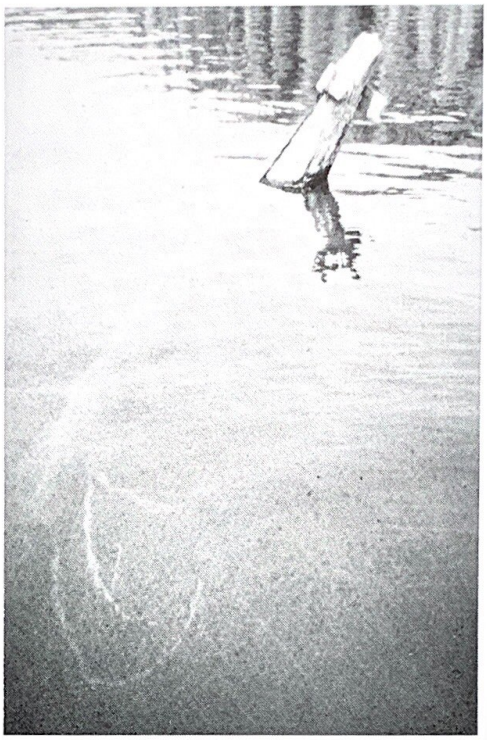


Fig. 9. Same Douglas fir snag as in Figure 8, drowned by rise of 60 feet or more in lake level less than 500 years ago. Slender branches are still visible beneath the lake surface, preserved there from decay.

Fig. 10. Snags near Spirit Lake outlet viewed westward from highway bridge, July 9, 1958. More careful study should be made of this fossil forest.

from the fossil trees sampled and to Wilma Monserud for preparing the photos. Provision for the dating of the samples was arranged by James B. Griffin, Director of the University of Michigan Museum of Anthropology, and the work is credited to the Memorial-Phoenix Project under the direction of Professor H. R. Crane.

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The Busy Mountain

By LT. COL. ERWIN G. NILSSON

IT IS SAID THAT over 100,000 people climb Mt. Fuji, Japan's sacred mountain, each year and I don't doubt it, for on a midweek day last July, Don Wilks of Portland and I made the journey and the mountain was alive with hundreds of people, boys and girls, young and old, rich and poor. I had read in a Tokyo newspaper that 3,229 people had climbed the mountain the previous Sunday. Fuji-San as it is known to the Japanese is 12,395 feet high and its southern slopes run unbroken and evenly down to the Pacific Ocean. Fuji is a mass of cinders, ash and rather firm and solid lava of quite recent origin and it certainly is a much more beautiful mountain from a distance than on the peak itself. There is an almost complete lack of meadows and alpine vegetation as we know it, due probably to the relatively recent volcanic action and great amounts of shifting ash and cinders. Timberline runs to almost 8,000 feet and on leaving the dense forests of large timber one steps out onto rather steep slopes of cinders and lava streching evenly to the summit.

Last summer on my return to the states from duty in Korea I had a few days leave in Tokyo and I hoped to sandwich in a quick trip to Fuji-San. On a Wednesday morning I met Don Wilks of Portland in the hotel and propositioned him with the trip. Don had climbed in the Cascades and quickly agreed to a fast trip to Fuji. Lieutenant Wilks is an Army aviator and is currently an aviation advisor to a Republic of Korea Army unit. So after equipping ourselves with some directions from the hotel clerk and a pair of $1.25 climbing shoes (low quarter Japanese rubber sole sneakers) we set out for the Shinjuku Station and the 4:10 p.m. interurban to the village of Karazuawa and the Southeast slope of Fuji. Traveling on Japanese trains is an experience; the service is good but the huge crowds of people are unbelievable and then there is always the uncertainty of getting on the right train. But by obtaining the correct track number, the time of departure and the direction of the train one stands a good chance of making the right train. Japanese time schedules are exact and must be to sustain the heavy traffic. Shijuku is one of the four main Tokyo stations for connections to outlying points, and from these four stations to points in the city one takes a taxi or the subway.

After threading our way through the crowds and the hundreds of climbers, some well equipped and headed for the excellent and more difficult climbing areas of the Japanese Alps, we caught our train jammed with home bound workers. It was an oppressive day, hot and humid with occasional showers and the train, even with open windows, was an oven. One hasn't experienced hot weather until he has seen Japan or Korea in July and August. The only thing that can be said for the weather is that it makes the rice grow.